INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

C.C.I.R.

DOCUMENTS OF THE

VIIIth PLENARY ASSEMBLY

WARSAW 1956

VOLUME I

RECOMMENDATIONS, REPORTS, RESOLUTIONS

QUESTIONS AND STUDY PROGRAMMES

CCIR · 1956
WARSZAWA

Published by the
INTERNATIONAL TELECOMMUNICATION UNION
GENEVA, 1957

ADDENDUM No. 1

to

Volume I of the Documents
of the VIIIth Plenary Assembly of the C.C.I.R.
Warsaw, 1956

Note by Director, C.C.I.R.

The 1st Plenary Assembly of the C.C.I.T.T. has submitted a new Question to the C.C.I.R. for study (in accordance with Article 7, para. 2 of the Buenos Aires Convention). This Question thus becomes officially a C.C.I.R. Question and the Director has allocated it to Study Group No. IX as Question No. 165 (IX). The text is given overleaf for insertion between pages 572 and 573 of Volume I. The necessary additions should be made on page 30 and in the middle of page 619.

This opportunity is taken to draw attention to the following corrections concerning the English text of Volume I:

Pages 147 and 148 Delete present Para. **5**.

Present Para. **4** becomes new Para. **5**.

The text of new Para. **4** is as follows:

" **4.** that, in cases where operation over a frequency band with a high degree of stability is required, it is desirable to consider frequency-synthesis methods (e.g., methods whereby the frequency change oscillation is derived from the combination of two frequencies, one being a harmonic of a quartz-crystal oscillator and the other being a variable frequency (interpolating) oscillator of limited range), noting, however, that special care may have to be taken to avoid undesired responses in the receiver from unwanted frequency components present with the frequency-change oscillations; "

Page 175 Second formula of Annex II, for " $P(F) = \frac{1}{\delta\sqrt{2\pi}} \ldots$ " read " $P(F) = \frac{1}{\sigma\sqrt{2\pi}} \ldots$ "

Page 183 Footnote, insert: " **Czechoslovakia** ".

Page 217 Formula (9), for " $0 = -Ax\,\frac{1}{2} \ldots$ " read " $0 = -A\,\frac{1}{x^2} \ldots$ ".

Page 274 Third line of Report No. 21, for " Austria (Doc. No. 379) " read " Austria (Doc. No. **329**) ".

Page 381 Twelfth line, add after " radiation diagram ": " **, in the purely theoretical case when the antenna is situated in free space, the effect of the ground being neglected ".**

Page 382 Lower figure. This figure is not drawn with sufficient accuracy. In particular, near the origin, the angles of intersection between the main lobe and the radial line $\varphi = 0$ should be $\pm 60°$.

The corrected radiation diagram will be published as a supplement to the " C.C.I.R. Antenna Diagrams ".

Page 383 At the top of the page, for " $E = \left| \sin \ldots \right.$" read " $\frac{E}{E_{max}} = \text{Const.} \left| \sin \ldots \right.$ ".

Pages 406 and 416 Interchange the bottom diagrams of Fig. 11, p. 406, and Fig. 19, p. 416.

Page 416 Right hand part of Fig. 19 (1), delete " $\mathbf{g} + (\mathbf{5}^{+2}_{-1})\ \%$ ".

Page 419 Fig. 1, insert " **Long distance international television circuit** " between " outgoing junction line " and " incoming junction line ".

Page 476 Fourteenth line, for " resolves ", read: " **unanimously** resolves. "

Page 569 The English text of Question No. 97(IX) should read as follows, to fall in line with the French text: " . . . . . the elements appropriate to such a circuit and the **sub-division** of the noise power appropriate to the complete circuit **between** the various circuit elements."

Page 616 *Chairman and Vice-Chairman of Study Group No. VI*

By a letter dated 16th December 1957, Dr. J. H. Dellinger (United States), Chairman of CCIR Study Group No. VI, has announced his retirement as Chairman of that Study Group.

In conformity with Chapter 15, para. 3 of the General Regulations annexed to the International Telecommunication Convention, the Vice-Chairman of Study Group No. VI, **Dr. D. K. Bailey** (United States) will take his place as Chairman of this Study Group, which will elect a new Vice-Chairman from among its members.

Page 622 *Chairman and Vice-Chairman of Study Group No. XIV*

By a letter dated 11th November, 1957, Professor Tullio Gorio (Italy), Chairman of CCIR Study Group No. XIV, has announced his retirement as Chairman of that Study Group.

In conformity with Chapter 15, paragraph 3, of the General Regulations annexed to the International Telecommunication Convention, the Vice-Chairman of Study Group No. XIV, **Mr. R. Villeneuve** (France), will take his place as Chairman of this Study Group, which will elect a new Vice-Chairman from among its members.

ADDENDUM No. 2

to

Volume I of the Documents

of the VIIIth Plenary Assembly of the C.C.I.R.

(Warsaw, 1956)

Note by Director, C.C.I.R.

The meeting of C.C.I.R. Study Group XI, which took place in Moscow from 28th May to 9th June 1958, proposed one new Question and four Study Programmes for study by the C.C.I.R. This Question and two of the Study Programmes are intended to replace one existing Question and two existing Study Programmes. New numbers have been given to them and it will remain for the IXth Plenary Assembly of the C.C.I.R. to decide, where necessary, on the cancellation of existing ones. The two other Study Programmes are new.

Of the Administrations, Members of the I.T.U., present at this meeting of Study Group XI, nineteen have requested that this Question and these Study Programmes, should be studied (see Art. 7, para. 2 of the Buenos Aires Convention) and accordingly they become officially a C.C.I.R. Question and Study Programmes. The texts are given overleaf for insertion between pages 592 and 593 of Volume I. The necessary additions should be made near the top of pages 30 and 621 and at the bottom of pages 33 and 620.

This opportunity is taken to draw attention to the following corrections concerning the English text of Volume I:

Page 49 First line, for " 2000 km " read: " **200** km ".

Page 216 Formula (8), for "... $(2\pi\Delta f_1)^4$ " read: "... $(2\pi\Delta f_1)^2$...".

Page 346 Figure 15. Near 8° N—110° E for " 90 " read " **80** ".

Page 348 Figure 17. The small closed contour line over Madagascar should be labelled " **70** ".

Page 349 Figure 18. The small closed contour line over Madagascar should be labelled " **40** ".

Page 399 Figure 5, (1) Even fields, at the bottom, for:

" (e) Vertical blanking 0.05 V $\begin{cases} +0.003 \text{ V} \\ -0 \end{cases}$ " read:

" (e) Vertical blanking 0.05 V $\begin{cases} +\mathbf{0.03} \text{ V} \\ -0 \end{cases}$ "

Page 400 Figure 6 (3) add after: " (i) 0.18 H max. ": " **See note 4** ".
Figure 6 (4) for " (l) 0.045 H " read: (l) **0.04** H " and for
" (r) 0.08 H ± 0.01 H " read: " (r) **0.07** H ± 0.01 H ".
Figure 6 (5) for " 1/10 0 max. sync. ", read: " **1/10** of max. sync. ".

Page 401 Table III. Notation e. for " 13 H to 21 H " and " 826 μs to 1334 μs " read " **0.05 V to 0.08 V** " and " **833 μs to 1333 μs** "

Page 408 Top of the page. For " Notes concerning Figures 11 and 12 (Belgian 625-line system) " read: " Notes concerning Figures **5 and 6 (525-line system, notes 1 to 6)**, 11 and 12 (Belgian 625-line system) ".

Page 539 Fifth line of the Annex. For " 0,1 g " read " 0,1 g/**kg** ".

INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

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DOCUMENTS OF THE

VIIIth PLENARY ASSEMBLY

WARSAW 1956

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RECOMMENDATIONS

REPORTS

RESOLUTIONS

QUESTIONS AND STUDY PROGRAMMES

QUESTIONS

submitted by the C.C.I.R. to the C.C.I.F. and the C.C.I.T.

ALLOCATION OF REPORTS, RESOLUTIONS, QUESTIONS AND STUDY PROGRAMMES TO STUDY GROUPS

VARIOUS ORGANISATIONS

mentioned in this volume

ALPHABETICAL INDEX

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INTRODUCTION

The International Radio Consultative Committee (C.C.I.R.) held its VIIIth Plenary Assembly in Warsaw from 9th August to 13th September 1956. It was attended by about 400 delegates, representatives, experts and observers from some 40 countries Members of the I.T.U., 16 recognised private operating agencies, 8 international organisations and 7 scientific or industrial organisations.

At the same time all the fourteen Study Groups of the C.C.I.R. held meetings in Warsaw and the Plenary Assembly adopted 83 Recommendations, 58 Reports and 19 Resolutions put forward by the Study Groups.

The programme of work for the next three years was also established. It consists of 71 Questions and 57 Study Programmes dealing with all aspects of radio communication, including problems of the transmission, propagation and reception of electromagnetic waves which arise in the operation of all radio services.

This volume contains all the texts adopted at Warsaw, as well as those which were adopted during the three preceding Plenary Assemblies and still remain valid. Hence it forms an up to date collection of the texts of the C.C.I.R.

The three preceding Plenary Assemblies of the C.C.I.R. took place in Stockholm in July 1948 (Vth C.C.I.R. Plenary Assembly), Geneva in June/July 1951 (VIth C.C.I.R. Plenary Assembly), and London in September/October 1953 (VIIth C.C.I.R. Plenary Assembly), respectively.

During its first meeting the VIIIth Plenary Assembly of the C.C.I.R. accepted unanimously and by acclamation an invitation from the Administration of the United States of America to hold the IXth Plenary Assembly of the C.C.I.R. in that country.

“The duties of the International Radio Consultative Committee (C.C.I.R.) shall be to study technical radio questions and operating questions, the solution of which depends principally on considerations of a technical radio character and to issue recommendations on them.”

— *Extract from Article 7, paragraph 1 of the International Telecommunication Convention (Buenos Aires, 1952).*

TABLE OF CONTENTS

Note. — *For ease of reference the page numbering in the English and French editions has been made the same.*

LIST OF PARTICIPANTS IN THE VIIIth PLENARY ASSEMBLY

Administrations

Albania (People's Republic of)
Argentine (Republic of)
Australia
Austria
Belgium
Bielorussian Soviet Socialist Republic
Bulgaria (People's Republic of)
Canada
China
Denmark
Egypt
Spain
United States of America
Finland
France
Hungarian People's Republic
India
Ireland
Italy
Japan
Laos
Monaco
Norway
New Zealand
Pakistan
Netherlands
Poland (People's Republic of)
Federal German Republic
Federal People's Republic of Yugoslavia
Ukrainian Soviet Socialist Republic
Roumanian People's Republic
United Kingdom of Great Britain and Northern Ireland
Sweden
Switzerland (Confederation)
Syrian Republic
Czechoslovakia
Overseas Territories of the French Republic
Turkey
Union of South Africa
Union of Soviet Socialist Republics
Venezuela (United States of)

Private Operating Agencies

American Telephone & Telegraph Co.
British Broadcasting Corporation (B.B.C.)
Cables & Wireless Ltd.
Compagnie générale de Télégraphie sans Fil
Independent Television Authority
International Marine Radio Co., Ltd. (I.M.R.C.)
Italcable S.A.
Kokusai Denshin Denwa Co., Ltd. (K.D.D.)
Marconi International Marine Communication Co., Ltd. (M.I.M.C.C.)
Nippon Hoso Kyokai (N.H.K.)
Nippon Telegraph & Telephone Public Corporation (N.T.T.)
Radio Austria A.G.
Radiotelevisione Italiana (R.A.I.)
Radiojänst A.B.
South African Broadcasting Corporation (S.A.B.C.)
Transradio Española S.A.

International Organisations

Association Internationale des Intérêts Radio-Maritimes (A.I.I.R.M.)
Bureau International de l'Heure (B.I.H.)
International Radio Maritime Committee (C.I.R.M.)
International Special Committee on Radio Interference (C.I.S.P.R.)
International Chamber of Shipping (I.C.S.)
International Broadcasting Organisation (O.I.R.)
European Broadcasting Union (E.B.U.)
International Scientific Radio Union (U.R.S.I.)

Scientific and Industrial Organisations

Ateliers de Constructions Electriques de Charleroi (A.C.E.C.)
Brown, Boveri & Co., Ltd.
Hasler S.A.
Magneti Marelli
Siemens & Halske A.G.
Telefonaktiebolaget L.M. Ericsson
Telefunken G.m.b.H.

Specialised Agencies of the United Nations

International Civil Aviation Organisation (I.C.A.O.)
World Meteorological Organisation (W.M.O.)

NOTE BY THE DIRECTOR OF THE C.C.I.R.

DOCUMENTATION FOR C.C.I.R. MEETINGS

In order to secure economy in the reproduction of documents for C.C.I.R. meetings (both with regard to time and money), the Director draws particular attention to Resolution No. 35 which deals with the contents and length of documents. It is printed on page 483 of this volume. Further, as requested by the Organisation Committee of the C.C.I.R. in Warsaw, the Director offers the following additional suggestions concerning the preparation and presentation of documents:

1. *General:*

(a) On each document it should be clearly indicated to which Study Group, and to which meeting it is to be presented;

(b) each document should treat only *one* Question, Study Programme, etc.;

(c) the texts of Questions, Study Programmes, etc. should not be quoted *in extenso* where a simple reference to the number (or paragraph) will suffice;

(d) when announcing a C.C.I.R. meeting, the Director, in consultation with the Study Group Chairmen concerned, will state the last date by which documents should be received, taking into account C.C.I.R. Resolution No. 36;

(e) in conformity with paragraph 1 of C.C.I.R. Resolution No. 37, when documents are sent to a Study Group Chairman, three copies should be simultaneously despatched to the Director of the C.C.I.R. for translation and reproduction.

2. *Texts:*

Texts, not longer than approximately 2,500 words (5 pages), should be presented in one of the working languages of the Union, typewritten on one side of the paper only.

In addition, mathematical formulae should only be included where absolutely necessary for clarification. The derivation of formulae should, in general, be avoided.

3. *Figures:*

In general, not more than three pages of figures should be included with any one document and, in the interests of economy, the use of photographs and other half-tone reproductions should be avoided.

In view of the several languages in which C.C.I.R. documents must be reproduced, no text should appear on figures, with the exception of standard abbreviations (e.g. " Fig. 1 ", " Mc/s ", " km ", etc.). Should any explanatory text be required, this should be given on a separate page.

If possible, figures should be submitted on transparent paper for speedier reproduction.

The overall dimensions of figures should not exceed 17 × 25 cm. ($6\frac{1}{2} \times 10$ inches) so that they may be reproduced on paper of the standard size used by the C.C.I.R.

TERMS OF REFERENCE OF THE C.C.I.R. STUDY GROUPS *

(Warsaw, 1956)

Study Group No. I (Transmitters):

1. To make specific studies and proposals in connection with radio transmitters and generally to summarise and co-ordinate proposals for the rational and economical use of the radio spectrum.
2. To study a number of problems concerning telegraphy and telephony from the transmission point of view.
3. To study spurious radiation from medical, scientific and industrial installations.

Study Group No. II (Receivers):

Measurement of the characteristics of receivers and tabulation of typical values for the different classes of emission and the various services. Investigation of improvement that might be made in receivers in order to solve problems encountered in radio communication.

Study Group No. III (Fixed service systems):

1. To study questions relating to complete systems for the fixed and allied services and terminal equipment associated therewith (excluding radio relay systems). Systems using the so-called ionospheric-scatter mode of propagation, even when working on frequencies above 30 Mc/s, are included.
2. To study the practical application of communication theory.

Study Group No. IV (Ground-wave propagation):

To study the propagation of radio waves over the surface of the earth, taking into account changes in the electrical constants of the earth and irregularities of terrain, and including the effect of a standard radio atmosphere.

Study Group No. V (Tropospheric propagation):

To study the influence of the troposphere on radio-wave propagation insofar as it concerns radio communication.

Study Group No. VI (Ionospheric propagation):

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

Study Group No. VII (Standard frequencies and time signals):

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

* Doc. No. 995 (Warsaw), unanimously adopted.

Study Group No. VIII (International monitoring):

To study problems relating to the equipment, operation and methods of measurement used by monitoring stations established for checking the characteristics of radio-frequency emissions. Examples of such measurements are: frequency, field-strength, bandwidth, etc.

Study Group No. IX (Radio relay systems):

To study all aspects of radio relay systems and equipment operating at frequencies above about 30 Mc/s, including systems using the so-called tropospheric-scatter mode of propagation.

Study Group No. X (Broadcasting):

To study the technical aspects of transmission and reception in the sound broadcasting service (except for tropical broadcasting), including standards of sound recording and sound reproduction to facilitate the international exchange of programmes.

Study Group No. XI (Television):

Television.

Study Group No. XII (Tropical broadcasting):

To study standards required for good quality service in the tropical zone, and for tropical broadcasting systems; interference in the shared bands; power requirements for acceptable service; design of suitable aerials for short-distance tropical broadcasting; optimum conditions for the utilisation of frequency bands used for broadcasting in the tropical zone; other associated questions.

Study Group No. XIII (Mobile services):

To study technical questions regarding the aeronautical, maritime, land mobile and radio location and navigation services, and miscellaneous operating questions of concern to several services.

Study Group No. XIV (Vocabulary):

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

Co-ordinating committees:

Ad hoc committees for the co-ordination of the work common to two or more study groups, constituted by the chairmen and vice-chairmen of the study groups, and chaired by the Director of the C.C.I.R.

DEFINITION

of the Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R.

The following definitions of Recommendations, Resolutions and Questions are those which appear in Doc. No. 272 of Geneva (Drafting Committee). The definition given for Study Programmes is that which appears in Doc. No. 630 of London (Drafting Committee). The definition given for Reports is that which appears in Doc. No. 731 of London (U.S.A.) modified by the addition of the words " by a study group ".

Recommendation	Statement issued when the study of a Question, or part of a Question, has been concluded.
Report	Statement on the studies carried out by a study group on a given subject, for information.
Resolution	Statement of an opinion of the C.C.I.R. on a non-technical subject.
Question	Statement of a technical problem which the C.C.I.R. is to consider.
Study Programme	Text describing the work to be done on a given technical problem forming the subject of a Question.

GENERAL LAY-OUT IN THIS VOLUME

of the Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R.

The Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R., the texts of which appear in this volume, are those which have been approved by the VIIIth Plenary Assembly of the C.C.I.R., together with those which, approved by the Vth, VIth and VIIth Plenary Assemblies, have been retained.

The Recommendations, Reports and Resolutions are arranged in numerical order.

The Questions and Study Programmes are grouped together and arranged in the numerical order of the Study Groups. For each Study Group the Questions are laid out in numerical order, each being followed by the Study Programme or Programmes to which they are related. Study Programmes which are not the result of a Question are indicated by a Note.

Questions submitted to the C.C.I.F. and C.C.I.T. form the subject of a separate chapter.

References to the texts, if any, forming the basis of Recommendations, Reports, Resolutions, Questions and Study Programmes, are given below the title. On the right, under this reference, is shown the Plenary Assembly or Assemblies which have approved or subsequently modified the text.

Mention is made in a footnote, when the occasion arises, of the text or texts which have been replaced by the text in question; in the case of Questions, the Study Programmes are shown which arise from it; and in the case of Study Programmes, mention has been made, where necessary, of the Question to which they refer.

ORIGIN

of certain documents referred to in this volume

The documents referred to in this volume as " Stockholm " ," Geneva ", " London " and " Warsaw ", are respectively the documents of the Vth, VIth, VIIth and VIIIth Plenary Assemblies of the C.C.I.R. held in Stockholm in 1948, Geneva in 1951, London in 1953 and Warsaw in 1956.

The documents referred to in this volume as of " Mexico " and " Florence/Rapallo ", are respectively those of the High-Frequency Broadcasting Conferences of Mexico City (1948/49) and of Florence/Rapallo (1950).

Other documents referred to in this volume are the documents of the meetings of certain Study Groups of the C.C.I.R. The following list of the meetings of these Study Groups is given for information:

Zurich (July 1949)	Meeting of Study Group No. XI
Washington (March 1950)	Meeting of Study Groups Nos. VI and X
London (May 1950)	Meeting of Study Group No. XI
Geneva (July 1950)	Meeting of Sub-Group Gerber of Study Group No. XI
The Hague (April 1952)	Meeting of Study Groups Nos. I and III
Stockholm (May 1952)	Meeting of Study Groups Nos. V, VI and XI
Geneva (August 1952)	Meeting of Study Group No. X
Geneva (September 1954)	Meeting of Study Group No. IX
Brussels (March-April 1955)	Meeting of Study Groups Nos. I and XI

NUMBERING

of the Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R.

The Recommendations, Reports, Resolutions, Questions and Study Programmes of the C.C.I.R. are numbered consecutively in five series, each starting at No. 1.

The series of Recommendations, Questions and Resolutions were started at the Vth Plenary Assembly (Stockholm, 1948).

The series of Reports and Study Programmes were started at the VIth Plenary Assembly (Geneva, 1951).

Questions and Study Programmes remaining for study after the VIIIth Plenary Assembly (Warsaw, 1956) carry in Roman figures after the serial number, the number of the Study Group to which they have been submitted.

The following table serves as a guide to the numbering of C.C.I.R. documents:

Plenary Assembly of C.C.I.R.	Recommendation No.	Report No.	Resolution No.	Question No.	Study Programme No.
Vth Stockholm (1948)	1 to 35	Nil	1 and 2	1 to 33 *	Nil
VIth Geneva (1951)	36 to 85 **	1 to 15	3 to 9	46 to 73	1 to 38
VIIth London (1953)	87 to 144	16 to 37	10 to 19	74 to 112 ***	39 to 78 ***
VIIIth Warsaw (1956)	145 to 227	38 to 95	20 to 38	123 to 163	82 to 115

* Questions Nos. 34 to 45 were submitted to the C.C.I.R. between the Vth and VIth Plenary Assemblies.

** Recommendation No. 86 was issued after the meeting of Study Group No. X of the C.C.I.R. held at Geneva, 1952.

*** Questions Nos. 113 to 122 and Study Programmes Nos. 79 to 81 were submitted to the C.C.I.R. between the VIIth and VIIIth Plenary Assemblies.

COMPLETE LIST OF RECOMMENDATIONS OF THE C.C.I.R.

COMPLETE LIST OF REPORTS OF THE C.C.I.R.

COMPLETE LIST OF RESOLUTIONS ADOPTED BY THE C.C.I.R.

COMPLETE LIST OF QUESTIONS FORMULATED BY THE C.C.I.R.*

* The numbers of the Questions and Study Programmes still under study are followed by a Roman numeral indicating the study group to which they have been allocated.

COMPLETE LIST OF STUDY PROGRAMMES OF THE C.C.I.R.*

* The numbers of the Questions and Study Programmes still under study are followed by a Roman numeral indicating the study group to which they have been allocated.

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RECOMMENDATIONS

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RECOMMENDATION No. 19 *

ORGANISATION OF AN INTERNATIONAL MONITORING SERVICE

The C.C.I.R., (Stockholm, 1948)

CONSIDERING

(a) that the rapid supply of accurate monitoring information, on a world-wide scale, is essential to the I.F.R.B. in the efficient performance of its duties, and to administrations in the effective control of their radio services;

(b) that such monitoring information will be essentially required in respect of a vast number of radio stations of many types, including those operating short-range services on low power; and that, in such circumstances, a large number of monitoring stations spread throughout the world is necessary if the required measurements are to be quickly and accurately made;

(c) that the information at the disposal of the C.C.I.R. shows that large and important areas of the world are not at present provided with monitoring stations; and that, in consequence, the I.F.R.B. will have great difficulty in obtaining full and proper information from these areas, and especially from the tropical regions where, on account of the high levels of atmospheric noise and the large number of low-power services in operation, the effective coverage of any individual monitoring station is likely to be small;

(d) that in Art. 18 and App. C of the Radio Regulations of Atlantic City (1947), it is recognised that certain stations may not participate in the whole field of monitoring but may operate only within a limited part of that field;

(e) that owing to the different characteristics of transmitters and the different techniques and operating procedures employed in the various types of radio services, it would be advantageous for the I.F.R.B. to receive regularly the results of measurements by specialised monitoring stations operated by personnel experienced in the type of service concerned;

(f) that, in particular, the radio stations of the mobile services, due to the special character of their exploitation and to the vital importance of certain categories of these stations for the safety of life at sea and in the air, should be systematically monitored and the results of the measurements transmitted to the I.F.R.B.;

(g) that the exchange of requests for, and the results of measurements would be greatly facilitated if a single national centralising office were designated in each country participating in a world-wide service of monitoring, in conformity with the provisions of Art. 18 of the Radio Regulations of Atlantic City (1947); that on the one hand a uniform distribution, between the monitoring stations of any country, of requests emanating from the I.F.R.B. and from administrations and of actual measurements, and on the other hand the distribution of actual measurements to the I.F.R.B. and to those administrations, would be facilitated through the agency of a single national centralising office, thereby reducing the possibility of overloading certain monitoring stations and thus affording the possibility of expediting the clearance of harmful interference;

RECOMMENDS

1. that administrations, recognised private operating agencies, and international organisations should participate forthwith in the establishment of a coordinated, world-wide, monitoring service;

* The Roumanian P. R. reserved its opinion on this Recommendation.

2. that administrations, recognised private operating agencies, and international organisations in the regions of the world where few, or no, monitoring stations at present exist, particularly in the tropical regions, should endeavour, as far as they are able and as soon as possible, to establish such stations in order to ensure efficient monitoring not only of long-distance but of short-distance transmissions and with a view to the operation of not less than six monitoring stations suitably distributed in each continent;

3. that some monitoring stations be principally devoted to the monitoring of mobile service transmissions and that their locations be chosen within the regions of the world where the density of such transmissions is the greatest and where harmful interference is most likely to be experienced;

4. that the administrations of each country should designate, as far as they deem it possible and at an early date, a single national centralising office for the exchange of all requests and information relating to the monitoring service;

5. that the attention of the administrations is drawn to the need for rapid communications between the I.F.R.B. and the centralising offices, between centralising offices and between individual centralising offices and the individual monitoring stations under their control.

RECOMMENDATION No. 22

FORM OF REPORT FOR FREQUENCY AND FIELD-STRENGTH MEASUREMENTS MADE AT MONITORING STATIONS

The C.C.I.R., (Stockholm, 1948)

CONSIDERING

the desirability of uniformity in furnishing monitoring data;

UNANIMOUSLY RECOMMENDS

1. that the form used in reporting frequency measurements should contain, at least, the following data:

(a) serial number;

(b) identification of the monitoring station (administration or organisation and location);

(c) date;

(d) time (G.M.T.);

(e) call letters and/or other means of identification of the measured station;

(f) classification of emission;

(g) assigned frequency or reference frequency;

(h) frequency tolerance;

(i) measured frequency;

(j) accuracy of measurement;

(k) deviation from assigned or reference frequency;

(l) additional observations (e.g. period covered by measurement, drift of measured frequency during that period, quality of signal and conditions of reception, etc.);

(m) remarks;

(n) signature of responsible official of the administration or organisation;

2. that the form used in reporting field-strength measurements should contain, at least, the following data:

   (a) serial number;

   (b) identification of the monitoring station (administration, organisation, location);

   (c) date;

   (d) time (G.M.T.);

   (e) call letters and/or other means of identification of the measured station;

   (f) classification of emission;

   (g) assigned frequency;

   (h) value of measured field;

   (i) estimated accuracy of measurement;

   (j) polarisation component;

   (k) other elements or characteristics of the measurement;

   (l) remarks;

   (m) signature of responsible official of the administration or organisation;

3. that the I.F.R.B. should study the forms to be universally used in furnishing the foregoing data.

RECOMMENDATION No. 23

SIGNALS MAYDAY AND PAN

The C.C.I.R., (Stockholm, 1948)

CONSIDERING

(a) that the results of the tests presented to the C.C.I.R. by the various administrations and the interpretation and discussions thereon, relating to the question of changing the radiotelephone distress signal MAYDAY and the radiotelephone urgency signal PAN indicate that some technical advantage may be gained in using SOS instead of MAYDAY as the distress signal;

that no such advantage, on the other hand, appears in the proposed use of URGENT instead of PAN;

(b) that, from the operational point of view, the signal SOS is used in radiotelegraphy and is known to laymen as well as to persons in the field of communications throughout the world as the distress signal;

(c) that, from the operational point of view, the association with the spoken signal SOS of an aurally recognisable signal, as proposed in Atlantic City Recommendation No. 6 to the C.C.I.R. (relative to ensuring the watch on the distress frequency 2182 kc/s by the aid of automatic devices), will tend to lessen any difficulty in changing from MAYDAY to SOS;

UNANIMOUSLY RECOMMENDS

1. that the international radiotelephone distress signal should henceforth consist of the three spoken letters S O S instead of the spoken word MAYDAY pronounced as the French expression " m'aider ";

2. that the present international radiotelephone urgency signal PAN be retained.

RECOMMENDATION No. 27

METHODS OF MEASUREMENT AND LIMITS OF TOLERANCES FOR INTERFERENCE CAUSED TO BROADCASTING BY ELECTRICAL INSTALLATIONS

The C.C.I.R., (Stockholm, 1948)

CONSIDERING

(a) that there is no need to resume within the C.C.I.R. the study of methods of measurement since this question has already been entrusted to the Special International Committee on Radio Interference (C.I.S.P.R.), founded under the auspices of the International Electrotechnical Commission (I.E.C.);

(b) that the C.C.I.R. should keep in regular contact with the C.I.S.P.R. and send a representative to the meetings of this latter Committee;

(c) that in view of the importance of the work undertaken by the various countries since the last meeting of the C.I.S.P.R., and which still remains unpublished, a detailed study of the results obtained by that Committee cannot be usefully carried out at this meeting;

(d) that the measuring equipment designed by the C.I.S.P.R. may prove useful for the study of disturbances other than those caused by electrical apparatus, for example by atmospherics;

(e) that the measurements should be extended to disturbances affecting all types of receivers constructed according to modern transmission technique, especially television;

(f) that Bucharest Recommendation No. 88 should be extended to all disturbances due to causes other than signals produced by transmitters;

(g) that in this respect, the most urgent problem relates to the disturbances affecting television receivers and caused particularly by other radio receivers, electrical ignition systems, industrial, scientific and medical equipment producing hertzian radiations;

(h) that, in consequence, the means of measurement is to be extended to all the frequency bands used for sound and visual broadcasting;

(i) that the work of the C.I.S.P.R. is directed according to the four preceding paragraphs;

(j) that, with regard to the precautions to be taken for electrical apparatus and installations and radio equipment, collaboration is essential between the administrations and the organisations representing electrical industry on the one hand, and broadcasting on the other hand;

RECOMMENDS

1. that the C.I.S.P.R. maintain regular contact with the C.C.I.R. and admit a representative of the C.C.I.R. to its meetings;
2. that, if necessary, the C.I.S.P.R. take into consideration the suggestions by the C.C.I.R. regarding the relative urgency of the work carried out in various fields;
3. that, in particular, C.I.S.P.R. pursue actively its work on interference caused to television receivers by other receivers, ignition systems, and industrial, scientific and medical equipment producing hertzian radiations.

RECOMMENDATION No. 28 *

HIGH-FREQUENCY BROADCASTING
BANDWIDTH OF EMISSIONS

The reasons which justify the following Recommendation are given in the Annex

The C.C.I.R., (Stockholm, 1948)

CONSIDERING

that there is no evidence that, under present day conditions, sensibly increased interference between broadcasting stations is caused by the use of modulating frequencies between 5000 and 6400 c/s, when the channel separation is 10 kc/s;

RECOMMENDS

that broadcasting stations with assigned frequencies near the edge of the bands allocated to broadcasting, should be so adjusted that none of the sideband frequencies fall outside the broadcasting bands.

ANNEX

Listening tests have been made in connection with this investigation on the quality obtainable on short-wave and the effect of reducing the frequency band occupied. From the tests made it is considered that, although there will be some loss in audio-frequency quality in restricting the highest modulating frequency to 6400 c/s, the loss is not serious. Tests have also been made in further restricting the band of frequencies to 5000 c/s. The loss of quality in this further restriction is quite noticeable.

The principal causes of unsatisfactory reception of short-wave signals in decreasing order of importance are considered to be :

(a) fading and particularly selective fading resulting in heavy distortion,

(b) insufficient signal/noise ratio at the receiving point,

(c) heterodynes between carrier frequencies,

(d) heterodynes between sidebands of different stations or between a sideband of one station and the carrier of another, due to sideband frequencies being transmitted.

In the last case it has sometimes been found that the actual difficulties arise more from harmonics and spurious radiations generated during the process of modulation at the transmitter than from the actual fundamental modulating-frequency components themselves. Of the above causes the first two are outside the scope of the present question. The third cause will be eliminated when all stations move to fully planned frequency allocations, while in the case of the fourth cause, a considerable amount of remedy is in the hands of the listener, who can usually so restrict the bandpass characteristics of his receiver as to eliminate or reduce interference.

It would be regrettable to eliminate desirable frequency bands from transmissions unless clearly necessary and effective in eliminating interference in particular cases.

The conclusion reached is that it is desirable to maintain the normal bandwidth of modulating frequencies at an upper limit of 6400 c/s.

* The P. R. of Albania did not accept this Recommendation and the P. R. of Poland reserved its opinion on it.

In order to make bandwidth restrictions as effective as possible, steps should be taken to minimise the radiation of harmonic and intermodulation products in the transmitter and to avoid overmodulation with its inherent production of spurious frequencies.

To consider in some detail the effect in a receiver, the interfering signal is assumed to be a high-frequency broadcasting double-sideband signal with modulating frequencies up to and including 6400 c/s, and with the carrier 10 kc/s removed from the desired carrier. The out-of-band radiation (distortion) of the high-frequency broadcasting signal shall not exceed 5 %, and thus the out-of-band radiation falling within the band of the desired signal will be approximately 32 db below the level of the undesired carrier.

The receiver to be considered is the type in general use by the public. Comparison of a number of such receivers has indicated an average selectivity curve which will apply both to European and American receivers, and most employ a diode for demodulation. The average selectivity curve of such a receiver indicates that a signal 10 kc/s removed from the centre of the pass band (assumed position of the desired carrier) will be attenuated 24.4 db. The curve further shows that a signal 5 kc/s removed will be attenuated 8 db, and a signal 3.6 kc/s removed (6.4 kc/s sideband) will be attenuated 5.1 db.

Before considering the actual interference reproduced by the receiver it should be noted that the relatively simple problem of a carrier and two sidebands demodulated by a diode becomes a complex problem when only one sideband reaches the diode or when the amplitude or phase of the carrier and sidebands is altered. Of primary importance to this problem is the further fact that when a carrier is present at the diode, if another carrier is also applied at a lower level, the resultant output is less than either signal. This effect may be analysed by the use of Bessel functions indicating that as the ratio of desired to undesired input to the diode is increased the ratio of desired to undesired output increases much more rapidly.

Assuming no pre-emphasis at the transmitter, and a ratio of desired to undesired signal of 1, the average receiver would admit a 5 kc/s undesired signal to the diode 22.2 db below the desired carrier. Similarly, the 6.4 kc/s interfering sideband would be 21.1 db below the desired carrier and the undesired diode output signal would be more than 40 db below the desired output signal at 100% modulation. The exact value of the diode output is complicated by the fact that the diode linearity varies with input signal and that, in most cases, the diode load varies with audio frequency. However, at desired-to-undesired signal ratios of one or greater, and without pre-emphasis, interference should not be caused.

If receivers are improved, and a much lower ratio of desired-to-undesired signal is then adopted, a point will be reached where interference will be caused by the part of the interfering signal which lies within the receiver pass band.

It has been shown that under usual circumstances the amplitude of the interference should not be troublesome. It may be further noted that the interfering signal will usually beat with the desired carrier and therefore be inverted, the 6400 c/s modulation becoming 3600 c/s interference. The interfering signal would not be intelligible to the listener, and it has been shown that such interference is more easily tolerated than intelligible interference.

At the present time there is no evidence that interference will be caused to the average receiver due to the transmission of normal signal intensities in those portions of the sidebands 5 to 6.4 kc/s removed from the carrier. It does not appear that a reduction in the desired-to-undesired signal ratio will change this conclusion with respect to present receivers. However, the use of pre-emphasis, more selective receivers and modified signal ratios, or a combination of these, may cause the transmission of energy at modulating frequencies up to 5000 c/s and 6400 c/s respectively to assume new importance.

RECOMMENDATION No. 32

USE OF SIMULTANEOUS INTERPRETATION

The C.C.I.R., (Stockholm, 1948)

with reference to the question set by the Administrative Council in Resolution No. 21, § 4, sub-para *(b)*, worded as follows:—

"should the simultaneous interpretation system be used for the sessions of the Plenary Assembly and/or the Study Groups? ";

UNANIMOUSLY RECOMMENDS

that in principle there is reason to use simultaneous interpretation only for the sessions of the Plenary Assemblies and for Committees and Study Groups attended by a large number of members.

RECOMMENDATION No. 40

INTERCONTINENTAL RADIOTELEPHONE SYSTEMS AND USE OF RADIO LINKS IN INTERNATIONAL TELEPHONE CIRCUITS

(Questions Nos. 29 and 41)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that radiotelephone systems connecting the various continents at the present time usually employ carrier frequencies under about 30 Mc/s *;

(b) that the use of such a radio link in a long-distance telephone circuit implies certain special conditions which introduce particular difficulties not encountered when purely metallic connections are used;

(c) that such a radiotelephone circuit differs from a metallic circuit in the following ways:

c.1 such a radiotelephone circuit is subject to attenuation variation with the special difficulty of fading;

c.2 such a radiotelephone circuit suffers from noise caused by atmospherics whose intensity may reach, or even exceed, a value comparable with that of the signal which it is desired to receive;

c.3 special precautions are ncessary in the setting up and maintenance of such a radiotelephone circuit so as to avoid disturbance of the radio receiver by any radio transmitter and especially by its own radio transmitter;

c.4 so as to maintain the radiotelephone link in the best condition from a point of view of transmission performance, it is necessary to take special measures to ensure that the radio transmitter always operates so far as is possible under conditions of full loading

* Further reference to "30 Mc/s" in this Recommendation means "about 30 Mc/s".

whatever may be the nature and the attenuation of the telephone system connected to the radiotelephone circuit;

c.5 it is necessary to take measures to avoid or correct abnormal oscillation or crosstalk conditions;

c.6 although the effectively transmitted frequency band recommended for international landline circuits has been determined by a study of the requirements of the human ear, this band (in the case of a radiotelephone circuit operating at a frequency below 30 Mc/s) may be limited by the necessity of obtaining the maximum number of telephone channels in this part of the radio-frequency spectrum and in order that each telephone channel does not occupy a radio-frequency band larger than necessary;

c.7 in general, such a radiotelephone circuit is a long distance intercontinental circuit giving telephone service between two extended networks, and this fact is of great importance from two points of view:

c.7.1 on the one hand, intercontinental conversations, in general, are of great importance to the subscribers and, on the other hand, they are made in languages which are not always their mother tongue so that high quality reception is particularly important;

c.7.2 the public should not be deprived of a very useful service under the pretext that it does not always satisfy the degree of excellence desirable for long distance communication from the point of view of transmission quality;

UNANIMOUSLY RECOMMENDS

1. *Circuits above 30 Mc/s.*

that between fixed points, telephone communications should be effected wherever possible by means of metallic conductors or radio links using frequencies above 30 Mc/s so as to make the allocation of radio frequencies less difficult, and where this can be realised, the objective should be to attain the transmission performance recommended by the C.C.I.F. for international telephone circuits on metallic conductors.

2. *Circuits below 30 Mc/s.*

2.1 that, since it becomes necessary to economise in the use of the frequency spectrum when considering intercontinental circuits which consist mainly of single long-distance radio links operating on frequencies less than 30 Mc/s, it is desirable to use single-sideband transmission to the maximum extent possible, to employ a transmitted band less than the 300 to 3400 c/s recommended by the C.C.I.F. for land-line circuits and preferably to reduce the upper frequency to 3000 c/s or below, but to not less than 2600 c/s except in special circumstances;

2.2 that, although it will be necessary to tolerate large variations in noise level on such a radiotelephone circuit, every possible effort should be made to obtain minimum disturbance to the circuit from noise and fading by the use of such techniques as full transmitter modulation, directional antennae and single-sideband operation; with present technical development, it is not yet practicable to recommend either a minimum value for the signal-to-noise ratio or a method of measuring the disturbing noise;

2.3 that during the time that such a radiotelephone circuit is connected to an extension circuit equipped with echo suppressors the intensity of disturbing currents should not be sufficient to operate frequently the echo suppressor;

2.4 that such a radiotelephone circuit should be provided with a reaction suppressor (voice-operated switching device) so as to avoid singing or echo disturbance on the complete circuit;

2.5 that such a radiotelephone circuit should be equipped with automatic gain control so as to compensate automatically, so far as possible, for the phenomenon of fading;

2.6 that the terminal equipments of such a radiotelephone circuit should be such that it may be connected, in the same way as any other circuit, with any other type of circuit;

2.7 that in the cases where privacy equipment is used, this equipment should not appreciably affect the quality of telephone transmission;

2.8 that when suitable automatic devices are not provided the circuit should be controlled as often as necessary by an operator in order to ensure optimum adjustment of transmitter loading, received volume and the operating conditions of the reaction suppressor.

Note. — Although the requirements contained in Part 2 of the Recommendation are much less severe than those imposed on international land-line circuits, the ideal remains to attain the same standards of telephone transmission in all cases. In view of this, it is desirable that the telephone systems connected to a radiotelephone circuit should conform to C.C.I.F. recommendations referring to the general conditions to be met by international circuits used for land-line telephony especially in respect of equivalent, distortion, noise, echoes and transient phenomena.

Bearing in mind the recommendations contained in Parts 1 and 2 above, it is desirable that in each particular case, administrations and private companies concerned should first reach agreement on how far the standards usually employed for international land-line circuits may be attained in the case considered. If the technique of Part 1 of the recommendation can be used, the objective should be to obtain as far as possible the characteristics recommended by the C.C.I.F. for international land-line circuits. Otherwise, the administrations and private companies concerned should study the best solution from the point of view of both technique and economy.

RECOMMENDATION No. 45

AVOIDANCE OF INTERFERENCE FROM SHIPS' RADAR TO OTHER RADIOCOMMUNICATION APPARATUS ON BOARD

(Question No. 35)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that experience has proved that with well-designed and properly installed radar the possibility of interference occurring in practice is very remote;

(b) that the possibility of interference to radio reception and to direction finding on a vessel other than that upon which the radar is located is exceedingly remote and that no instances of such interference have been reported;

(c) that in the unlikely case where radar interference might result to radio reception aboard a radar equipped vessel, the presence of such interference may be readily detected and identified by listening on the radio receiver or direction finder;

(d) that where interference has occurred to radio reception aboard ships equipped with well designed radar, in each case the cause of the interference has been faulty initial installation and has been removed by correcting the installation;

UNANIMOUSLY RECOMMENDS

1. that administrations shall see to it that radar equipments placed aboard ships are well designed and properly installed so as not to cause interference to radio reception aboard the radar equipped vessel. In this regard, particular attention shall be paid to shielding, bonding and to fitting line filters, especially in the modulator circuits, for the conductors which are routed between the major components of the installation;

2. that the absence of interference shall be assured either by test procedures of prototypes or by installation inspection procedures whereby an investigation is made to determine whether or not there exists any noticeable interference to ships' radio receivers or direction finders under practical conditions of installation and operation.

RECOMMENDATION No. 48

CHOICE OF FREQUENCY TO AVOID INTERFERENCE IN THE BANDS SHARED WITH TROPICAL BROADCASTING

(Question No. 4 *)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that an audible interfering beat note may occur irrespective of the position of the frequencies used by other services between two adjacent broadcasting carriers in the shared bands;

(b) that the minimum tolerable field-strength ratio of the wanted to unwanted signal depends primarily upon the frequency separation between the carrier waves;

(c) that it is extremely important that all stations operate with the best frequency stability obtainable;

(d) that transmitters of poor frequency stability may be capable of causing harmful interference to tropical broadcasting when operated in the shared bands;

(e) that mobile stations, due to their lower frequency stability and variable location, are likely to cause more interference than fixed stations to tropical broadcasting when operated within the shared bands, particularly when using A3 emissions;

RECOMMENDS

1. that it is not necessary for frequencies of other services sharing frequency bands with broadcasting in the tropical zone to be assigned only midway between the broadcasting frequencies. When mid-spaced frequencies are not assigned, however, it is desirable that the same frequencies be assigned for other services as for broadcasting. The use of frequencies midway between broadcasting station carriers would have the advantage that less stringent tolerances would be required to maintain the required degree of protection than would be the case when frequencies of other services are assigned indiscriminately between adjacent broadcasting frequencies;

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* This Question has been replaced by Question No. 102 (XII).

2. that administrations should attempt to improve, as soon as possible, the frequency stability of fixed stations and, more generally, of all stations operating in the shared bands to the values specified in App. 3, Col. 3, Radio Regulations, 1947. Administrations should arrange for transmitters which do not meet this requirement to operate only on frequencies outside the shared bands, unless there is little possibility of interference to tropical broadcasting services;

3. that, wherever possible, administrations should avoid the operation of mobile stations in the tropical zone within the bands shared with broadcasting, particularly as regards the use of A3 emissions by such mobile stations.

RECOMMENDATION No. 49

CHOICE OF SITE OF STATIONS AND TYPE OF ANTENNA TO AVOID INTERFERENCE IN THE BANDS SHARED WITH TROPICAL BROADCASTING

(Question No. 4 *)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) the provisions of Art. 13, § 3, Radio Regulations, 1947;

(b) that all possible sources of interference to broadcasting should be minimised;

RECOMMENDS

1. that administrations should make every effort to comply, as soon as possible, with the regulations with regard to the siting of stations and the use of directional antennae when the nature of the service permits;

2. that administrations should take steps to ensure that all interference to broadcasting and other radio services in the tropical zone produced by radiation, such as key-clicks, sideband spread, etc., be kept to a minimum;

3. that the broadcasting services in the tropical zone should, for their part, reciprocally take similar precautions to facilitate the operation of other services working in other zones in the shared bands.

RECOMMENDATION No. 52

GROUND-WAVE PROPAGATION CURVES BELOW 10 Mc/s

(Question No. 6 **)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that ground-wave propagation curves for an extended range of frequencies are of continued importance for all types of radio communication including navigational aids;

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* This Question has been replaced by Question No. 102 (XII).

** This Question has been replaced by Question No. 134 (IV).

(b) that such curves for a range of land conductivities are needed for the varying conditions along the land paths met with in practice;

RECOMMENDS

1. that the curves in the Annex hereto be used for the determination of ground-wave field strength on frequencies below 10 Mc/s under the conditions stated;

2. that these curves supersede the existing C.C.I.R. (1937) curves for frequencies below 10 Mc/s.

ANNEX

The attached curves apply to propagation on frequencies below 10 Mc/s.

The following points are to be especially noted with regard to them:

(a) they refer to a smooth homogeneous earth, as in the corresponding C.C.I.R. (1937) curves;

(b) no account is taken of tropospheric effects on these frequencies, i.e. they are calculated for the actual radius of the earth. It is realised that the troposphere exerts some influence below 10 Mc/s, but experimental evidence suggests that on medium frequencies the usually assumed $^4/_3$ earth's radius over-estimates the effect of normal refraction in the troposphere. Moreover, mathematical analysis shows that with decreasing wavelength the concept of an effective earth's radius is no longer strictly valid as the necessary transformation involves not only the frequency used but also the conductivity of the earth. It was therefore decided to retain the use of the actual earth's radius as in the case of the C.C.I.R. (1937) curves, and the consideration of the effect of the troposphere is accordingly made the subject of Study Programme No. 11*;

(c) the frequency range has been extended down to 10 kc/s in view of the suggested use of very low frequencies for navigational aids;

(d) in order to cater more adequately for the differences of land conductivity met with in practice the curves for the value 10^{-13} e.m.u. of the conductivity σ have been supplemented by curves for the further values $10^{-12.5}$, $10^{-13.5}$, 10^{-14} e.m.u. The value of the permittivity assumed is $\epsilon = 4$ as in the C.C.I.R. (1937) curves, but it may be stated that the precise value assumed is not of practical significance for the frequency range under consideration. For the sea curves, the values $\sigma = 4 \times 10^{-11}$ e.m.u. and $\epsilon = 80$ have been retained;

(e) it should be pointed out that the sea curves and the land curves for $\sigma = 10^{-13}$ e.m.u. differ from the C.C.I.R. (1937) curves only in the extension of the frequency range and in the slightly modified method of presentation, as they are based on the same rigid analysis of the problem given by van der Pol and Bremmer;

(f) the presentation is given in two forms:

1. with a linear scale of distance out to 2000 km as abscissa and an ordinate scale which is linear in decibels for which the datum is a field strength of 1 μV/m. A subsidiary scale reading directly in μV/m is added on the right-hand side. The linear distance scale has been retained to exhibit the linear aspect of the curves in the diffraction region where the field strength is approximately exponentially attenuated with distance. The linear scale in decibels replaces the logarithmic scale for μV/m used in the C.C.I.R. (1937) curves in view of its greater convenience in most engineering applications;

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* This Study Programme has been replaced by Study Programme No. 87 (IV).

2. with a logarithmic distance scale for short distances out to 2000 km. This has been done to make the curves more useful in the neighbourhood of the transmitter where they are very steep when the linear distance scale is used. It should be noted that at these short distances it is not practicable to include all the curves down to 10 kc/s where they differ very little from one another and from the unattenuated inverse distance curve; in fact it is not practicable to label all the curves that have actually been included;

(g) the curves are no longer referred to a radiated power of 1 kW, but to what has been called an unattenuated field strength of $3 \times 10^5/D$ in μV/m where D is the distance from the transmitter in kilometres. This field would actually correspond to the case of a vertical antenna, shorter than one quarter wavelength, radiating 1 kW when placed on the surface of a perfectly conducting plane earth. The engineer should regard as an auxiliary problem the determination of the appropriate value of the unattenuated field in a given practical case and the value of the necessary multiplier;

(h) the transmitter and receiver are both assumed to be on the ground. In most practical cases in the frequency range concerned, the height-gain effects with elevated antennae would not be significant. Although height-gain curves exist which refer to this frequency range, their restriction to the diffraction region makes them of very limited use, and it was decided not to include them;

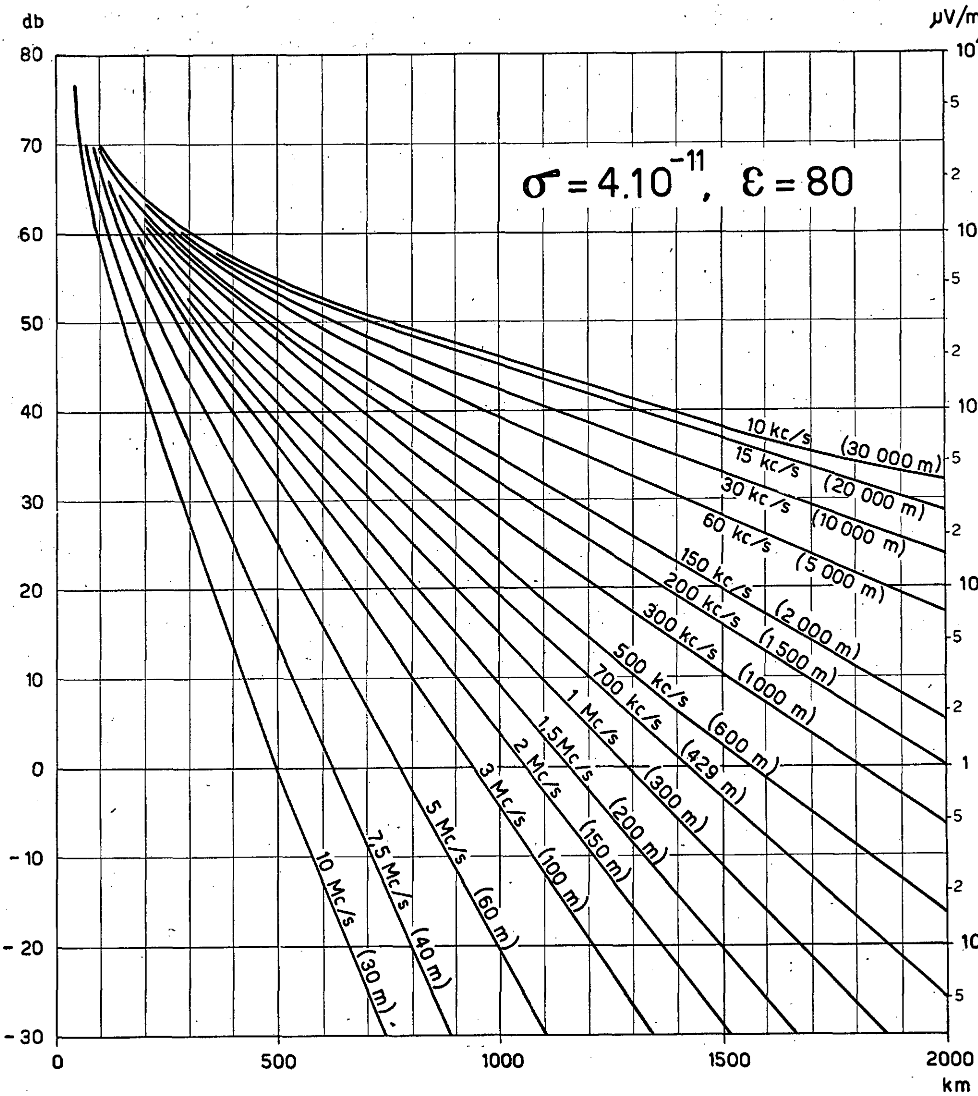
(i) the curves should, in general, be used to determine field strength only when it is known that ionosphere reflections of the frequency under consideration will be negligible in amplitude —for example propagation in daylight between 150 kc/s and 2 Mc/s. However, under conditions where the sky wave is comparable with, or even greater than, the ground wave, the curves are still applicable when the effect of the ground wave can be separated from that of the sky wave by the use of pulse transmissions, as in some forms of direction-finding systems and navigational aids.

Note by the Director of the C.C.I.R.

Figures 1 to 10 which follow are the curves which were included in Recommendation No. 52 (Geneva, 1951). Subsequently, in accordance with Resolution No. 10 (London, 1953), the Secretariat of the C.C.I.R. extended the curves for distances up to 10,000 km. These new curves, together with those contained in Recommendation No. 52, have been reproduced on 5 graphs, one for each of the 5 groups of ground conductivity and dielectric constant given in Recommendation No. 52, and are included here for reference (Figures 11 to 15).

PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5/D_{km}$ $\mu V/m$

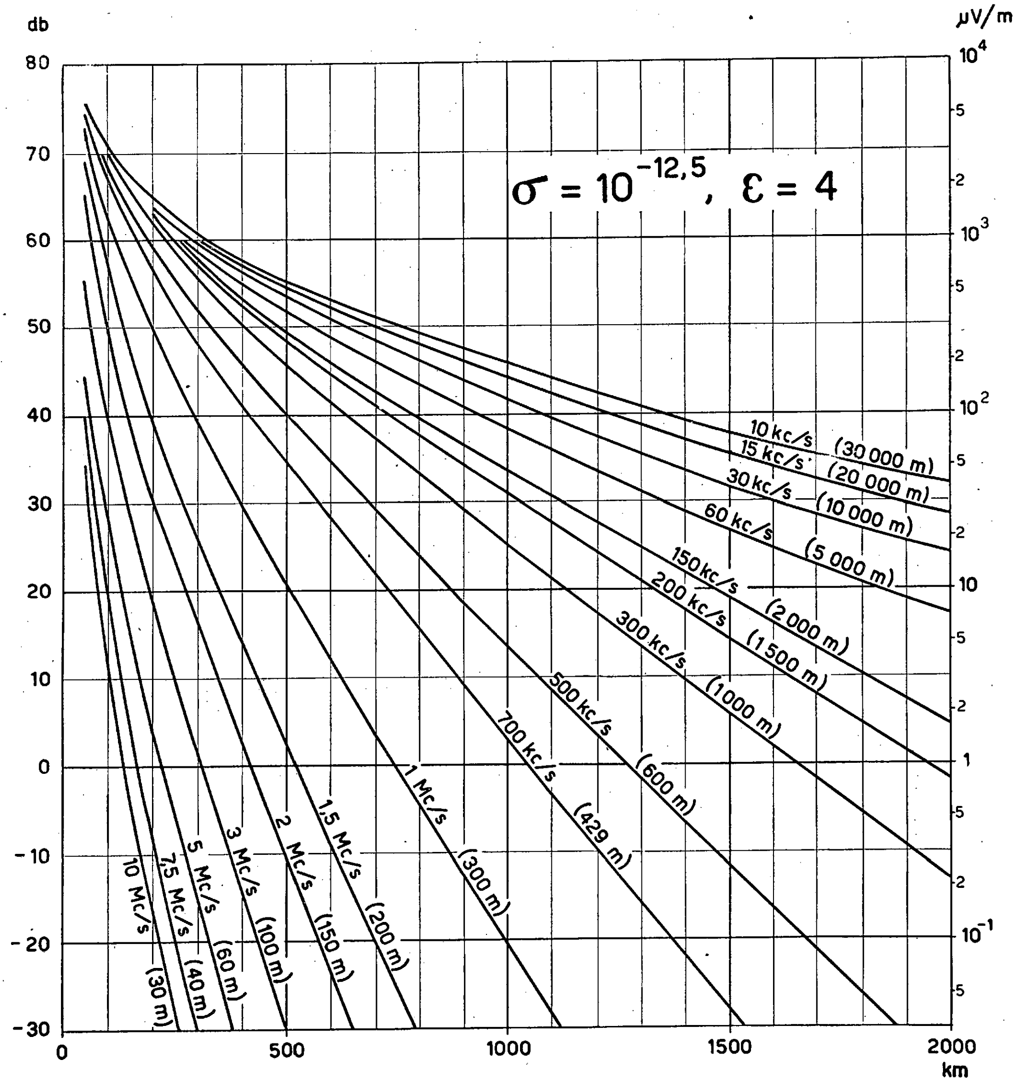


Propagation over sea (conductivity $\sigma = 4 \times 10^{-11}$ e.m.u., dielectric constant $\epsilon = 80$ e.s.u.)

FIGURE 1

PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5 / D_{km}$ μV/m

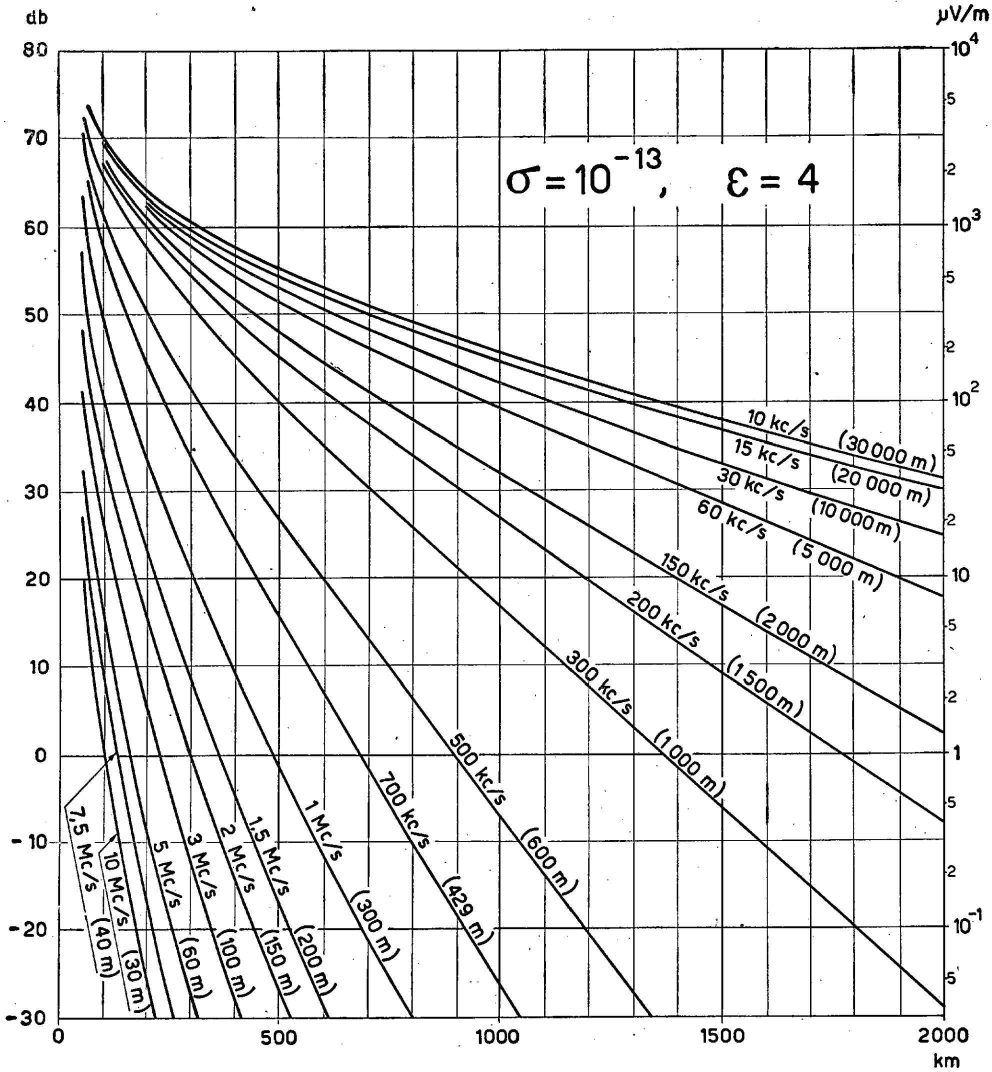


Propagation over land (conductivity $\sigma = 10^{-12,5}$ e.m.u., dielectric constant $\epsilon = 4$ e.s.u.)

FIGURE 2

PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5/D_{km}$ $\mu V/m$

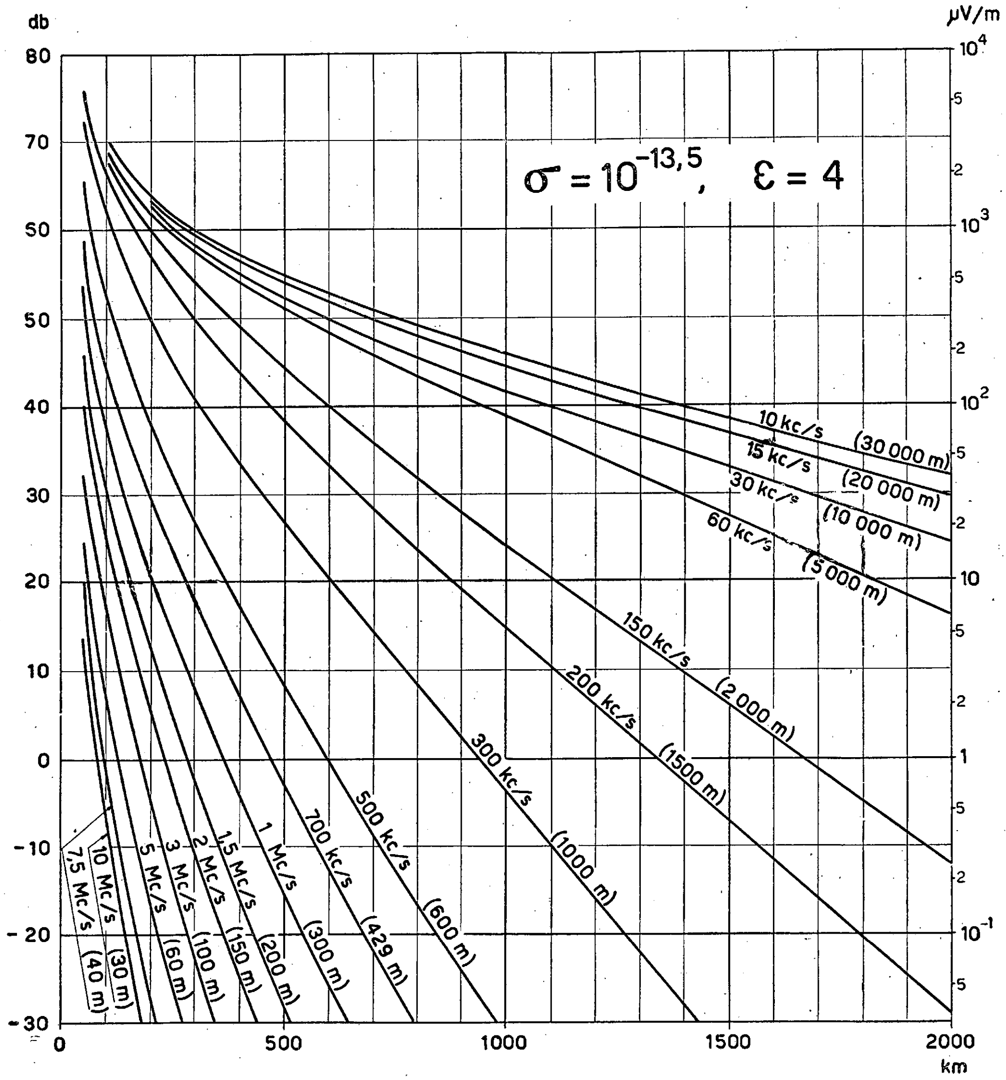


Propagation over land (conductivity $\sigma = 10^{-13}$ e.m.u., dielectric constant $\epsilon = 4$ e.s.u.)

FIGURE 3

PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5/D_{km}$ μV/m

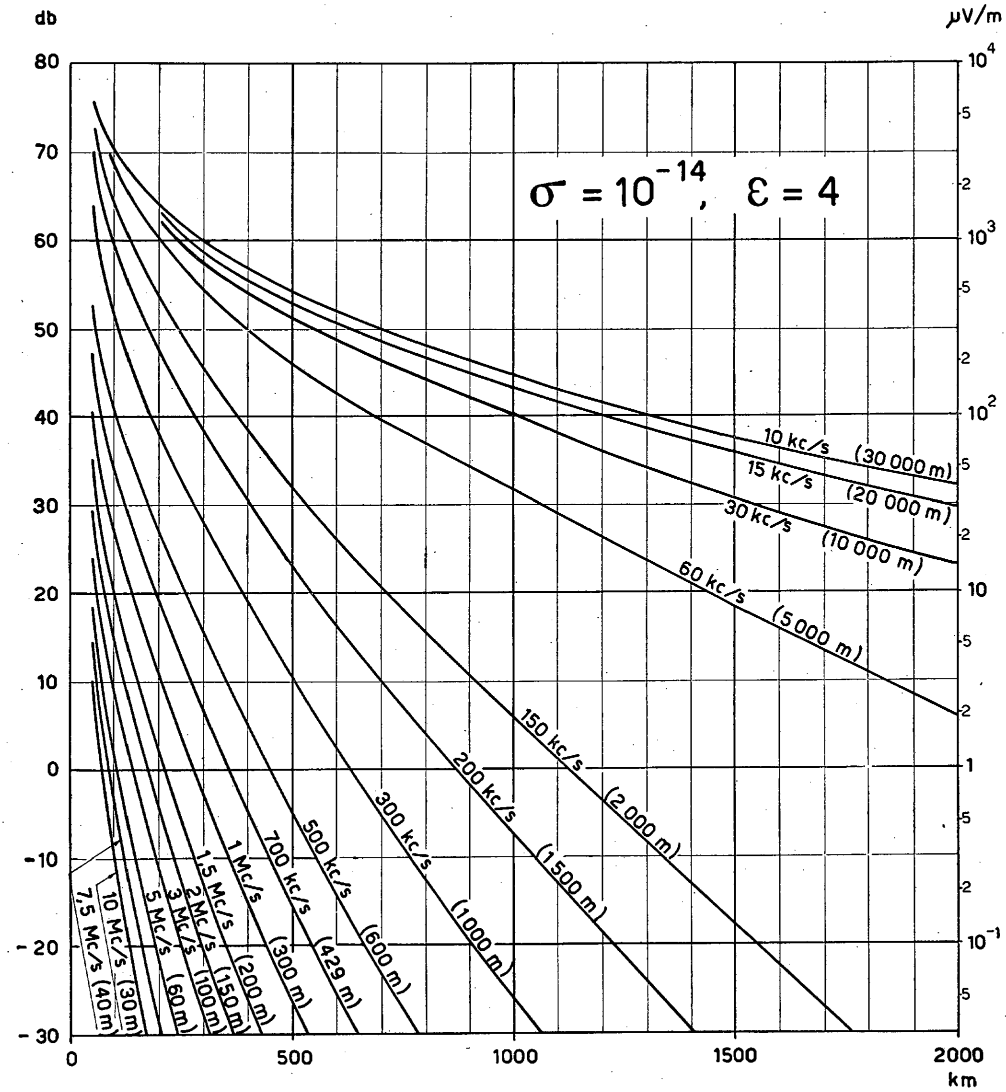


Propagation over land (conductivity $\sigma = 10^{-13,5}$ e.m.u., dielectric constant $\epsilon = 4$ e.s.u.)

FIGURE 4

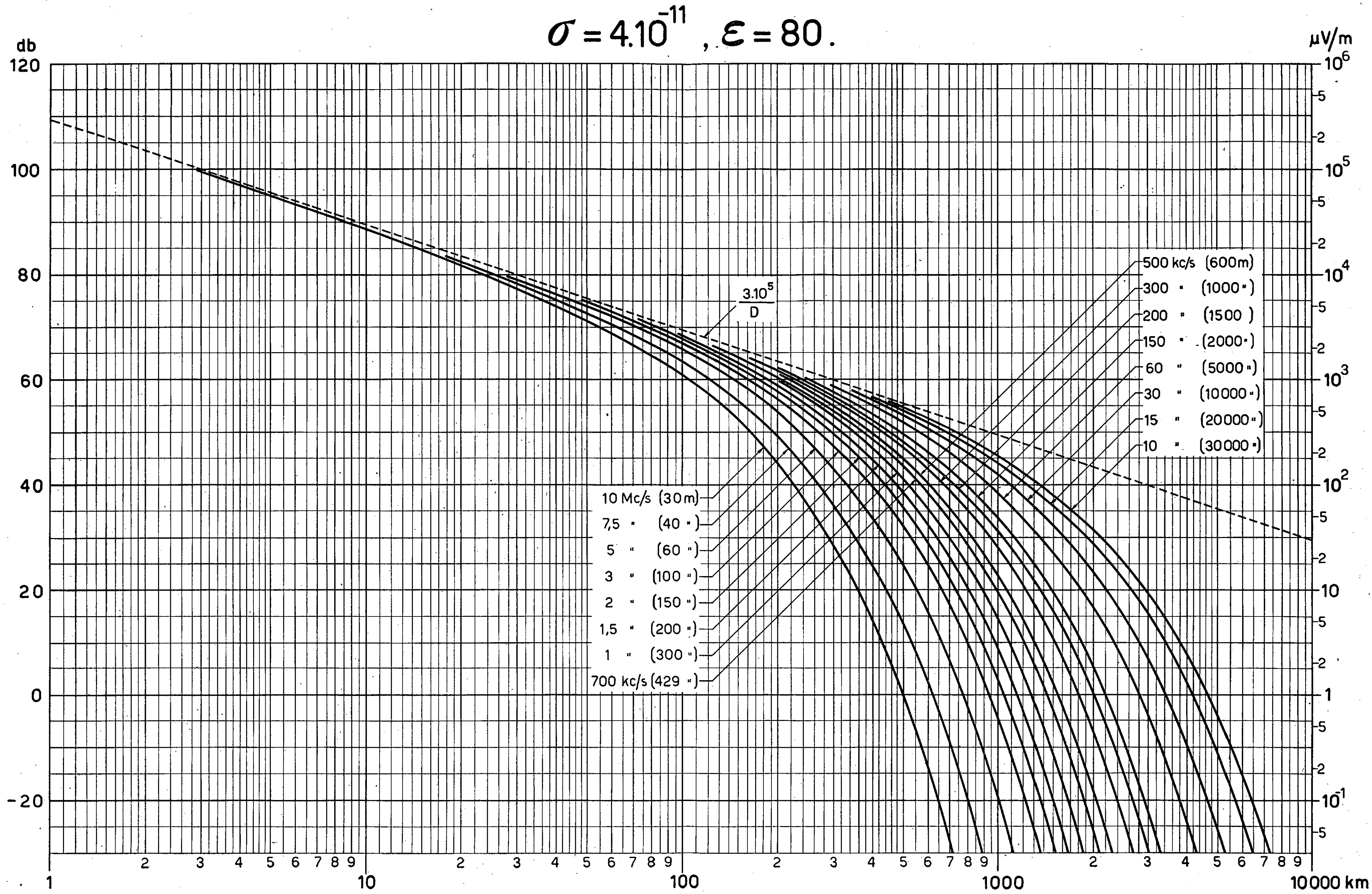
PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5 / D_{km}$ μV/m



Propagation over land (conductivity $\sigma = 10^{-14}$ e.m.u., dielectric constant $\epsilon = 4$ e.s.u.)

FIGURE 5



$\sigma = 4.10^{-11}$, $\varepsilon = 80$.
db
μV/m
$\frac{3.10^5}{D}$
500 kc/s (600m)
300 " (1000 ")
200 " (1500)
150 " (2000 ")
60 " (5000 ")
30 " (10000 ")
15 " (20000 ")
10 " (30000 ")
10 Mc/s (30m)
7,5 " (40 ")
5 " (60 ")
3 " (100 ")
2 " (150 ")
1,5 " (200 ")
1 " (300 ")
700 kc/s (429 ")
10000 km

FIGURE 11

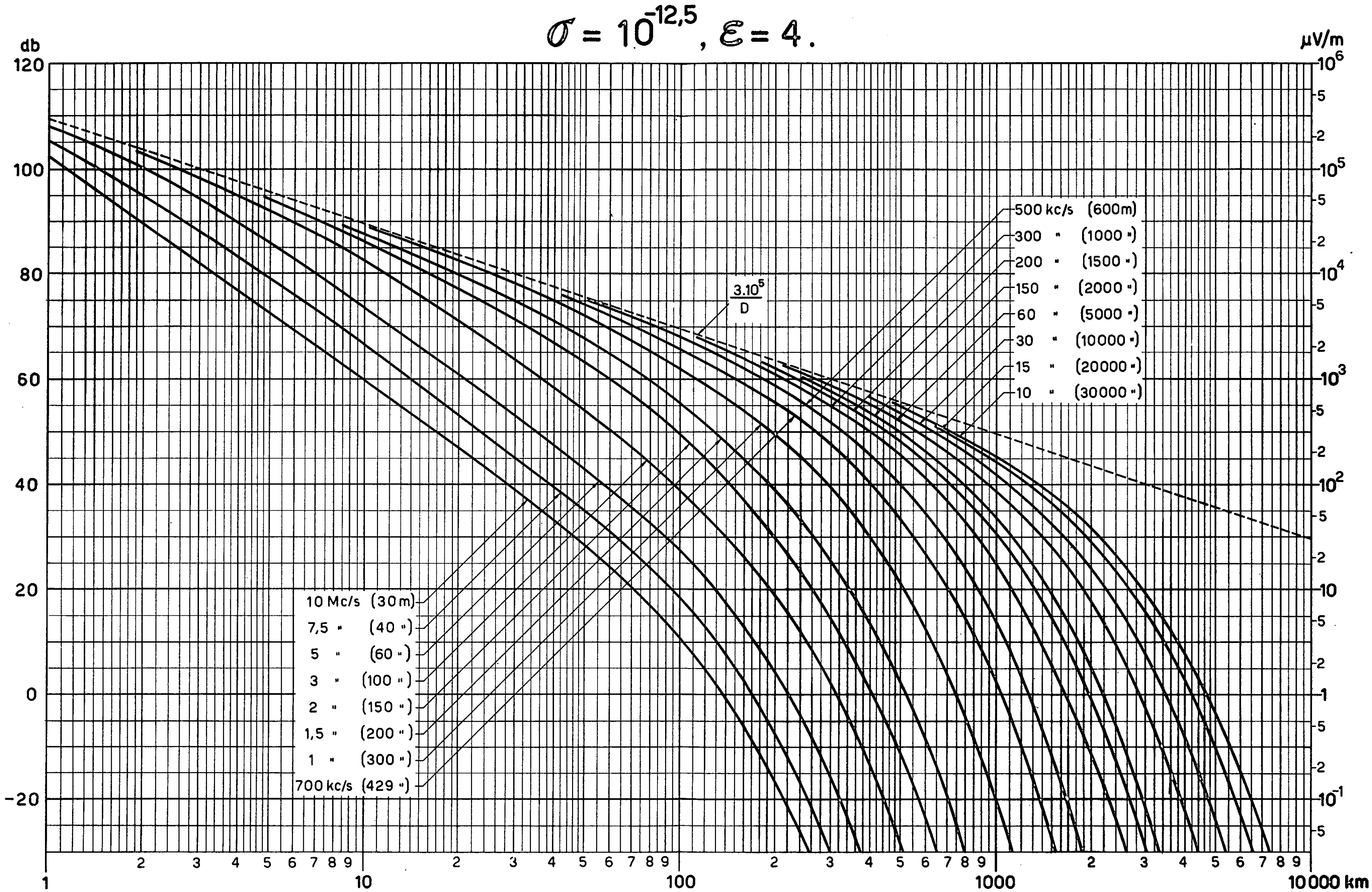
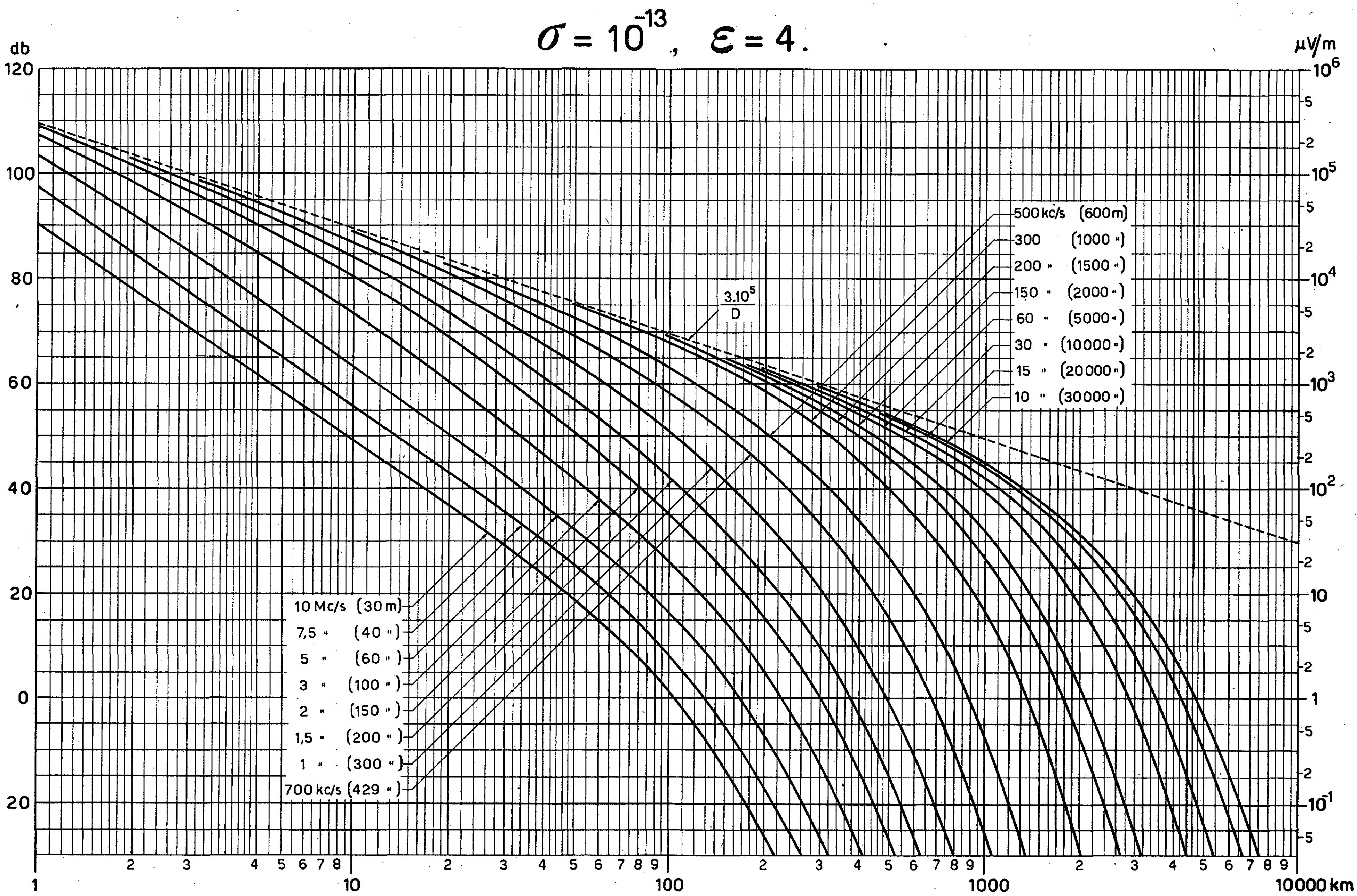
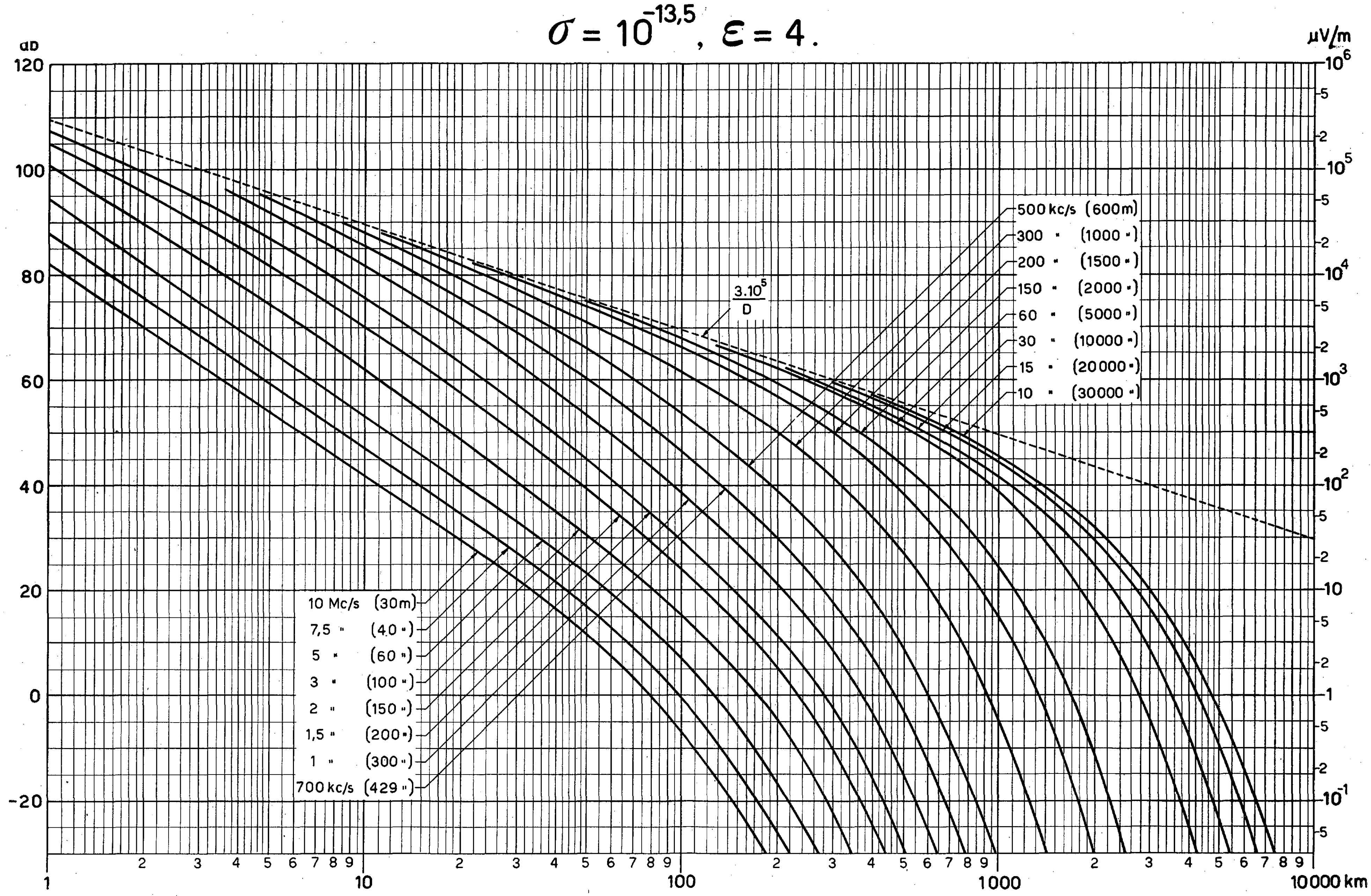

$\sigma = 10^{-12,5}$, $\varepsilon = 4$.
db
μV/m
120
100
80
60
40
20
0
-20
10^6
10^5
10^4
10^3
10^2
10
1
10^{-1}
$\frac{3.10^5}{D}$
500 kc/s (600m)
300 " (1000 ")
200 " (1500 ")
150 " (2000 ")
60 " (5000 ")
30 " (10000 ")
15 " (20000 ")
10 " (30000 ")
10 Mc/s (30m)
7,5 " (40 ")
5 " (60 ")
3 " (100 ")
2 " (150 ")
1,5 " (200 ")
1 " (300 ")
700 kc/s (429 ")
1
10
100
1000
10000 km

FIGURE 12



σ = 10^-13, ε = 4.
db
μV/m
3.10^5 / D
500 kc/s (600 m)
300 (1000 ")
200 " (1500 ")
150 " (2000 ")
60 " (5000 ")
30 " (10000 ")
15 " (20000 ")
10 " (30000 ")
10 Mc/s (30 m)
7,5 " (40 ")
5 " (60 ")
3 " (100 ")
2 " (150 ")
1,5 " (200 ")
1 " (300 ")
700 kc/s (429 ")
120
100
80
60
40
20
0
20
10^6
10^5
10^4
10^3
10^2
10
1
10^-1
1
10
100
1000
10000 km

FIGURE 13



$\sigma = 10^{-13,5}$, $\varepsilon = 4$.
dB
μV/m
120
100
80
60
40
20
0
-20
10^6
10^5
10^4
10^3
10^2
10
1
10^-1
500 kc/s (600 m)
300 " (1000 ")
200 " (1500 ")
150 " (2000 ")
60 " (5000 ")
30 " (10000 ")
15 " (20000 ")
10 " (30000 ")
3.10^5 / D
10 Mc/s (30 m)
7,5 " (40 ")
5 " (60 ")
3 " (100 ")
2 " (150 ")
1,5 " (200 ")
1 " (300 ")
700 kc/s (429 ")
1
10
100
1000
10000 km

FIGURE 14

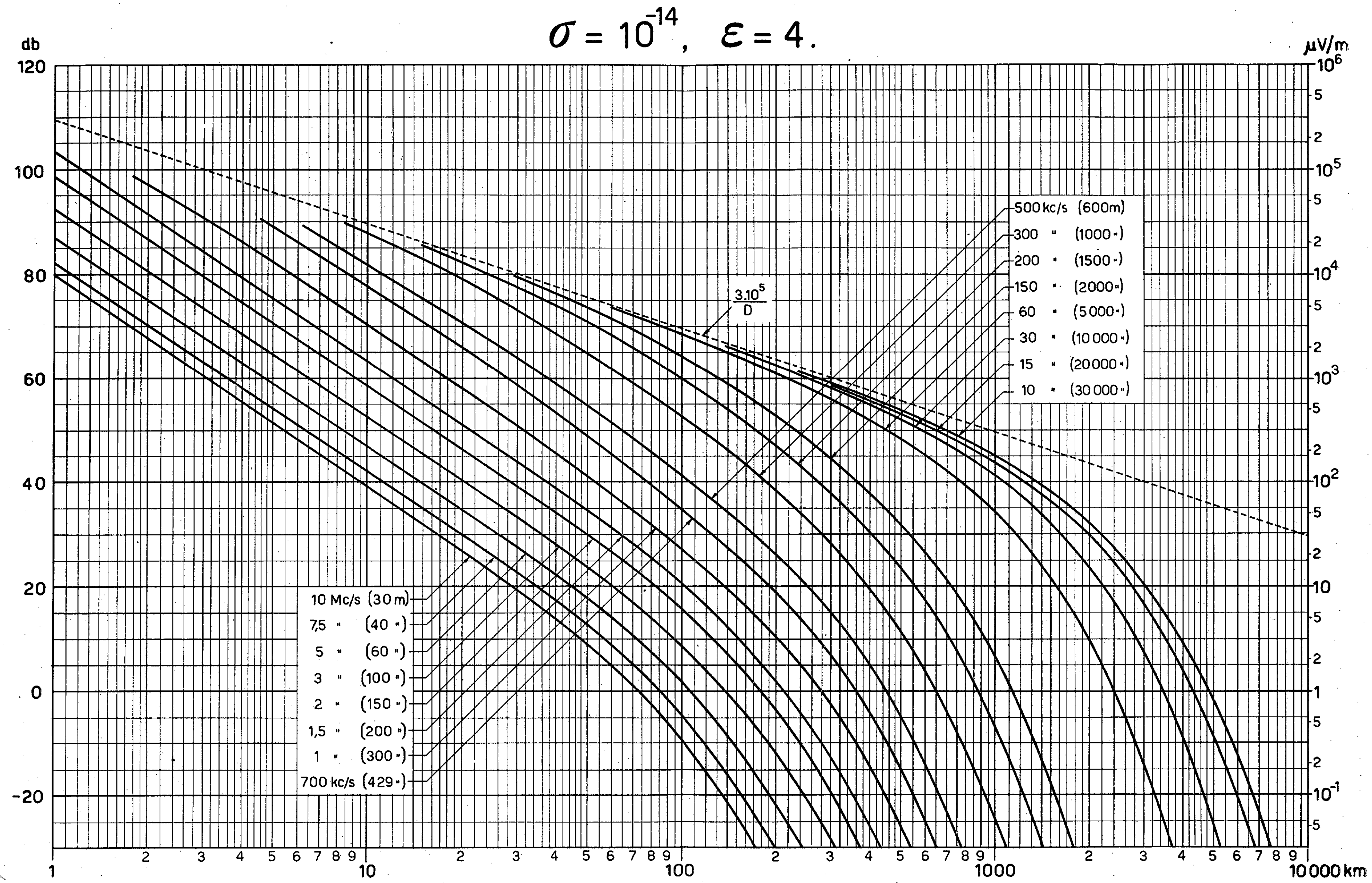
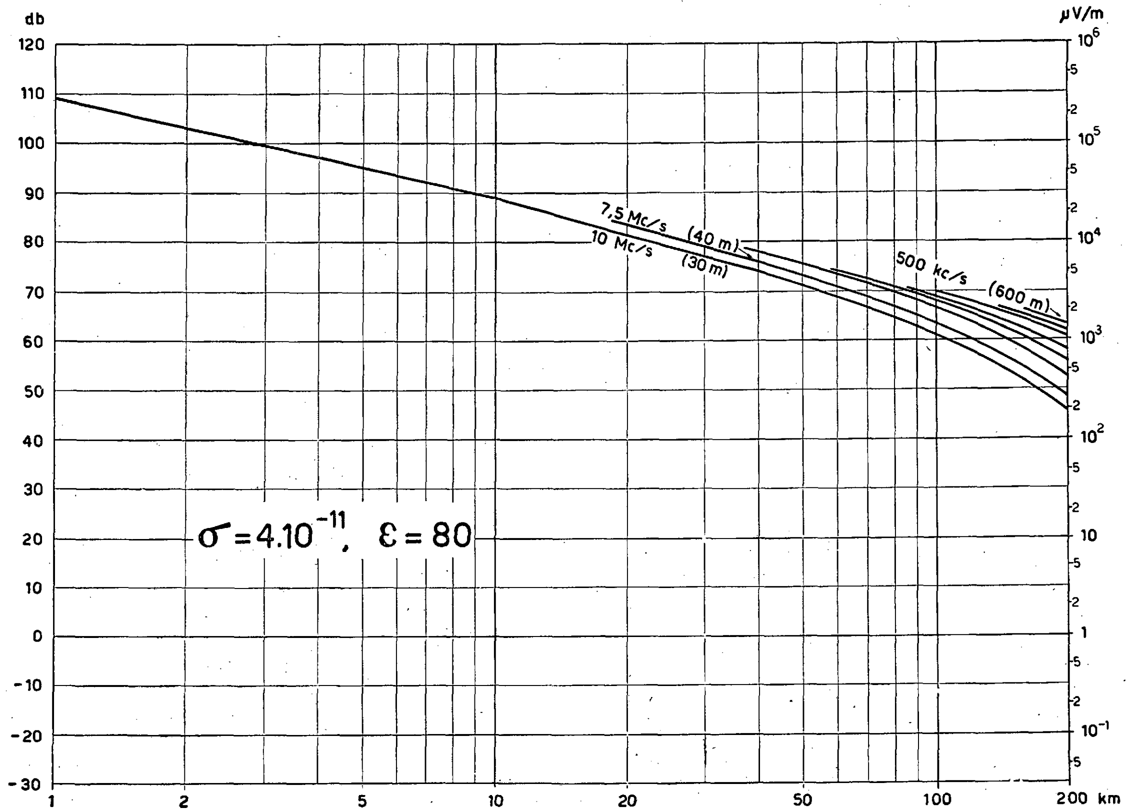

σ = 10^-14, ε = 4.
db
μV/m
3.10^5 / D
500 kc/s (600m)
300 " (1000 ")
200 " (1500 ")
150 " (2000 ")
60 " (5000 ")
30 " (10 000 ")
15 " (20000 ")
10 " (30 000 ")
10 Mc/s (30 m)
7,5 " (40 ")
5 " (60 ")
3 " (100 ")
2 " (150 ")
1,5 " (200 ")
1 " (300 ")
700 kc/s (429 ")
10 000 km

FIGURE 15

PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5 / D_{km}$ $\mu V/m$

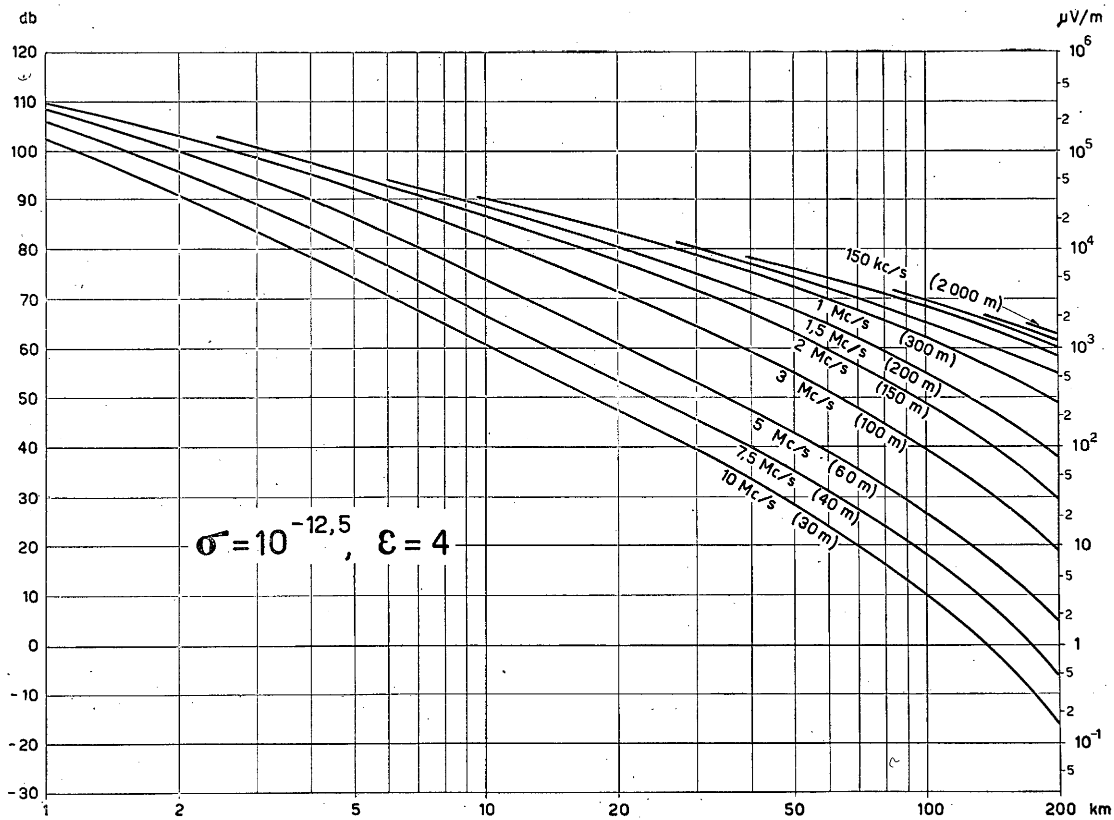


Propagation over sea (conductivity $\sigma = 4 \times 10^{-11}$ e.m.u., dielectric constant $\epsilon = 80$ e.s.u.)

FIGURE 6

PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5 / D_{km}$ μV/m

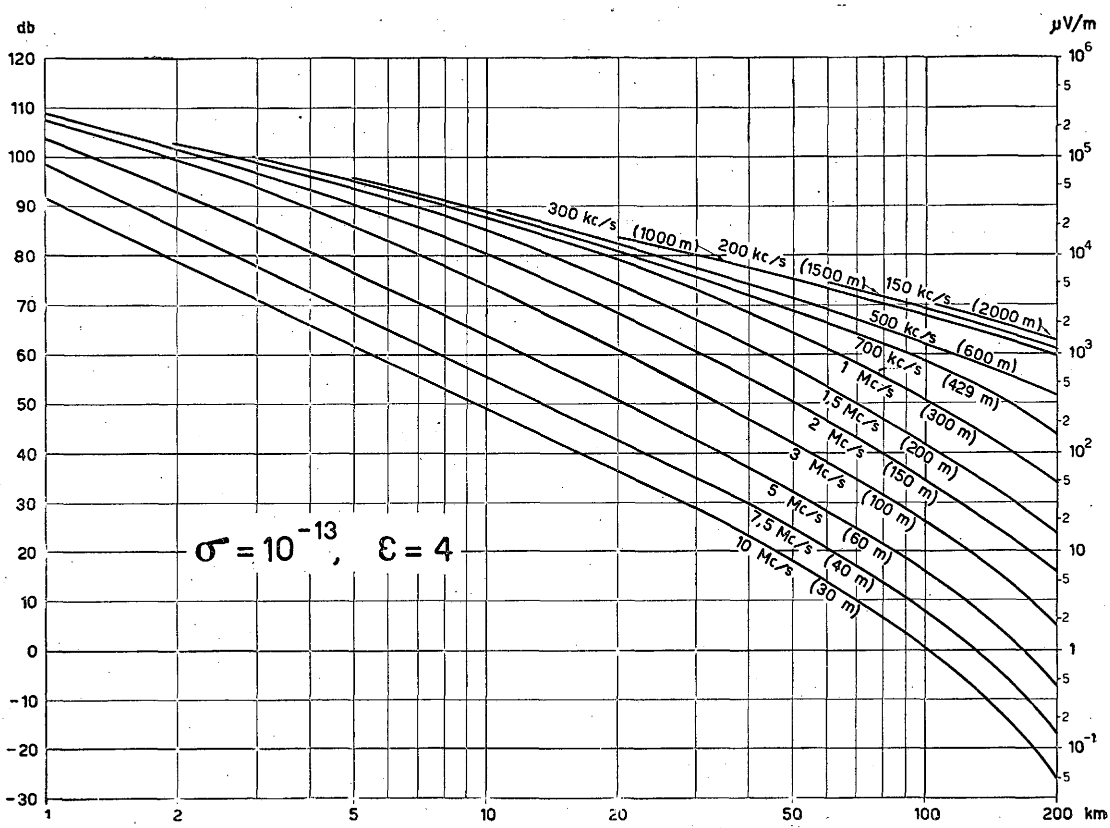


Propagation over land (conductivity $\sigma = 10^{-12,5}$ e.m.u., dielectric constant $\epsilon = 4$ e.s.u.)

FIGURE 7

PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5/D_{km}$ μV/m

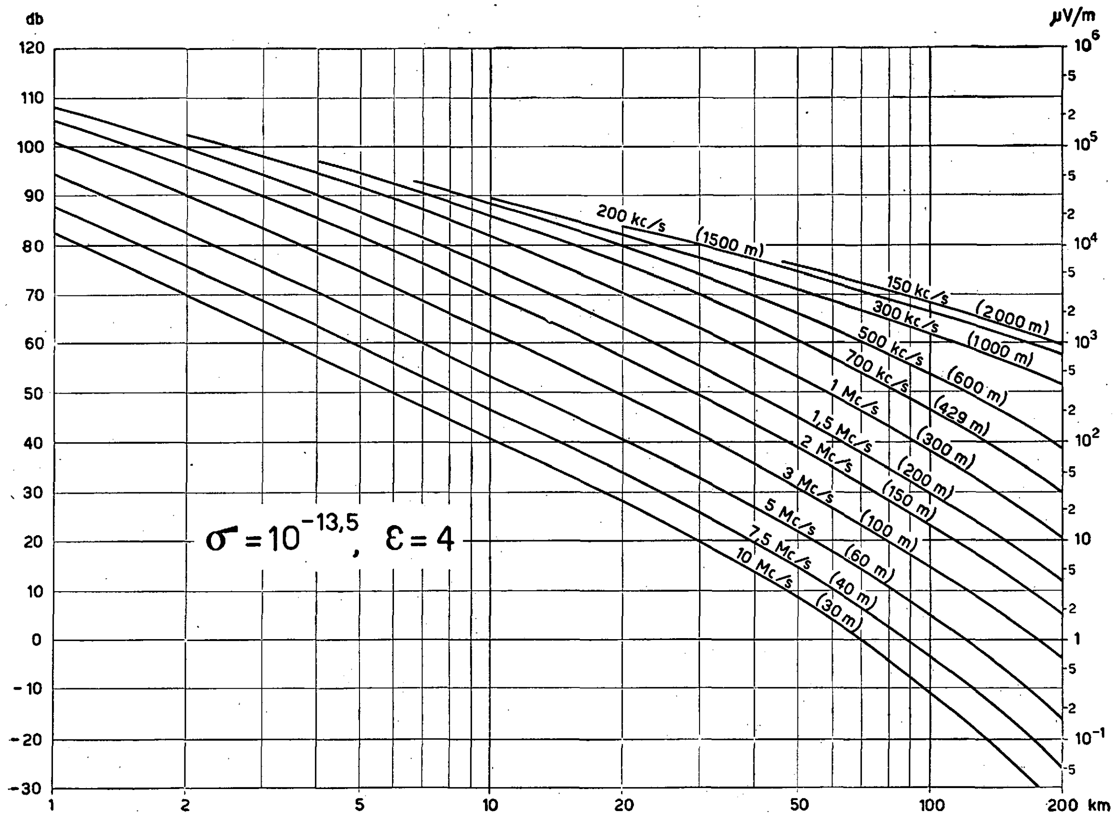


Propagation over land (conductivity $\sigma = 10^{-13}$ e.m.u., dielectric constant $\epsilon = 4$ e.s.u.)

FIGURE 8

PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5 / D_{km}$ $\mu V/m$

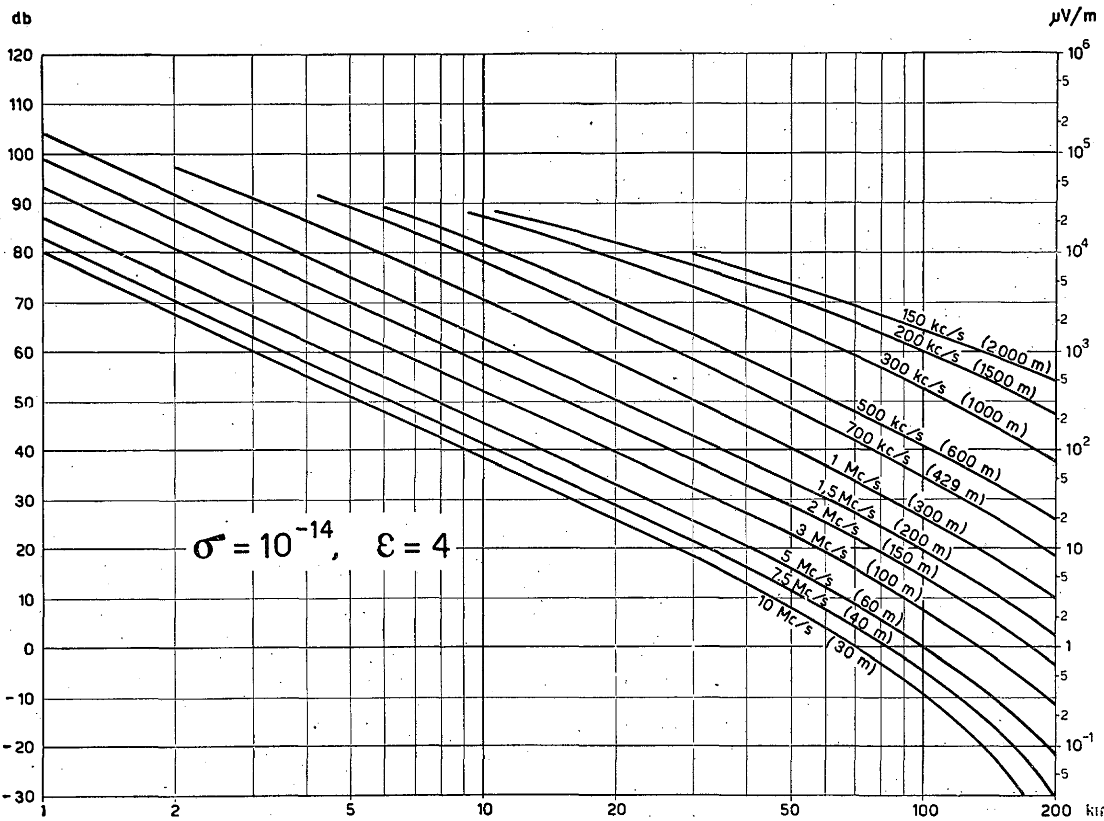


Propagation over land (conductivity $\sigma = 10^{-13,5}$ e.m.u., dielectric constant $\epsilon = 4$ e.s.u.)

FIGURE 9

PROPAGATION CURVES

Ground wave corresponding to an unattenuated field of:
$3 \times 10^5/D_{km}$ $\mu V/m$



Propagation over land (conductivity $\sigma = 10^{-14}$ e.m.u., dielectric constant $\epsilon = 4$ e.s.u.)

FIGURE 10

RECOMMENDATION No. 54

DEFINITIONS OF TERMS RELATING TO PROPAGATION IN THE TROPOSPHERE

(Recommendation No. 15)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

that it is well known that the propagation of waves of frequencies greater than 30 Mc/s is greatly influenced by meteorological conditions in the troposphere,

UNANIMOUSLY RECOMMENDS

that the list of definitions annexed hereto be adopted for incorporation in the vocabulary related to Recommendation No. 34.

VOCABULARY OF TERMS USED IN RADIO PROPAGATION THROUGH THE TROPOSPHERE

Term	Definition
1. *Troposphere*	The lower part of the earth's atmosphere extending upwards from the earth's surface, in which temperature decreases with height except in local layers of temperature inversion.
2. *Tropopause*	The upper boundary of the troposphere, above which the temperature increases slightly with respect to height, or remains constant.
3. *Temperature inversion*	In the troposphere: an increase in temperature with height.
4. *Modified refractive index*	For a given height above sea level: the sum of the refractive index of the air at this height and the ratio of this height to the radius of the earth.
5. *Refractive modulus*	One million times the amount by which the modified refractive index exceeds unity.
6. M *unit*	A unit in terms of which refractive modulus is expressed in accordance with the preceding definition.
7. M *curve*	A curve showing the relationship between refractive modulus and height above the earth's surface.
8. *Standard refractive modulus gradient*	That uniform variation of refractive modulus with height above the earth's surface which is regarded as a standard for comparison. The gradient considered as normal has a value of 0.12 M units per metre (3.6 M units per hundred feet).
9. *Standard radio atmosphere*	For tropospheric propagation: an atmosphere having the standard refractive modulus gradient.
10. *Standard refraction*	The refraction which would occur in a standard radio atmosphere (See Fig. 1).

Term	Definition
11. *Super-refraction*	Refraction greater than standard refraction (See Fig. 1).
12. *Sub-refraction*	Refraction less than standard refraction (See Fig. 1).
13. *Standard propagation*	The propagation of radio waves over a smooth spherical earth of uniform electrical characteristics under conditions of standard refraction in the atmosphere.
14. *Tangential wave path*	In radio-wave propagation over the earth: a path of propagation of a direct wave, which is tangential to the surface of the earth. The tangential wave path is curved by atmospheric refraction.
15. *Radio horizon*	The locus of points at which direct rays from the transmitter become tangential to the earth's surface.
16. *Effective radius of the earth*	The radius of a hypothetical earth for which the distance to the radio horizon assuming rectilinear propagation is the same as that for the actual earth with an assumed uniform vertical gradient of refractive index. (For the standard atmosphere, the effective radius is $^4/_3$ that of the actual earth).
17. *Tropospheric radio duct*	A stratum of the troposphere within which an abnormally large proportion of any radiation of sufficiently high frequency is confined and over part or all of which there exists a negative gradient of refractive modulus. The upper bounding surface is determined by a local minimum value of the refractive modulus. The lower bounding surface is either the surface of the earth or a surface parallel to the local stratification of refractive properties at which the refractive modulus has the same values as that at the local minimum value of the refractive modulus (See Figs. 2, 3 and 4).
18. *Surface duct* *Ground-based duct*	A tropospheric radio duct having the earth as its lower boundary and in which the modified refractive index is everywhere greater than the value at the upper boundary (See Figs. 2 and 3).
19. *Elevated duct*	A tropospheric radio duct of which the lower boundary is an elevated surface at which the modified refractive index has the same value as at the upper boundary (See Fig. 4).
20. *Duct thickness* *Duct width*	The difference in height between the upper and lower boundaries of a tropospheric radio duct.
21. *Duct height*	The height above the surface of the earth of the lower boundary of an elevated duct (See Fig. 4).
22. *Tropospheric mode*	Any one of the possible modes of propagation in the troposphere.
23. *Trapped mode*	A mode of propagation in which the energy is substantially confined within a tropospheric radio duct.

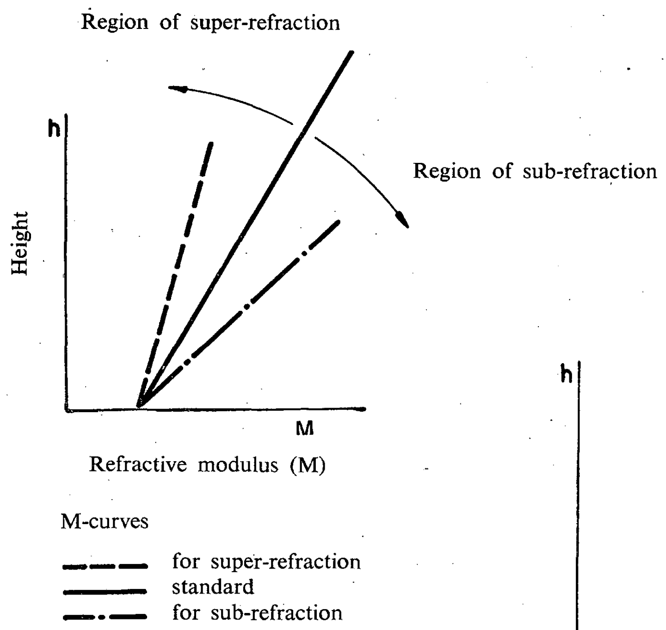


FIGURE 1

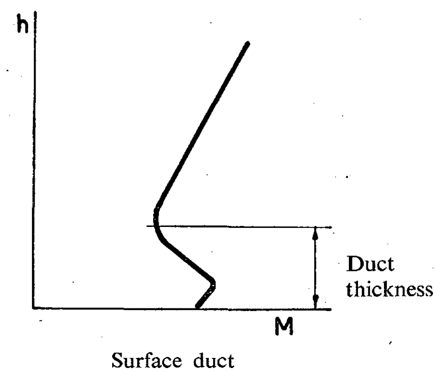


FIGURE 2

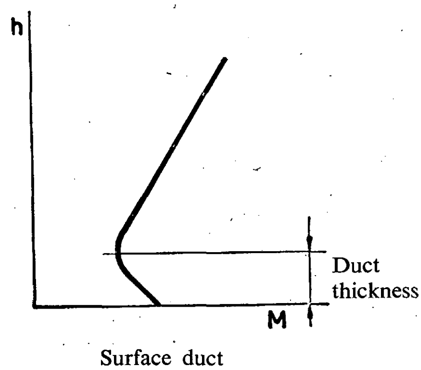


FIGURE 3

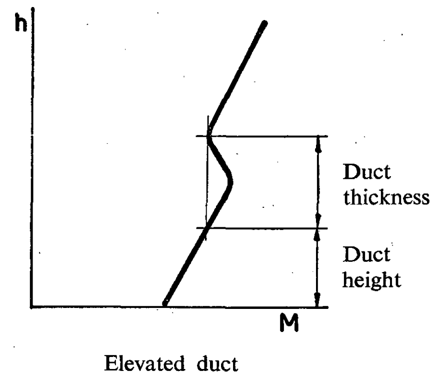


FIGURE 4

RECOMMENDATION No. 59

EXCHANGE OF INFORMATION FOR THE PREPARATION OF SHORT-TERM FORECASTS AND THE TRANSMISSION OF IONOSPHERIC DISTURBANCE WARNINGS

(Recommendations Nos. 11, 13 and 16)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that it is important to give administrations and operating services (navigation and other services) using ionosphere-propagated waves the earliest possible warning of the onset of disturbances to ionospheric propagation conditions, so that they may arrange their traffic schedules accordingly;

(b) that it is desirable to find an easier method of drawing up a plan for the rational use of frequencies in place of the system based on long-term mean values, when the latter is temporarily unsatisfactory on account of ionospheric disturbances;

(c) that it would therefore be advisable for all organisations publishing ionospheric forecasts to study the technique of forecasting disturbances;

(d) that it is of great importance to take steps to secure the greatest possible accuracy of such forecasts and the maximum of speed in their dissemination;

(e) that, for the exchange and dissemination of propagation information, there are three categories of users: those who make forecasts, those who make operational use of propagation information and those who require the information for scientific research or other purposes; and that, to meet these different requirements, it is desirable to use the most appropriate methods of exchange in each case;

(f) that collaboration is desirable between administrations or operating services and the organisations studying the characteristics of the ionosphere and deducing forecasts therefrom, with a view to checking the accuracy of the forecasts periodically;

(g) that provisional codes, prepared by the International Radio Scientific Union (U.R.S.I.) such as the code used in French Ursigrams, or due to organisations such as the Central Radio Propagation Laboratory (C.R.P.L.), the Arbeitsgemeinschaft Ionosphäre, the Japanese Central Propagation Laboratory and others, have proved their usefulness in the dissemination of information for the preparation of short-term forecasts;

RECOMMENDS

1. that each country participating in radio propagation research should designate an official agency for the reception, coordination and exchange of such data and for liaison with corresponding agencies in other countries;

2. that the information required for the preparation of short-term forecasts should be centralised by the agencies mentioned in § 1, as far as possible by the most direct electrical means of communication between the centralising agency and the various scientific institutes for solar, magnetic and other observations;

3. that, of the data thus assembled, those which are of use for forecasting within 48 hours should be disseminated in accordance with the U.R.S.I. decisions by suitable available communication channels;

4. that the other data, of use for the improvement of forecasting technique in general and for other purposes, should be disseminated by ordinary post or airmail; if they deem it of use for the organisation of regional forecasts or for scientific research, interested administrations may organise alone or preferably collectively after centralisation of information, the dissemination of detailed information by radio;

5. that certain short but regular transmissions, giving short-term warnings of ionospheric disturbances, should be effected by long-range radio stations;

6. that the attention of the U.R.S.I. should be drawn to the advantages of the fullest possible standardisation of the codes to be used either for the short warnings mentioned in § 5, or for the exchange of the limited information mentioned in § 3 or the general information mentioned in § 4;

7. that administrations should be invited to conform to the resulting codes and to make them known to their operating services;

8. that administrations should invite these services, together with operating agencies, to study the accuracy of the forecasts, to submit records and to make any suggestions which might assist the studies undertaken to improve the methods used;

9. that special attention should be paid to the comparison between the forecasts and the actual behaviour of radio circuits; it is particularly desirable that administrations should adopt identical methods of assessing the quality of the circuits by using a suitable classification;

10. that it is also desirable that a common method should be adopted to describe ionospheric perturbations, taking account of such factors as the starting time, zone affected, duration and importance of the perturbation.

RECOMMENDATION No. 60

BEST METHODS FOR EXPRESSING THE FIELD STRENGTH OF UNMODULATED CONTINUOUS-WAVE TRANSMISSIONS

(Question No. 8, § A.1a)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that the field strength which is most easily measured is that of a stable plane wave of linear polarisation and constant amplitude;

(b) that fields to be measured are in practice usually composed of several waves;

(c) that field strengths to be measured generally vary as a function of time;

(d) that a single component of the resultant field is generally used but that one or several other components may also be present;

UNANIMOUSLY RECOMMENDS

1. that a field at a given point due to a stable plane wave of linear polarisation and constant amplitude be expressed:

1.1 in respect to intensity,

1.1.1 for frequencies below 300 Mc/s by the r-m-s- value of the electric vector in volts (or submultiples) per metre,

1.1.2 for frequencies higher than 3000 Mc/s by the power flux of the Poynting vector in watts (or submultiples) per square metre,

1.1.3 for frequencies between 300 and 3000 Mc/s by either of these two quantities;

1.2 in respect to direction, by the direction of the electric vector;

2. that a complex field of constant strength be represented by the component or components to be studied. The variation of the apparent field strength as a function of the orientation of the antenna constitutes a first element of practical information on the complexity of the field;

3. that a complex field, the strength of which varies in time, be represented by recordings of the component or components to be studied. These recordings should be made with a time constant adapted to each case, with a view to ascertaining, according to practical requirements, the average strength of the field and the percentages of time during which it exceeds certain values.

RECOMMENDATION No. 61

BEST METHODS FOR EXPRESSING THE FIELD STRENGTH OF MODULATED CONTINUOUS-WAVE TRANSMISSIONS

(Question No. 8, § A.1b)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that this question should be confined to classical amplitude modulation, since for purposes of field-strength measurement a frequency-modulated wave can be considered as an unmodulated continuous wave, and telegraph modulation can be regarded as a particular case of pulse transmission;

(b) that satisfactory processes and apparatus for field-strength measurement have been evolved and are well known for this type of transmission;

(c) that in the large majority of field-strength measurement processes use is made of the observation of a rectified current;

UNANIMOUSLY RECOMMENDS

1. that the field produced by a modulated continuous-wave transmission can normally be satisfactorily measured by a field-strength measuring apparatus provided that the linearity of the apparatus is adequate;

2. that to allow for certain special cases such as overmodulation of the transmitter or carrier amplitude variation with modulation, it is desirable to make the measurement during the absence of modulation in order to measure the normal field strength of the carrier.

Note. — The case of overmodulation or of carrier amplitude variation with modulation is of importance from the point of view of monitoring and control, and should be the object of further studies.

RECOMMENDATION No. 63

BEST METHODS FOR EXPRESSING THE FIELD STRENGTH OF REDUCED CARRIER TRANSMISSIONS

(Question No. 8, § A.1d)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that the field strength of a reduced carrier transmission in a given place depends among other factors on:
— the type of transmission,
— the magnitude of the independent sidebands, relative to the carrier;

(b) that in current practice the maximum nominal power and distortion of a channel may at times be exceeded during a transmission;

(c) that the power of the carrier is the only constant element during transmission but that there is nothing to prevent the carrier from being adjusted to a level different from normal nor is there anything to prevent the channels from having different maximum nominal powers;

(d) that consequently the field strength of such a transmission cannot be satisfactorily represented by the field strength of its carrier nor can it be represented by the field strength of any one of the channels without a detailed description of the condition of operation of the channel;

(e) that for a reduced-carrier transmission there exists for each channel a peak field produced when the transmitter is delivering to this channel its maximum nominal power;

(f) that the peak field-strength so defined represents the field strength of this transmission for the channel under consideration and that complete representation of the transmission necessitates knowledge of the peak field-strength for each channel;

UNANIMOUSLY RECOMMENDS

that the field strength produced by a reduced-carrier transmission be represented by the maximum peak field strength, and also by the average of the peak field strengths, taken over an interval long enough to include a sufficient number of peaks of maximum modulation, for

1. each channel operating separately,
2. all channels simultaneously in normal operation.

Note. — The measurement of the field strength for reduced-carrier transmission needs in principle the cooperation of the station being measured. It is desirable but not indispensable that during the measurement the station should transmit in the channel being measured a single modulating frequency selected near the centre of the band allotted for the channel.

RECOMMENDATION No. 65

FIELD-STRENGTH MEASUREMENT

Desirable and attainable accuracy of field-strength measurement for each frequency band

(Question No. 8, § A.4)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that the attainable accuracy of measurement of field strength depends on the design of equipment, carefulness of installation and use, location of measuring sites, conditions under which the measurements are made and the skill of the operator;

(b) that the principles of field-strength measurement have remained unchanged since the Vth Plenary Assembly of the C.C.I.R., but that equipment is gradually being improved in range, accuracy and convenience of operation;

(c) that the principal instrument error is caused by inaccuracy in voltage measurement over a wide range of voltage;

(d) that portable field-strength measuring equipment covers a smaller voltage range and is less stable than that at fixed installations;

(e) that the degree of accuracy needed at present can be obtained, but only by the use of costly, complex and non-portable equipment;

UNANIMOUSLY RECOMMENDS

1. that more stable and less complex portable field-strength measuring equipment should be developed, in order to increase the attainable accuracy of such measurement in each frequency band;

2. that the accuracy of measurements on unmodulated continuous wave transmissions now attainable in normal operation using present-day portable equipment is probably somewhat better than shown in Table I, taken from the proposals submitted to the Vth Plenary Assembly of the C.C.I.R., Stockholm, 1948, as published by the General Secretariat of the I.T.U., Geneva, 1949, page 263;

Table I

Frequency band	Accuracy of measurement (db)	Minimum field strength at which this accuracy is obtained (μV/m)
10-30 kc/s	± 2	10
30-300 kc/s	± 2	5
300-3000 kc/s	± 2	2
3-30 Mc/s	± 2	2
30-300 Mc/s	± 3	5
300-3000 Mc/s	± 5	50
3000-30 000 Mc/s	± 5	10 *

* 10 μV/m corresponds approximately to 2.7×10^{-13} watts/sq. m.

3. that a study be made to discover the accuracy requirements for field-strength measurements for various purposes such as communications, control, and scientific and industrial applications.
A number of these require accuracies greater than those shown in Table I;

4. that field-strength measuring equipment should be so designed and operated that the accuracy of measurement will be limited principally by the accuracy of the voltage measuring device;

5. that in reporting the results of field-strength measurements, the estimated accuracy of the measurements should always be given.

RECOMMENDATION No. 73

STUDY OF RELATIONSHIPS BETWEEN PEAK POWER AND MEAN POWER

(Question No. 22)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that the Radio Regulations, Atlantic City, 1947, Art. 1, Section IV, Nos. 60 to 64, call for the use of " peak power " in specifying the power of a radio transmitter, but allow the additional use of " mean power " in cases where the peak power specification is not satisfactory or adequate;

(b) that in many cases it will be possible to measure the peak power directly and in others it will be possible to derive the peak power from measurements made under suitably arranged test conditions;

(c) that a specification of radiated power is advantageous for use in calculations of radio propagation, channel spacing, signal-to-interference ratios and signal-to-noise ratios involved in radio communications;

(d) that for administrative purposes or for the calculations in *(c)*, the specification of peak power as defined in the Radio Regulations, Atlantic City, 1947, is not sufficient to evaluate adequately the interference-producing capabilities of a signal;

(e) that in monitoring or field-intensity recording of the strength of radio signals the use of automatic recorders frequently involves measurements of average rather than peak field strength; for some types of modulated signal, the mean field intensity is not affected by the modulation;

(f) that consequently it is necessary for the field strength as measured by use of monitoring equipment to be interpreted consistently in terms of the rated power of the transmitter;

(g) that information on transmitter power expressed in terms of peak or mean power alone, as defined in the Radio Regulations, Atlantic City, 1947, is adequate only for certain types of emission and for certain uses of the information; in many cases it is desirable to use power ratings expressed otherwise;

RECOMMENDS

that the table attached in the Annex, which presents, for each type of emission specified in the Radio Regulations, Atlantic City, 1947, the relationships between peak power and mean power, and also the power under conditions of no modulation, should wherever practicable, supersede the Annex to Question No. 22.

ANNEX

Conversion table for relationships between peak power and mean power

1. In the following table the symbols Pp and Pm indicate peak power and mean power, respectively, as defined in Art. 1 of the Radio Regulations, Atlantic City, 1947, which states that:

   1.1 peak power of a radio transmitter is the mean power supplied to the antenna during one radio-frequency cycle at the highest crest of the modulation envelope, taken under conditions of normal operation;

   1.2 the mean power of a radio transmitter is the power supplied to the antenna during normal operation, averaged over a time sufficiently long compared with the period corresponding to the lowest frequency encountered in actual modulation (in general, a time of 1/10 second, during which the mean power is a maximum, will be selected).

2. In the following table the average power which a transmitter supplies to its antenna during one radio-frequency cycle under conditions of no modulation is considered to have a value of unity. Conditions of no modulation are specified in the table. With these conditions as a reference, relative values of Pm and Pp for various modulated emissions are indicated by conversion factors under the columns Pm and Pp, where applicable.

3. Specification of modulating wave form is essential for conversions between peak power ratings and power ratings of other types. Accordingly, one or more " characteristic modulations " are assumed and described for each class of emission evaluated in the following table. To permit proper evaluation of potential geographical interference ranges, these " characteristic modulations " are chosen, as far as possible, to give maximum ratios of Pp to Pm.

Type of modulated emission	Characteristic modulation	Condition of no modulation	Conversion factors (See § 2 of this Annex)	
			Pm	Pp
Amplitude modulation				
A1 (On-off telegraphy)	Series of rectangular dots; equal marks and spaces; zero space amplitude	Key down	0.5 (Note 1)	1
A2 (Telegraphy with keying of audio-frequency modulating tone, or of modulated emission)	Series of rectangular dots; equal marks and spaces; single sine-wave audio-frequency modulating tone; 100% modulation *(a)* Modulating tone keyed *(b)* Modulated emission keyed	 *(a)* Key up (tone removed) *(b)* Key down (tone removed)	 *(a)* 1.25 *(b)* 0.75	 *(a)* 4 *(b)* 4
A3 (Double-sideband telephony, full carrier)	*(a)* Single sine-wave audio-frequency modulating tone; 100% modulation *(b)* Smoothly read text	*(a)* Carrier only (Note 2) *(b)* Carrier only (Note 2)	*(a)* 1.5 *(b)* 1 to 1.08	*(a)* 4 *(b)* 4
A3a (Single-sideband, reduced carrier)	See Supplementary Table I and Note 3			
A3b (Two independent sidebands, reduced carrier)	See Supplementary Table II and Note 3			
A4 (Facsimile)	Black and white checkerboard picture giving square modulating wave; 100% modulation	Full carrier amplitude	0.5 (Note 6)	1 (Note 6)
A5 (Television)	(See Note 4)			
Frequency or phase modulation F1 F2 F3 F4 F5 F9	(For all types of frequency or phase-modulated transmissions the modulation changes the distribution of power in the frequency band of the emissions while leaving the total power of the emissions unchanged)		 1 1 1 1 1 1	 1 1 1 1 1 1
Pulse modulation P1 (Simple telegraphy)	Pulse train keyed on and off; mark and space equal; rectangular pulses, constant amplitude and duty cycle	Key down (Note 5)	0.5 (Note 5)	1/duty cycle

Type of modulated emission	Characteristic modulation	Condition of no modulation	Conversion factors (See §2 of this Annex)	
			Pm	Pp
	Audio-frequency tone-modulated telegraphy. Series of equal rectangular marks and spaces; single sine-wave audio-frequency modulating tone; 100% modulation			
P2d (Pulses, amplitude-modulated; constant duty cycle)	*(a)* Modulating tone keyed *(b)* Modulated emission keyed	*(a)* Key up (tone removed) (Note 5) *(b)* Key down (tone removed) (Note 5)	*(a)* 1.25 *(b)* 0.75	*(a)* 4/duty cycle *(b)* 4/duty cycle
P2e (Pulses, width or duration modulated; constant amplitude)	*(a)* Modulating tone keyed *(b)* Modulated emission keyed	*(a)* Key up (tone removed) (Note 5) *(b)* Key down (tone removed) (Note 5)	*(a)* 1 *(b)* 0.5	*(a)* 1/average duty cycle *(b)* 1/average duty cycle
P2f (Pulses, position or phase modulated; constant amplitude)	*(a)* Modulating tone keyed *(b)* Modulated emission keyed	*(a)* Key up (tone removed) (Note 5) *(b)* Key down (tone removed) (Note 5)	*(a)* 1 *(b)* 0.5	*(a)* 1/average duty cycle *(b)* 1/average duty cycle
P3d (Pulses, amplitude-modulated; constant duty cycle)	Telephony *(a)* Single sine-wave audio-frequency modulating tone; 100% modulation *(b)* Smoothly read text	*(a)* Pulse carrier only (Note 5) *(b)* Pulse carrier only (Note 5)	*(a)* 1.5 *(b)* 1 to 1.08	*(a)* 4/duty cycle *(b)* 4/duty cycle
P3e (Pulses, width or duration modulated; constant amplitude)	Single sine-wave audio-frequency modulating tone; 100% modulation; rectangular pulses	Pulse carrier only (Note 5)	1	1/average duty cycle
P3f (Pulses, position or phase modulated; constant amplitude)		Pulse carrier only (Note 5)	1	1/average duty cycle

Note 1. — For Morse: Pm = 0.49 Pp.
For International Alphabet No. 2: Pm = 0.58 Pp.

Note 2. — The peak power of double-sideband transmitters is nominally four times the power of the unmodulated carrier. To determine the proper level for applying speech two tones are employed, as in the single-sideband case described in Note 3. In a well-constructed transmitter, this should result in reasonably high percentages of modulation.

It has been found in connection with smoothly-read text that a reading of 2 (VU * meter readings) corresponds to a mean power of zero dbm ** measured in the audio-frequency band, nominally up to 3000 or 4000 cycles/second.

Note 3. — The two-tone method of rating the power of single-sideband radiotelephone transmitters consists of setting the level of each of two equal tones applied to the audio-frequency input so that the resulting cross-modulation term ($2f_1 - f_2$) is 25 db below the level of either tone, measured in the r.f. output of the transmitter; the peak power rating of the transmitter is taken as four times the r.f. power output, after removal of one of the two tones. Single channel speech is applied at the audio-frequency input at a VU level equal numerically to the mean dbm level of one of the two aforementioned tones. For multichannel single-sideband transmission, the level of each channel is reduced 0.5 (N − 1) db, where N is the number of channels, up to a total of about four.

Note 4. — Depending on the standards used, the condition of no modulation may not apply. For any particular case, the ratio of mean power to peak power can be calculated, for the extreme conditions of all-black and all-white pictures, by taking into account the relative amplitudes and durations of blanking signals, synchronising pulses and picture signals. As examples, in the 525-line, 60-field system used at present in the United States, this results in a ratio of Pm to Pp of 0.164 for an all-white picture and 0.608 for an all-black picture; in the 405-line, 50-field system now used in the United Kingdom, the ratios are 0.800 for an all-white picture and 0.080 for an all-black picture.

Note 5. — The average power which a pulse transmitter supplies to its antenna during one pulse period of an unmodulated pulse train (PO conditions) is considered to have a value of unity.

Note 6. — The values listed here are based upon direct facsimile scanner modulation of the main radio-frequency carrier. When the output of the facsimile scanner modulates a sub-carrier and this sub-carrier is then applied as amplitude or frequency modulation of the main carrier, the resultant emission has A3, A3a, A3b, or F3 characteristics and the appropriate power relationships, therefore, must be sought in the corresponding section of the table.

SUPPLEMENTARY TABLE I

Ratio of P_m to P_p for A3a emission

Condition of no modulation	Characteristic modulation		
Carrier level, referred to peak power of sideband	† Single sine-wave audio-frequency modulating tone; transmitter fully loaded	†† Smoothly-read text, transmitter fully loaded	††† "Other" programme material; transmitter fully loaded
—10 db	0.636 (—1.97 db)	0.149 (—8.27 db)	0.115 (—9.39 db)
—20 db	0.835 (—0.78 db)	0.139 (—8.57 db)	0.091 (—10.4 db)
—30 db	0.940 (—0.27 db)	0.150 (—8.24 db)	0.095 (—10.2 db)
— ∞ (fully suppressed)	1.000 (0 db)	0.158 (—8.00 db)	0.100 (—10.0 db)

For notes see page 73.

* This refers to readings of a VU meter, which is a volume indicating device having certain specific dynamic characteristics, and which is described in *Proc. I.R.E.*, 28,1 (January 1940). Such a device reads zero for a 1000-cycle tone delivering 1 milliwatt to a load impedence of 600 ohms. When speech volume is measured by it according to I.R.E. standards, a reading of zero corresponds to zero VU.

** dbm defined as "power in decibels referred to one milliwatt".

SUPPLEMENTARY TABLE II

Ratio of P_m to P_p for A3b emission

Condition of no modulation	Characteristic modulation			
Carrier level, referred to peak power of either sideband	† Single sine-wave audio-frequency modulating tone on each channel; transmitter fully loaded	†† Each channel fully loaded by smoothly-read text; transmitter fully loaded	††† Each channel fully loaded by " other " programme material; transmitter fully loaded	Channel 1 smoothly-read text and channel 2 " other " programme material
—10 db	0.392 (—4.07 db)	0.078 (—11.1 db)	0.056 (—12.5 db)	0.067 (—11.8 db)
—20 db	0.456 (—3.41 db)	0.074 (—11.3 db)	0.048 (—13.2 db)	0.061 (—12.1 db)
—30 db	0.485 (—3.14 db)	0.077 (—11.1 db)	0.049 (—13.1 db)	0.063 (—12.0 db)
— ∞ (fully suppressed)	0.500 (—3.01 db)	0.079 (—11.0 db)	0.050 (—13.0 db)	0.065 (—11.9 db)

† For a single sine-wave audio-frequency modulating tone, the mean radio-frequency power of each sideband channel is equal to its peak radio-frequency power (Atlantic City definition), but is 3 db below its maximum instantaneous radio-frequency power: this 3 db difference corresponds to the 3 db difference between the mean and the instantaneous peak audio-frequency power levels of the impressed modulation.

†† For smoothly-read text, it is assumed that the mean radio-frequency power of each sideband channel is 8 db below its peak radio-frequency power (Atlantic City definition), or 11 db below its maximum instantaneous radio-frequency power; the corresponding underlying assumption of an 11 db difference between the mean and equivalent instantaneous peak audio-frequency power levels of the impressed modulation is made in accordance with the most recent information available.

††† For conversational speech and certain programme material other than smoothly-read text, it is assumed that the mean radio-frequency power of each sideband channel is 10 db below its peak radio-frequency power (Atlantic City definition), or 13 db below its maximum instantaneous radio-frequency power: the corresponding underlying assumption of a 13 db difference between the mean and equivalent peak radio-frequency power levels of the impressed modulation is made in accordance with the most recent information available.

RECOMMENDATION No. 74

PRINCIPLES OF THE DEVICES USED FOR ACHIEVING PRIVACY OF RADIOTELEPHONE CONVERSATIONS

(Question No. 30)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that the devices referred to are intended for achieving *privacy* rather than *secrecy* of radiotelephone conversations;

(b) that in the interests of maximum privacy, the details of the systems employed and of their performance should be agreed upon between the administrations and private enterprises concerned;

UNANIMOUSLY RECOMMENDS

1. that the following statement of principles and characteristics of the devices concludes the study of Question No. 30 for radio circuits operating on frequencies less than about 30 Mc/s*.

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* Information regarding this matter may be found in Docs. Nos. 47 and 48 of Geneva.

1.1 *Principles of the devices*

Two general types of systems are used for achieving " privacy " or " relative secrecy " of radiotelephone circuits operating on frequencies less than about 30 Mc/s as follows:

1.1.1 *For double-sideband systems*

inverter systems with or without wobbling of the carrier (i.e. rapid cyclic variation of the carrier frequency over a few hundred c/s), the speech band being inverted about a fixed frequency;

1.1.2 *For single-sideband systems*

band-splitting systems in which the speech band is subdivided into equal frequency bands, the speech components in the sub-bands being interchanged, with or without frequency inversion, and according to a prearranged repetitive sequence, to give " scrambled " speech. The process is reversed at the receiving terminal to reform the speech signals. Accurate synchronisation of the switching processes at the two terminals is required;

1.2 *Characteristics of the devices*

1.2.1 the band-splitting system provides superior privacy to that obtained with the inverter system, but for satisfactory operation it can tolerate less radio distortion such, for example, as is caused by selective fading on the radio link;

1.2.2 the apparatus is designed to reduce to a minimum attenuation distortion and the levels of unwanted products of modulation and of carrier signals. The extent of the permissible distortion due to the presence of the privacy devices is, in general, dependent on the type of privacy and is usually agreed between the administrations or private enterprises concerned;

1.3 *Location of the devices*

to facilitate control and maintenance, and on the grounds of economy, the privacy apparatus is normally located at the point where the transmitting and receiving channels of a radiotelephone circuit are combined;

2. that for frequencies above about 30 Mc/s the details of the systems to be employed and of their performance should be agreed upon between the administrations or private enterprises concerned.

RECOMMENDATION No. 75

CLASSIFICATION AND ESSENTIAL CHARACTERISTICS OF FEED-BACK SUPPRESSORS

(Question No. 31)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

that the feed-back suppressors now generally used are of a type whose operation is sufficiently independent of the characteristics of those at the opposite end of the circuit;

UNANIMOUSLY RECOMMENDS

that no classification of types nor terminology be adopted.

Essential characteristics

(§ *(b)* of Question No. 31)

The essential characteristics of the feed-back suppressors used on radiotelephone circuits in the United Kingdom and in the United States of America for fixed services are described respectively in Docs. Nos. 49 and 51 of Geneva. These are in substantial accord with the characteristics described in C.C.I.F., 1950-1951, 5th Study Group, Doc. No. 7. Question No. 2.

RECOMMENDATION No. 76

VOICE-OPERATED DEVICES FOR SHIP STATIONS AND CARRIER-OPERATED DEVICES FOR SHORE STATIONS

(Question No. 32)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that the essential characteristics of the devices controlled by voice currents and acting on the carrier wave in radiotelephone stations on board ships and of the carrier-operated devices in receivers of coast stations are their " operate " and " release " times;

(b) that the operate times of the devices should be short to minimise clipping, and their release times should be sufficiently long to enable the devices to remain operated in the intervals between words in normal speech;

UNANIMOUSLY RECOMMENDS

1. that the operate and release times of the voice-operated carrier switching unit on the ship should be as follows:

Input level *(Note a)*	Net operate time *(Note b)*	Net release time *(Note c)*
—30 db	less than 25 ms	between 75 and 170 ms
—20 db	less than 15 ms	between 75 and 170 ms

2. that the operate time *(Note d)* of the carrier-operated device in the coast station receiver should be as short as practicable to allow somewhat longer operate times in the ship's apparatus and should not exceed 5 milliseconds when the carrier level at the input to the receiver is more than 1 db above the level just necessary to operate the device. The required value of release time *(Note e)* is dependent on several factors, including the time constants of the automatic gain control of the radio receiver and a value between 10 and 50 milliseconds is generally suitable.

Note a. — Input level refers to the level of a test sinusoidal signal of frequency corresponding to the middle of the voice-frequency range relative to that producing 100% modulation.

Note b. — Net operate time is the time which elapses between the instant the test signal is applied to the input to the modulator of the transmitter, and the instant when the carrier reaches 50% of its maximum amplitude.

Note c. — *Net release time* is the time which elapses between the instant when the test signal is disconnected and the instant the carrier is reduced to within 5 db of the maximum carrier suppression achieved.

Note d. — *Operate time* of the carrier-operated device is the time which elapses between the sudden application of a test signal simulating the carrier wave from the ship and the instant of opening of the receiving channel (the instant when the attenuation of the receiving channel is within 5 db of the final value of attenuation for the receiving condition).

Note e. — *Release time* of the carrier-operated device is the time which elapses between the cessation of a test signal simulating the carrier wave from the ship and the instant of blocking of the receiving channel (the instant when the attenuation of the receiving channel is within 5 db of the final value of attenuation in the blocked condition).

RECOMMENDATION No. 77 *

CONDITIONS NECESSARY FOR INTERCONNECTION OF MOBILE RADIOTELEPHONE STATIONS (FOR INSTANCE, AUTOMOBILES, AIRCRAFT AND SHIPS) AND INTERNATIONAL TELEPHONE LINES

(Question No. 33)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that the conditions concerning which international agreement is necessary appear to be few in number;

(b) that these conditions, if met, would permit suitable interconnection between mobile radiotelephone stations and international telephone lines;

RECOMMENDS

1. that mobile radiotelephone circuits, intended for connection to international telephone systems, should terminate (on a 2-wire basis, for the present at least) in such a way that they may be connected to international lines in the same manner as other land-line connections;

2. that the mobile radiotelephone circuits should accept from and deliver to the land-line system, speech volumes conforming, as far as possible, to the C.C.I.R. and C.C.I.F. standards for connections to international circuits;

3. that the attenuation-frequency characteristics of the radio system (including the land-lines to the radio receiver and radio transmitter) should be such that the grade of transmission is not unduly affected; and in particular, the effectively transmitted band should be not less than 300 to 2600 c/s;

4. that the noise from a radio circuit connected to an international circuit should not be unduly great and should be insufficient to operate frequently echo suppressors or other devices on domestic or international circuits;

5. that in the case of mobile radiotelephone stations which may have to communicate with land stations in more than one country, consideration be given to the necessity for agreement as to a method of signalling for use between the land mobile stations.

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* The Roumanian P. R. reserved its opinion on this Recommendation.

RECOMMENDATION No. 80

HIGH-FREQUENCY BROADCASTING DIRECTIONAL ANTENNAE

(Question No. 23 (X))

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) Question No. 23 (X);

(b) that the formation of strong subsidiary lobes of radiation can be avoided by the multiple feeding of, and appropriate current distribution in, appropriately spaced radiation elements;

(c) that, by this means, it is theoretically possible to reduce the subsidiary lobes to a small value for a limited angle of slew of the main beam, provided the working frequency does not materially differ from the frequency for which an array is designed;

(d) that the realisation of these conditions is, however, not considered to be practicable on grounds of complexity of installation, difficulty of operation and maintenance of designed performances;

RECOMMENDS

that in practical operating conditions, for purposes of calculating interference, the field strength in directions other than that of the main lobe cannot be assumed to be less than 222 mV/m at a distance of one kilometre for one kilowatt of power supplied to the antenna*.

RECOMMENDATION No. 83

DISTURBANCES IN TELEVISION RECEIVERS RESULTING FROM HARMONICS AND OTHER NON-ESSENTIAL RADIATIONS FROM RADIO TRANSMITTERS

(Question No. 26)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that the Study Programme No. 2 (I) relating to Question 1 (I) *b*, covers the general problem of harmonic radiation from transmitters;

(b) that the general study of the interference to other services by those harmonic radiations will include that caused to television reception;

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* Refer to statement of Specialised Secretariat of the C.C.I.R. on the subject *The gain, directivity and protection ratio of a directional antenna or antenna array*, Doc. No. 24 of Washington as reproduced in Geneva, 1951.

RECOMMENDS

that the administrations should collect all possible data relating to such interference with broadcasting (television) in order to assist the Study Group concerned with transmitter questions.

Note. — This Recommendation concludes the study of Question No. 26.

RECOMMENDATION No. 88 *

BANDWIDTH OF EMISSION MEASUREMENTS MADE NEAR THE TRANSMITTER

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that accurate determination of bandwidths actually occupied by emissions is of increasing importance;

(b) that Question No. 1 (I) *(a)*, part 2, speaks of " practical methods of measuring the bandwidths actually occupied by emissions ";

(c) that new methods of measurements are proposed;

(d) that important progress has been made in the design of measuring apparatus;

(e) that it is now possible to present some tentative values of the degree of accuracy to be attained;

(f) that a practical basis must be furnished for the final determination of the bandwidth necessary for a service of appropriate quality;

UNANIMOUSLY RECOMMENDS

that attention should be paid to the following:

1. **Method of measurement on frequencies below 30 Mc/s**

Three main methods are at present in use.

1.1 The first one consists in completely analysing the spectrum of the transmission by means of a narrow band filter of fixed frequency, the frequency of each component being made to coincide with the central filter frequency by frequency transposition on the superheterodyne principle either manually or automatically.

1.2 The second method of measurement consists in directly measuring the proportion of the total energy which is contained in the frequency components more and more remote from the central frequency of the spectrum in order to determine the relative power of the out-of-band radiation.

The frequency components of the rectified signal are selected by means of a high-pass filter, the cut-off frequency of which is progressively increased; equipments based on this method are described in London Doc. No. 128 (Japan).

1.3 The third method consists in dividing the occupied band into narrow bands of say 100 c/s, for each of which a pass-band filter is provided; the output of each of these filters is connected either individually and permanently to a measuring device, or successively and automatically to a single measuring device. This method seems to be especially suitable for the examination of non-periodic signals such as telephone transmissions; equipments based on this method are described in London Docs. No. 79 (U.S.A.) and No. 274 (Austria).

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* This Recommendation replaces Recommendation No. 37.

2. Accuracies required for bandwidth measurement

2.1 *Periodic signals of Class A1:*

2.1.1 *Apparatus using the method described in para. 1.1*

2.1.1.1 *Laboratory apparatus.* This apparatus requires that the signals under test shall give rise to a spectrum the components of which should be stable in amplitude and in frequency. Amplitudes are measured by means of a calibrated attenuator with reference to a constant level; frequencies are measured by means of a frequency meter.

If the stability conditions referred to above are satisfied, the accuracy of the measurement depends only on the accuracy of calibration of the attenuator and of the frequency meter. An accuracy of $\pm 1\%$ in the measurement of the amplitude is obtainable, but an accuracy of $\pm 5\%$ is sufficient for most practical purposes.

2.1.1.2 *Automatic sweep apparatus.* Provided the frequency exploration speed is sufficiently slow to take full advantage of the high selectivity of the filter, the amplitudes of the components adjacent to the carrier can be measured with an accuracy of $\pm$2db, but a higher inaccuracy must be expected for the amplitudes of the remote components, especially in the case of narrow spectra and/or of slow telegraph speeds.

The accuracy of measurement of frequency deviations depends on the linearity of the sweep and on the width of the explored band. Nevertheless, in the case of periodic signals, the frequency deviations between successive components are generally known by the value of the telegraph speed.

2.1.2 *Apparatus using the method described in para. 1.2*

The accuracy of this measuring equipment depends on the accuracy of the measurement of power ratio, and on the steepness of the attenuation curve of the high-pass filter. The accuracy of the measurement of power ratio should be of the order of $\pm 0.1\%$ but the errors due to the attenuation characteristics of the filter will of course depend on the type of filter employed.

2.1.3 *Apparatus using the method described in para. 1.3*

When the component frequencies of the signal correspond approximately to the mid-band frequencies of the filters, accuracies of $\pm 1\%$ should be obtained.

2.2 *Periodic signals of Class F1 :*

2.2.1 *Apparatus using the method described in para. 1.1*

If it is possible to form periodic F1 signals for which there are corresponding components stable in amplitude and in frequency, the same accuracies as those mentioned in 2.1.1a and 2.1.1.b for periodic signals of type A1 can be achieved. It is pointed out that of course, in the present case, the components which can be measured with an accuracy of $\pm$2bd with automatic sweep apparatus, are those adjacent to the mark and space frequencies.

It is important to point out that for F1 signals it is generally difficult, in practice, to comply with the above mentioned conditions of stability. It is then necessary to consider the envelope of several spectra observed successively, but it is not yet possible to give a satisfactory physical significance to this envelope.

2.2.2 *Apparatus using the method described in para. 1.2* (see under 2.1.2).

2.2.3 *Apparatus using the method described in para. 1.3* (see under 2.1.3).

2.3 *Actual traffic signals :*

No data were presented in respect of such signals, which would allow the determination of the significance of the results given by the apparatus described above. It is thus not yet possible to propose any value of the accuracy to be recommended for such signals.

3. Continuation of studies

The studies, both on measuring equipment and on the methods of measurement itself, should be continued, and in particular for the frequencies above 30 Mc/s.

ANNEX I

Characteristics of measuring equipment with automatic frequency sweep

That equipment suitable for use in analysing the spectrum of transmitters operating in the medium and high frequency range should in general possess the following characteristics.

Filter bandwidth.

The filter bandwidth depends essentially on the characteristics of the signal to be studied. It should be small in comparison with the width of the spectrum to be measured, and whilst in the present state of the art it is inappropriate to specify a single bandwidth to the exclusion of others, it is desirable that the static bandwidth of the filter should not exceed 25 c/s. Its attenuation versus frequency characteristic should be steep-sided down to the region of 60 db.

Exploration speed.

Although rather high exploration speeds might prove to be useful for preliminary adjustments, when it is desired to take full advantage of the resolving power of the filter for fine analysis the exploration speed must be sufficiently slow for the response curve of the filter to be as near as possible to the steady state selectivity curve. The admissible value of the exploration speed depends essentially on the filter characteristics and should be determined experimentally in each case.

For information purposes only it can be said that for filters having a bandwidth of 10 c/s or so at —3 db, the exploration speed admissible is generally lower than 100 c/s per second.

Scanning range.

The scanning range shall be adequate to include the outermost significant sideband components likely to be encountered. A top limit of 30 kc/s total sweep should normally be adequate. For investigating narrow band transmissions, the range should be adjustable down to 1 kc/s.

Suppression of automatic sweep.

Provision should be made for the possibility of stopping the automatic sweep to enable a manual exploration to be used in certain cases.

Form of display.

For direct observation the display may take the form of a cathode ray tube, but other means such as recording meters may be used.

Amplitude range.

The range of amplitudes displayed should be such that it is possible to measure components differing in amplitude by at least 60 db. The amplitude scale of the display instrument may be

ANNEX II

Principal characteristics of the frequency spectrum analysers presented before the C.C.I.R. VIIth Plenary Assembly

Administration	Doc. No.	Exploration			Filter				Amplitude range db	Measuring instrument		Measurement of the component freq.
		Type	Sweep duration	Freq. band explored kc/s	Type	Bandwidth at −3 db	Bandwidth at other level	Freq. kc/s		Observations	Recording	
Japan	127	autom.	1 min. 5 min.	6 and 20	crystal	—	50 c/s at −25 db	55	60	voltm.	record. on paper	—
Netherlands	136	autom.	20 s. 2 min. 6.7 min.	1; 5; 25	Selective feed back amplifier	Adjustable between 8 and 40 c/s	—	40	0-20 20-40 40-60	oscillosc.	recorder	—
United Kingdom	168*	autom.	0.1; 0.3; 1; 3; 10; 30 s.	0 to 30	crystal	6 c/s 30 c/s 150 c/s	— — —	60	0-30 30-60	oscillosc.	photo	—
Switzerland	191	autom. and man.	0.1 to 60 s.	20; 60 in 3 steps	electro-mechn.	—	80 c/s at −43.5 db	3	—	oscill. or peak voltm.	photo	marks each 1 kc/s
Italcable	199	man.	—	—	LF	—	50 c/s at −80 db	1	calibrated attenuator	voltm.	—	frequency-meter
France	349	autom.	6 and 36 s.	2 and 6	crystal	—	6 or 30 c/s below 80 db	70	60	oscillosc.	photo	—
Belgium	**	autom.	6; 20; 45 s.	0.5 to 30	crystal	9 c/s	—	195	20 db lin. scale 60 db log. scale	oscillosc.	photo	marks 0.5 or 1 kc/s

* This apparatus has been demonstrated before S.G. Nº I.
** This apparatus has been demonstrated before S.G. Nº I, but was not described in a C.C.I.R. document.

linear or logarithmic. It may be desirable to measure the major and minor components separately and by stages such as may be obtained through the use of a calibrated attenuator or calibrated scale applied to the oscilloscope screen.

Frequency stability.

The frequency stability of the various beating oscillators must be such that the drift during the course of a measurement is small compared with the effective resolving power of the filter.

RECOMMENDATION No. 97 *

CHANNEL SEPARATION

The C.C.I.R., (Stockholm, 1948 — Geneva, 1951 — London, 1953)

CONSIDERING

(a) that the primary factors which determine frequency separation between channels in the more usual cases include :

— the signal power required by the receiver;

— the interference power intercepted by the receiver including that from interfering signals and from noise;

(b) that transmitters in general emit radiations outside the frequency bandwidth necessarily occupied by the emission;

(c) that a large number of factors are also involved, including the properties of the transmission medium, which are variable in character and difficult to determine, as well as the characteristics of the receiver and, in the case of aural reception, the discriminating properties of the human ear;

UNANIMOUSLY RECOMMENDS

1. that the required separation between channels be calculated by the following method:

— first finding the signal power intercepted by the receiver;

— finding the interfering power intercepted, including both noise and interfering signal, and

— from these data determining the degree of frequency separation that produces acceptable ratios of signal power to the interfering power for an acceptable percentage of the time for the type of communication desired, taking into account the fluctuating nature both of signal and interference and, whenever appropriate, the discriminating properties of the human ear;

2. that at every stage of the calculation, comparison should be made, as far as possible, with data obtained under controlled representative operating conditions, especially in connection with the final figure arrived at for the channel separation;

3. that the study of the problem should be undertaken in connection with Question No. 3 (III).

* This Recommendation replaces Recommendations Nos. 1 and 43.

RECOMMENDATION No. 98

CHANNEL SEPARATION ACHIEVED IN PRACTICE

(Question No. 3 (III))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that it is not yet possible to give a full answer to Question No. 3 (III);

(b) that in the case of telegraphy using A1 and F1 emissions, a large number of machine telegraph circuits are operating successfully with nominal separations of 2.5 kc/s, particularly in the frequency range below 12 Mc/s;

(c) that there is evidence (in particular Doc. No. 457 of Geneva, 1951) that, with reception of F1 at a speed of 50 bauds, a separation of about 1.5 kc/s is satisfactory when the two signals have the same median value at the input to the receiver, and that in certain cases a separation of about 2 kc/s provides fairly satisfactory operation when the median value of the wanted signal is 6 db below that of the unwanted signal *;

(d) that, when allowance is made for frequency tolerance, this evidence suggests the possibility of a separation of about 2.5 kc/s between emissions under the particular conditions of the test;

(e) that, while due regard must be paid to the frequency tolerances provided for in the Radio Regulations, 1947, App. 3, a higher degree of frequency stability is possible and is actually achieved in practice;

RECOMMENDS

1. that administrations should:

1.1 collect data relating to transmitters at present working in adjacent channels, indicating:
— the channel separations observed in practice;
— the field strengths of the signals on adjacent channels received at the same location;
— the effect of interference due to signals on adjacent channels (see Study Programme No. 45 (III) for the method of expressing the effect of interference);

1.2 carry out tests similar to those described in Doc. No. 457 of Geneva;

2. that administrations who have made these tests should submit the result to the Director of the C.C.I.R., as early as possible.

RECOMMENDATION No. 100

REDUCTION OF OCCUPIED BANDWIDTH AND TRANSMITTER POWER IN RADIO TELEPHONY

(Question No. 3 (III))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) the urgent need for improved utilisation of the radio spectrum, particularly in the range below 30 Mc/s;

* These tests are related to separate emissions without common control of the respective frequencies radiated.

(b) that a very great improvement in the utilisation of the spectrum will arise from the replacement of double-sideband by single-sideband technique (see Recommendation No. 40, § 2.1 and 2.2);

(c) that improvements can be obtained by the use of noise reducers and devices enabling the average percentage of modulation to be maintained at a high level, e.g. peak-clipping devices (see Recommendation No. 44*);

RECOMMENDS

1. that administrations should, whenever possible, make use of single-sideband systems in preference to double-sideband systems **;

2. that noise reducers should be employed at the receiving terminal of all circuits where an improvement in signal-to-noise ratio can be obtained ***;

3. that devices should be employed at the transmitting terminal of all circuits to enable the average percentage of modulation to be maintained at a high level (for example, peak-clipping devices). With the use of these devices adequate precautions must be taken to prevent radiation outside the necessary bandwidth (for example, by the use of an adequate low-pass filter after the device) ****.

RECOMMENDATION No. 101

BANDWIDTH REQUIRED AT A TELEGRAPH OR TELEPHONE RECEIVER OUTPUT

(Question No. 3 (III))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) the urgent need to determine the minimum separation between frequency assignments of stations operating on adjacent channels, in the range 10 kc/s to 30 000 kc/s;

(b) that the width of the frequency band which is necessary at the output of the receiver is one of the factors which determine the band of frequencies required for the overall system;

(c) that, in the case of telegraphy the permissible degree of distortion is not yet defined;

(d) that, in the case of telephony the bandwidth may depend among other factors upon the type of privacy equipment in use;

RECOMMENDS

1. that in the case of telegraphy a provisional value for the bandwidth necessary at the output of the receiver, under average practical conditions, should be as follows:

* This Recommendation has become Recommendation No. 161.

** Improvement of signal-to-noise ratio or a reduction in power of at least 9 db is obtained by the use of single-sideband systems instead of double-sideband systems.

*** The improvement which may be obtained in practice by the use of a noise reducer is dependent upon the signal-to-noise ratio at the input to the noise reducer (for example, an improvement of the order of 10 db may be obtained on radiotelephone circuits of good commercial quality).

**** The improvement which may be obtained in practice is dependent upon the original average percentage modulation of the transmitter. Improvement up to 6 db may be obtained in practice.

1.1 for A1 emissions, the bandwidth in cycles per second, after the final detector stage, should be equal to 2.5 times the signalling speed in bauds;

1.2 for F1 emissions, the bandwidth in cycles per second after the discriminator should be equal to 1.4 times the signalling speed in bauds.

The extent to which these values can be applied to permit closer spacing of adjacent channels, depends upon the degree and speed of amplitude variations due to fading and upon the differential fading of the mark and space frequencies;

2. that, in the case of telephony, as a compromise between intelligibility and economy of bandwidth, the bandwidth necessary for each speech channel at the output of the receiver should be as follows:

2.1 in accordance with Recommendation No. 40 the upper limit frequency should be reduced to 3000 c/s or less but not lower than 2600 c/s;

2.2 for systems employing privacy equipment the necessary bandwidth for satisfactory service may require the use of an upper limit frequency greater than 2600 c/s (e.g. in five-band privacy equipment the necessary bandwidth is 2750 c/s, the upper limit being 3000 c/s).

RECOMMENDATION No. 102 *

DIRECTIVITY OF ANTENNAE AT GREAT DISTANCES

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that the study of the directivity of antennae at great distances concerns chiefly radio communication on frequencies between 3000 and 30 000 kc/s;

(b) that in certain cases the phenomena of ionospheric propagation may be such as to modify appreciably both the theoretical directivity diagram and the practical diagram drawn up for measurements at short distances;

(c) that it would be very useful for operators to have the most accurate idea possible of the directional discrimination that can be expected of the antennae they are using;

RECOMMENDS

1. that all administrations in a position to do so should undertake systematic measurements on frequencies that can be used for long-distance circuits;

2. that the method used for the study of § *(c)* could be either the statistical method described in Doc. No. 23 of Geneva (see also Doc. No. 206 of London) or any other appropriate method;

3. that members of the C.C.I.R. who are able to provide either transmitting or receiving installations which could take part in the programme of studies proposed above should communicate full details of their installations to the Director of the C.C.I.R. as soon as possible, so that the latter may send them on to such other members of the C.C.I.R. as express a wish to receive them.

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* This Recommendation replaces Recommendation No. 46.

RECOMMENDATION No. 106

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(Question No. 43 (III))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that diversity reception on radiotelegraphy circuits is not general practice;

(b) that, in the case where voice-frequency equipment is used on radio circuits at frequencies lower than about 30 Mc/s, the quality of these circuits will in general be insufficient when no means of diversity reception is provided;

(c) that, in the presence of fading, space diversity or frequency diversity give comparable improvement to the quality of reception of telegraph signals transmitted on radio channels;

(d) that for adequate frequency diversity it appears necessary that the frequencies which are used in combination to obtain this diversity should differ by at least 400 c/s;

(e) that space diversity needs only half the bandwidth and less power for each telegraph channel when compared with the case of frequency diversity but, in general, requires more equipment;

UNANIMOUSLY RECOMMENDS

1. that, when voice-frequency telegraphy systems are used on radio circuits at frequencies lower than about 30 Mc/s, diversity reception should be used on the individual voice-frequency channels;
2. that, whenever practicable, space diversity should be used in preference to frequency diversity;
3. that, in the case of frequency diversity, the channel frequencies used in combination should have a separation of at least 400 c/s so that adequate diversity effects may be obtained.

RECOMMENDATION No. 111 *

TROPOSPHERIC-WAVE PROPAGATION CURVES

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that there is an urgent need to give a guide to engineers in the planning of services in the 30-300 Mc/s band, in particular for television and VHF (metric) broadcasting;

(b) that in the case of stations working in the same or adjacent frequency channels the determination of the minimum geographical distance of separation required to avoid intolerable interference due to long-distance tropospheric transmission is a matter of great importance;

* This Recommendation replaces Recommendation No. 55.

(c) that the annexed curves are based on the statistical analysis of a considerable amount of experimental data;

RECOMMENDS

that the revised curves given in Ann. II be adopted for use, *subject to the conditions stated in Ann. I.*

ANNEX I

(a) The curves of Ann. II were prepared principally from data obtained in the United States of America and the United Kingdom, supplemented by data from other European countries;

(b) it is not known to what extent these curves will be applicable in other parts of the world;

(c) for paths which lie wholly or mainly over the sea, the curves should be used with caution, as present experience suggests that, under these conditions, the field strengths may be considerably greater on the average than those given by the curves, particularly in areas having meteorological conditions such as are met with in the Mediterranean;

(d) the curves give field strengths exceeded for 1% and 10% of the time respectively over a long period of continuous observation. Curves for higher percentages are not given as they would scarcely be of interest in the planning of a system based on common channel working. It should be borne in mind that all the data that exist on this subject show that for short periods of time (in general much below 1% of the overall time) very high peak values of field strength may be obtained. There are even occasions when those peak values approach the free-space value;

(e) they apply only for distances greater than twice that of the radio horizon from the transmitter where the effects of different antenna heights are small;

(f) they are referred to a radiated power of 1 kW from a half-wave dipole several wavelengths, at least, above the ground;

(g) they refer equally to horizontal and vertical polarisation;

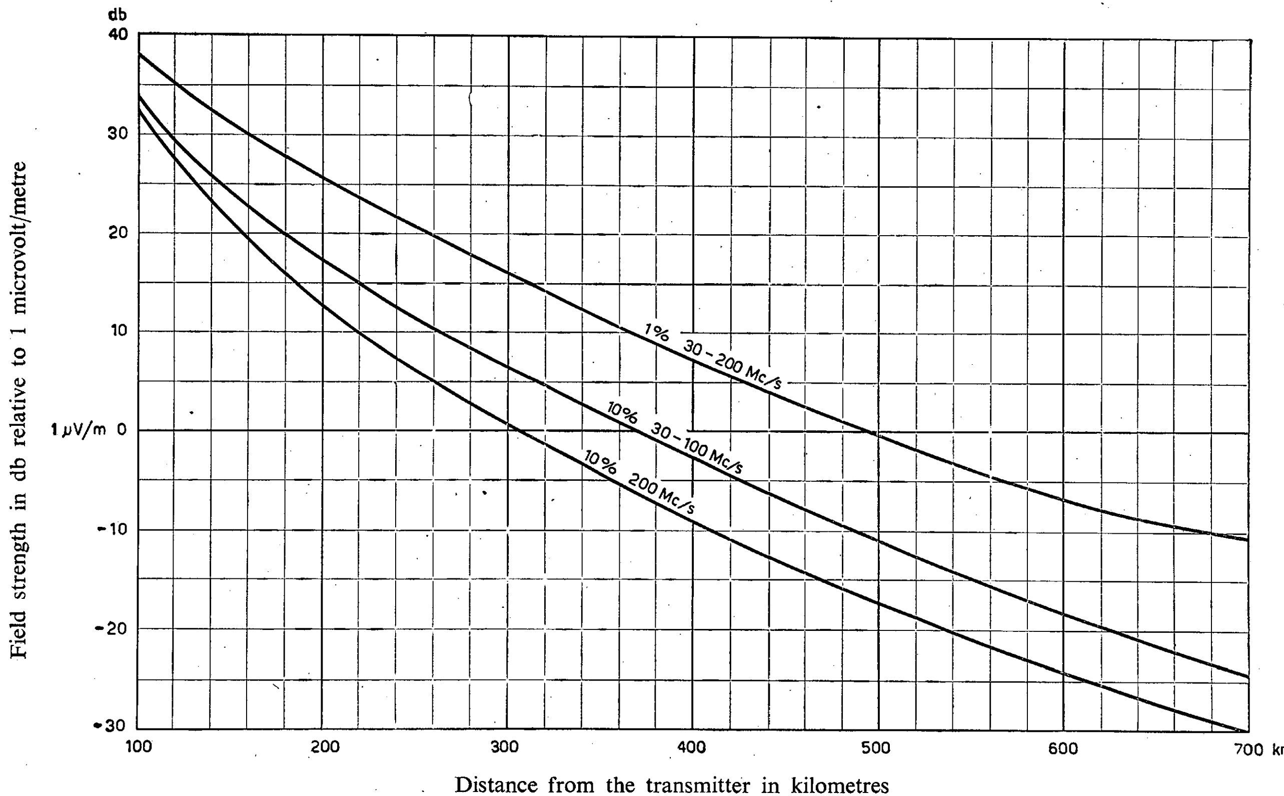
(h) the observed field strength depends upon the nature of the terrain over which the transmission takes place and these curves represent median values with respect to locations in the geographical areas (United States of America and Europe) in which the data were obtained;

(i) the curves are always subject to a wide scatter about the mean values given; they should therefore not be interpreted too precisely. In fact, each curve ought rather to be considered as a broad band with the curve as a mean value. On the other hand, the data show that in the case of the " 10% " curves there is a statistical dependence on frequency;

(j) these curves take no account of ionospheric propagation.

ANNEX II

ESTIMATED TROPOSPHERIC FIELD STRENGTH EXCEEDED FOR 1% AND 10% OF THE TIME



Frequency range 30-200 Mc/s. 1 kW radiated from a half-wavelength dipole, vertical or horizontal polarisation. Receiving aerial height 10 m above ground level, median values with respect to terrain.

RECOMMENDATION No. 112 *

BEST METHODS FOR EXPRESSING THE FIELD STRENGTH OF PULSE TRANSMISSIONS

(Question No. 8, § A.1c)

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that the characteristics of the field of a pulse-modulated transmission include the peak amplitude, the repetition rate, the shape of the pulse and the type of transmission;

(b) that the relative importance of these various quantities depends on the objectives of the measurement, but that the peak amplitude is, nevertheless, the most characteristic quantity;

(c) that the pulse shape may be altered by propagation phenomena;

(d) that the measurement of pulse field strengths will in principle involve the use of all the equipment required for the measurement of fields produced by continuous wave transmissions, with certain parts of the equipment modified or other equipment added in view of the special operating conditions necessitated by pulse modulation;

(e) that corrections may be necessary because of limited bandwidth and detector characteristics of the measuring equipment;

UNANIMOUSLY RECOMMENDS

1. that the field strength produced by pulse transmissions should be represented by the r.m.s. value of the field of the carrier corresponding to the peak amplitude of the pulse, normally disregarding transient peaks (spikes). If necessary these should be considered separately;

2. that in the special case of amplitude-modulated pulses the field strength should be represented by the average of the pulse amplitudes taken over an interval long compared with the periodicity of the modulation;

3. that the measurements should include determination of the shape, the repetition rate, and other characteristics of the pulses;

4. that apparatus for measuring and determining pulse characteristics should be developed;

5. that a cathode-ray oscilloscope should be included as a part of any pulse field-strength measuring equipment;

6. that the bandwidth of the receiving equipment should be large enough to reproduce the general form of the pulse.

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* This Recommendation replaces Recommendation No. 62.

RECOMMENDATION No. 113 *

FIELD-STRENGTH MEASUREMENT

Types of wave collector and equipment for use in each frequency band

(Question No. 8, § A.3)

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that the effective length of a loop antenna whose dimensions are small compared with the received wavelength is easily calculable;

(b) that the effective length of a doublet, sufficiently far from the ground, or of a stub-antenna, is calculable;

(c) that the effective length of the more complex directional antenna arrays cannot be calculated accurately;

(d) that the field-strength measurement apparatus commonly in use is composed essentially of a wave collector and a radio-frequency voltmeter;

UNANIMOUSLY RECOMMENDS

1. that the following wave collectors should be used for measuring field strengths stronger than a few microvolts per metre;
- — between 10 kc/s and 30 Mc/s, loop or stub-antennae (it is possible to use loops up to about 100 Mc/s);
- — above about 30 Mc/s, doublets, or stub-antennae, or loop antennae up to about 100 Mc/s;
- — above about 300 Mc/s, more complex directional wave collectors, as may be desirable;

2. that for the measurement of field strengths below a few microvolts per metre the more complex directional antenna arrays should be suitably calibrated and used, with due care in orientation of the wave collector for the component of the field being measured;

3. that in some cases, if so desired, the receiving equipment in use or available may be transformed into field strength measuring equipment by the addition of reference standards of voltage, indicators and the use of suitable calibration methods.

Note. — It is to be noted that longer single-conductor antennae may be used effectively to measure weak field strengths.

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* This Recommendation replaces Recommendation No. 64.

RECOMMENDATION No. 116 *

PRESENTATION OF BASIC PROPAGATION PREDICTION CHARTS

(Recommendation No. 53)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that basic propagation prediction charts produced by different organisations are not of uniform presentation;

(b) that the use of such charts for routine predictions, and their intercomparison, would be facilitated by the standardisation of the scales employed;

UNANIMOUSLY RECOMMENDS

that, keeping their present form, the charts should be made with a uniform scale using a centimetre grid on which one centimetre represents 10 degrees of latitude and 15 degrees of longitude or one hour of time.

RECOMMENDATION No. 121

LOCAL LIGHTNING-FLASH COUNTERS

(Study Programme No. 23 **)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that several devices designed for counting local lightning flashes have been proposed;

(b) that available performance data are insufficient to compare the merits of these devices;

RECOMMENDS

1. that direct comparisons should be made at several places, between various devices proposed for the counting of local lightning flashes;
2. that steps should be taken by the Director of the C.C.I.R. and Study Group No. VI in collaboration with the World Meteorological Organisation to arrange for direct comparison to be made between the several devices;
3. that the United States of America, France, India, Japan, the United Kingdom and the Union of South Africa should each be invited to propose a member to participate in this work and that the United Kingdom member should co-ordinate the work on behalf of the Chairman of Study Group No. VI.

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* This Recommendation replaces Recommendation No. 53.

** This Study Programme has become Study Programme No. 96 (VI).

Notes. — It is not possible to devise a simple radio device which will count all lightning flashes within a specified radius and none of those originating at greater distances.

It is considered that an instrument which responds to all major discharges will provide better indications of radio interference caused by storms than one which responds only to discharges to the ground.

It is considered that counters would provide a more satisfactory measure of thunderstorm activity if designed for a range greater than the 20 kilometres suggested in Study Programme No. 23 *.

It is considered that the most reliable indications of local thunderstorm activity are likely to be provided by instruments responding to a wide band of frequencies in the VLF (myriametric) band.

The standard or standards of reference to be used in the comparisons should be decided in close consultation with the Director of the C.C.I.R. and representatives of the World Meteorological Organisation.

RECOMMENDATION No. 124

WATCH ON THE RADIOTELEPHONY DISTRESS FREQUENCY OF 2182 kc/s

(Questions Nos. 56 & 57)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that, according to Atlantic City Radio Regulations No. 815, the frequency of 2182 kc/s may be used for calls and replies, and is the frequency to be used for the distress call and traffic, as well as for urgency and safety signals and messages;

(b) that there is, as yet, little experience of the world-wide use of a common frequency for calling and distress in the MF (hectometric) maritime radiotelephony service;

(c) that in certain areas distress calls at times suffer interference from traffic calls and replies;

(d) that certain countries use frequencies other than 2182 kc/s, especially working frequencies, for normal traffic calling and replies, in accordance with Radio Regulations No. 817;

(e) that, nevertheless, the exclusive use of the frequency of 2182 kc/s for distress purposes would militate against extensive watch-keeping on this frequency by ships;

(f) that the use of an alarm signal with strongly distinctive characteristics would facilitate the reception of distress calls in ships and coast stations carrying out aural watch as well as in those stations fitted with automatic alarms;

(g) that a loudspeaker distress watch in ships not fitted with automatic alarms would increase the efficiency of the distress watch;

UNANIMOUSLY RECOMMENDS

1. that an alarm signal of the type specified in Recommendation No. 219 should be adopted by all administrations and brought into use at an early date;

2. that administrations should encourage the keeping of a loudspeaker watch on the calling and distress frequency of 2182 kc/s on board those of their ships which are not fitted with

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* This Study Programme has become Study Programme No. 96 (VI).

automatic alarm receiving equipment for that frequency; nevertheless the automatic or aural watch for the alarm signal on the distress frequency of 2182 kc/s need be encouraged only on ships not fitted with radiotelegraph equipment in the 500 kc/s band;

3. that administrations should take special steps to enforce respect for the Radio Regulations (especially Nos. 815 and 816) regarding the use of the calling and distress frequency of 2182 kc/s;

4. that administrations should maintain observations over a sufficient period to determine whether there is a need to change the Radio Regulations regarding the use of the international calling and distress frequency of 2182 kc/s;

5. that the results of such observations should be submitted directly by administrations to an appropriate administrative conference.

Note. — This Recommendation concludes the study of Question No. 57.

RECOMMENDATION No. 126 *

PULSE TRANSMISSION FOR RADIO DIRECTION FINDING

(Question No. 61)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that certain studies, extending over many years, of the errors of direction finders show that, under ideal conditions of site, equipment and operation, the use of pulse transmissions offers only a slight improvement in accuracy over the use of continuous-wave transmissions;

(b) that, in practice, unavoidable departures from the ideal conditions referred to in *(a)* would tend to reduce this improvement in accuracy;

(c) that, for reasons of interference, their wide bandwidths make the use of pulse transmissions on frequencies below 20 000 kc/s generally undesirable;

UNANIMOUSLY RECOMMENDS

that the foregoing considerations should be brought to the notice of the administrations and other organisations concerned.

ANNEX

The following errors in high-frequency direction finding can occur:

1. observational errors introduced by the operator;

2. instrumental errors, including polarisation errors and those due to deficiencies of the direction-finder site;

3. errors due to radiation scattered from topographical features many wavelengths distant from the direction finder ;

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* This Recommendation completes the study of Question No. 61.

4. errors due to lateral deviation in the ionosphere;
5. errors due to wave interference caused by convergence of rays and by different modes of propagation.

The advantage of a pulse emission over a continuous-wave emission lies in its ability to allow signals arriving over different paths to be separated, and so to reduce errors arising from sources 4 and 5 above.

The degree of accuracy to be expected from the use of pulse emissions for radio direction finding has been studied, and it is estimated that in most favourable circumstances, for a frequency of about 8000 kc/s, the standard deviation of a single rapidly observed bearing might be about 3 degrees for a continuous-wave emission and about 2 degrees for a pulse emission. The corresponding figures for the mean of ten such bearings taken in a period of five minutes are: continuous-wave 2.5 degrees, pulse 1.7 degrees.

RECOMMENDATION No. 128

WIDE-BAND RADIO RELAY SYSTEMS OPERATING IN THE VHF (METRIC), UHF (DECIMETRIC) AND SHF (CENTIMETRIC) BANDS

Sub-control stations

(Study Programme No. 28 (IX))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that it is normal practice in multi-channel telephony to divide high-frequency cable systems for maintenance, supervision and monitoring purposes into line-regulated sections;

(b) that the length of such sections (which may include several relays or repeaters) varies with circumstances but is generally of the order of 100 miles (160 km);

(c) that supervisory, control and pilot signals are extracted and reinserted at the end of such sections in stations called sub-control stations;

UNANIMOUSLY RECOMMENDS

that in all cases where there is a junction between a wide-band multi-channel telephony cable system and a radio system, and where each system contains at least one intermediate repeater station, this junction should be made a sub-control station (i.e. the junction of two regulated sections), not necessarily attended.

RECOMMENDATION No. 129

METHODS OF SPECIFYING THE POWER SUPPLIED TO AN ANTENNA BY A RADIO TRANSMITTER

(Question No. 60)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that the Radio Regulations, Atlantic City, 1947, Art. 1, Section IV, Nos. 60 to 64, call for the use of peak power in specifying the power of a radio transmitter, but permit the use of mean power in cases where the peak power specification is not satisfactory or adequate;

(b) that in some cases the power of the unmodulated carrier may be a preferable method of rating the power of a transmitter with regard to monitoring and interference producing capabilities;

(c) that, although the two alternatives provided in the Radio Regulations may not always be adequate for all the uses made of transmitter power ratings, there is no satisfactory alternative form of specification immediately available;

(d) that there is no good reason for not specifying the power of a radio transmitter in a number of ways simultaneously, as long as each way can be shown to be necessary;

UNANIMOUSLY RECOMMENDS

1. that, for the time being the provisions of the Radio Regulations, Atlantic City, 1947, Art. 1, Section IV, Nos. 60 to 64 need not be altered;

2. that other methods of specifying and measuring the power of radio transmitters should be included when this is justified.

RECOMMENDATION No. 130 *

POWER RELATIONSHIPS FOR MODULATED EMISSIONS

(Question No. 59)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that the modulated signals likely to be used for field-strength measurements can be divided into two classes;

Class 1: where the radiated power is wholly or largely independent of the degree of modulation;

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* This Recommendation completes the study of Question No. 59.

Class 2: where the radiated power is largely dependent on the degree of modulation.

(b) that for modulation by speech, music or conversation, or by certain other forms of intelligence, the power relationships of the modulating signal are variable;

UNANIMOUSLY RECOMMENDS

1. that for signals of Class 1 it should suffice, for most field-strength measurements, to specify the unmodulated carrier power;

2. that for signals of Class 2, when it is necessary to make field-strength measurements of high precision, it appears desirable for the two terminals to co-operate, either by recording the transmitter output power with an instrument having similar characteristics to those of the field-strength recorder or by the transmission of special signals.

RECOMMENDATION No. 131 *

INTERFERENCE TO RADIO SERVICES **

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that the study of certain aspects of interference, affecting sound and television broadcasting, especially from industrial sources, is already entrusted to the International Special Committee on Radio Interference (C.I.S.P.R.) administered by the International Electrotechnical Commission (I.E.C.);

(b) that the C.C.I.R. in accordance with Recommendation No. 27 of the Vth Plenary Assembly (Stockholm, 1948) maintains regular contact with the C.I.S.P.R.;

(c) that the harmonious co-existence of radio services with industrial installations producing radio oscillations involves close collaboration between organisations representing the manufacturers and users of these installations on the one hand, and the radio services on the other, for which the existing collaboration between the C.C.I.R. and the C.I.S.P.R. provides;

(d) that the C.I.S.P.R. has already studied and is continuing to study extensively the permissible signal-to-interference ratios for sound and television broadcasting, but has not yet made equivalent studies for other radio services;

RECOMMENDS

1. that the existing collaboration between the C.C.I.R. and the C.I.S.P.R. should be actively maintained and extended;

2. that in the course of such collaboration the C.C.I.R. should bring to the notice of the C.I.S.P.R. those aspects of the work that are of the greatest urgency, so far as the C.C.I.R. is concerned, so that the results of their work can be used in future by the C.C.I.R.;

3. that the study of interference to radio services, required by Resolution No. 5 annexed to the International Telecommunication Convention, Buenos Aires, 1952, should be carried

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* France reserved its opinion on this Recommendation.

** See Buenos Aires Resolution No. 5.

out by the C.C.I.R., the latter continuing to study the maximum interference levels (including radiation from industrial scientific and medical equipment) tolerable in various radio systems, while avoiding duplication of the work already in progress in the C.I.S.P.R., and that the C.C.I.R. should transmit its findings to the C.I.S.P.R. to facilitate the latter's study of radio interference problems;

4. that the C.C.I.R. should continue to take cognisance of those aspects of this work which relate specifically to the study and establishment of conditions necessary to ensure the avoidance of harmful interference between services whose operation is covered by the Radio Regulations.

RECOMMENDATION No. 136

SINGLE-SIDEBAND SOUND BROADCASTING

(Question No. 62)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that the results of a series of laboratory experiments (see London Doc. No. 305) on the use of SSB or ASB transmissions for HF (decametric) broadcasting indicate that:

— with present types of HF (decametric) broadcast receivers no economy in the radio spectrum can be obtained by changing from double-sideband (DSB) to SSB or ASB transmission;

— a relatively small saving (about 7%) might be obtained by the use of SSB transmissions if substantial improvements were made in the selectivity of receivers, but the modifications could not be applied to receivers already manufactured;

— a greater saving (about 14%) might be obtained by the use of SSB with a " tête-bêche " system of channelling but this would necessitate elaboration in the design of receivers, which could not be applied to receivers already manufactured;

— closer carrier spacing might be possible if low-pass audio-frequency filters could be added to present receivers, but this would be almost equally true whether applied to the reception of SSB or of DSB transmissions;

(b) that the use of SSB or ASB transmissions for medium-frequency broadcasting would also necessitate considerable modifications to the receivers and, in addition, would reduce the range obtainable for an acceptable distortion from a transmitter of given power;

UNANIMOUSLY RECOMMENDS

that these results be accepted as a conclusive answer to Question No. 62.

RECOMMENDATION No. 139

DESIGN OF TRANSMITTING AERIALS FOR TROPICAL BROADCASTING

(Question No. 70, § 1)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that it is desirable to use transmitting aerials for tropical broadcasting that cause, outside the service area, a minimum of interference;

(b) that the aerials should be economical in design and simple in operation;

(c) that Report No. 36 * gives the principles on which aerials for tropical broadcasting should be designed and constructed;

(d) that it is desirable to obtain as much operational data as possible on tropical broadcasting using aerials designed on these principles;

RECOMMENDS

1. that administrations and organisations operating tropical broadcasting services should use aerial systems so designed that:

- — the power radiated is as large as possible at the high angles of elevation required for the needs of the service area;
- — a sufficient value of radiation should be maintained at angles of elevation necessary to serve the fringe of the service area;
- — the power radiated at angles of elevation lower than those used to serve the fringe of the service area is as low as possible;

2. that administrations and organisations should forward to the C.C.I.R. reports on the operation of such aerials so that an addendum can be issued to Report No. 36 * giving practical operational data concerning these aerials. The data and information should be forwarded in the following form:

- — type of aerial system used and its physical dimensions in relation to the frequency of operation;
- — electrical characteristics—polar diagram in the vertical and the horizontal planes;
- — power radiated by the aerial;
- — siting of the aerial with respect to the geographical configuration of the area to be served and the orientation of the aerial with respect to north;
- — hourly averages of field strength measured, whenever practicable every 100 or 200 km, up to a maximum distance of 2000 km in all directions;
- — fading characteristics of the received signal;
- — influence, if any, of the orientation of the aerial with respect to the magnetic meridian;
- — ground conductivity in the vicinity of the aerial system;
- — any other information considered useful in respect of this Recommendation.

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* *This Report has been replaced by Report No. 86.*

RECOMMENDATION No. 140

DESIGN OF RECEIVING AERIALS FOR TROPICAL BROADCASTING

(Question No. 70, § 3)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that for the great majority of domestic tropical broadcast listeners, only simple aerials are practicable;

(b) that the aerial has to be both cheap and simple to install and it has to be used on a number of frequencies with fields at varying angles of incidence;

RECOMMENDS

1. that the directivity of receiving aerials cannot be relied upon to improve the signal-to-noise ratio;

2. that it appears reasonable to assume that the aerial of the average listener cannot be better than that given in the Report of the Geneva Planning Committee (1948) and this consisted of an " L " type aerial with horizontal and vertical limbs, each 16 feet in length (4.80 metres).

RECOMMENDATION No. 143

UNIT SYSTEMS

(Resolution No. 6)

The C.C.I.R., (London, 1953)

CONSIDERING

that the use of the rationalised M.K.S. system (also known as the rationalised Giorgi system) has been recommended by the International Electrotechnical Commission (Technical Committee No. 24 meeting, held in Paris on 17th and 18th July, 1950) and that it is now very widely used by radio engineers and by the authors of radio publications;

RECOMMENDS

that administrations and private operating agencies should be encouraged gradually to adopt, in their relations with the I.T.U. and its permanent organs, the rationalised M.K.S. system (also known as the rationalised Giorgi system).

RECOMMENDATION No. 144

MEANS OF EXPRESSION
TERMS, DEFINITIONS, GRAPHICAL AND LETTER SYMBOLS AND THEIR CONVENTIONAL USAGE

(Resolution No. 5)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that it is of importance for the ease and efficiency of the work of the C.C.I.s that means of expression of all kinds (terms, symbols, etc.) and the conditions of their use be rendered and maintained as uniform as possible;

(b) that the C.C.I.F. has finished its "*Draft list of definitions of essential telephone terms*", that the C.C.I.T. has made considerable progress in its work of terminology and that a procedure for coordinating the vocabulary work of the three C.C.I.s is outlined in Resolution No. 283 of the I.T.U. Administrative Council;

(c) that the desired unification means avoiding, unless imperatively necessary, contradictions between the conventions accepted by the C.C.I.R. and those used by other qualified organisations, especially the International Electrotechnical Commission (I.E.C.) and that efficient cooperation must be secured for this purpose, not only in the final stage of the work but also in the preparatory stages, i.e. at the level of each of the participating countries;

(d) that the I.E.C. has on its part sought means of cooperation with the C.C.I.R.;

(e) that the Australian Administration has submitted to the C.C.I.R. (London Doc. No. 269) a proposal to the effect that the unification of graphical means of expression should not be restricted to elementary symbols but should be extended to circuit diagram lay-out, making them of greater practical utility to the engineer by giving each of the sub-circuits an appearance characteristic of the function it fulfils;

UNANIMOUSLY RECOMMENDS

1. that lists of the various categories of means of expression suitable for the work of the C.C.I.R. (terms, definitions, graphical and letter symbols) and the conventions for putting these means of expression to the best use should be prepared as soon as possible and kept up to date as constantly as possible, this permanent task being entrusted to the Study Group No. XIV specially set up for this purpose by the C.C.I.R.;

2. that each administration wishing to cooperate effectively in this work should nominate to the Study Group concerned a "*national correspondent*", and that the Study Groups of the C.C.I.R. should appoint "*representatives*" whose technical qualifications are required for the efficient performance of this work;

3. that the Study Group concerned should take all appropriate action for coordination and cooperation with the organisations active in this sphere, so as to avoid useless duplication of work already begun and harmful divergences in results, this being particularly important with reference to the C.C.I.F. and the C.C.I.T. on the one hand, and the International Electrotechnical Commission on the other;

4. that priority should be given to the preparation of that part of the I.T.U. vocabulary dealing with radio communication, so as to ensure as soon as possible the publication of the complete vocabulary, for which the work done by the C.C.I.F. and the C.C.I.T. is much more advanced; and for this purpose:

4.1 that the I.T.U. vocabulary should be published in separate sections so as to avoid, both for the edition at present in preparation and for any future revised editions, delay in the publication of certain sections not yet ready, merely because of delays in other sections; that consequently a section should be devoted to each of the following subjects: telegraphy, telephony, radio communication, terms common to all three branches of telecommunication;

4.2 that the initial document intended to serve as a basis for the " radio communication " section of the I.T.U. vocabulary, which was drawn up during the VIIth Plenary Assembly under the heading "*Preparatory list of terms and definitions used by the C.C.I.R.* " should be communicated to the Director of the C.C.I.R. for issue and distribution to the " *national correspondents* " and " *representatives* " referred to in point 2 above, so that they may examine it;

4.3 that replies to this first consultation be sent direct to the Chairman of the relevant Study Group (No. XIV); that comments should be made and amendments suggested bearing in mind the fact that the published section will in principle contain only the terminology peculiar to the work of the C.C.I.R. and not the terminology formally adopted by the I.E.C. for its vocabulary; so that for this common terminology only major objections to the corresponding terms or their definitions need be mentioned;

4.4 that the Chairman of the Study Group concerned should carry out in the most suitable manner an analysis of the results of this first enquiry; that he should then entrust the three " national correspondents "—of the U.S.A., United Kingdom and France—with the necessary translation work for the bilingual text (taking into account differences in American and British terminology) required to draw up a "*provisional list of terms and definitions peculiar to the work of the C.C.I.R.*"; that he should then request the Director of the C.C.I.R. to issue this document and to send it for study to all the Study Groups and the administrations participating in the work on terminology;

4.5 that replies to this second enquiry should be sent to the Director of the C.C.I.R.; that the Chairman of the Study Group concerned should carry out in the most appropriate manner an analysis of these replies; that, with the assistance of the Study Group, the final text of the (bilingual) "*List of terms and definitions peculiar to the work of the C.C.I.R.*" should then be drawn up, which would then constitute the draft sections to be placed before the joint Study Group of the three C.C.I.s provided for by the Administrative Council of the I.T.U.;

5. that work should also be started on means of expression other than those in the vocabulary, so long as work on the latter is not thereby held up, and using a procedure based on the experience acquired.

RECOMMENDATION No. 145 *

BANDWIDTH OF EMISSIONS

(Recommendations Nos. 3 and 36)

The C.C.I.R., (Stockholm, 1948 — Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that it is of the utmost importance to ensure economy of the radio spectrum by reducing the spacing between assigned frequencies;

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* This Recommendation replaces Recommendation No. 87.

(b) that, to this end, it is necessary to reduce the spectrum occupied by each emission, in compliance with the rules of Art. 13, § 4, of the Radio Regulations; that, moreover, the Radio Regulations have prescribed in Art. 17, § 2, that the bandwidths mentioned in App. 5 must be considered as a guide, until more recent recommendations of the C.C.I.R. are published;

(c) that for the determination of a spectrum of minimum width, the whole transmission circuit as well as all its technical working conditions, and particularly, propagation phenomena, must be taken into account;

(d) that one cannot, strictly speaking, mention bandwidth without having previously adopted quantitative definitions of the various bandwidths by fixing well determined points on the complete spectrum;

(e) that the definition of the bandwidth occupied, being the only definition mentioned in the Radio Regulations and satisfying the previous conditions, is useful to specify a given emission;

(f) that, however, this definition does not suffice when consideration of the complete problem is involved; and that one should be in a position to establish general rules limiting, on the one hand, the bandwidth occupied to the value strictly necessary in each case and, on the other hand, the amplitudes of the emitted components in that part of the spectrum which could interfere with adjacent channels;

(g) that one can thus realise the usefulness of three conceptions:

— the bandwidth necessarily occupied;
— the bandwidth occupied;
— the emitted spectrum outside the bandwidth necessarily occupied;

which can be defined and applied according to the following principles:

g.1 the bandwidth necessarily occupied should be established at the smallest value possible, while including the spectrum components useful to a good receiver to ensure communication with the quality required by the two correspondents (that is to say, for example, maintaining the telephone quality laid down, or the percentage of errors admitted in telegraphy), in the presence of given technical conditions;

g.2 the bandwidth occupied, as defined in the Radio Regulations, enables the operating agencies, and the national and international organisations to carry out measurements of the bandwidth actually occupied by a given emission and so to ascertain, by comparison with the bandwidth necessarily occupied, that such an emission does not occupy an excessive bandwidth in view of the service to be provided, and is, therefore, not likely to create harmful interference beyond the limits laid down for this class of emission. The use of this concept appears then to be a useful way of requiring the operating agencies to restrict the emitted energy outside the bandwidth necessarily occupied;

g.3 the emitted spectrum outside the bandwidth necessarily occupied must be determined by reconciling the following requirements:

— the necessity to limit to a strict minimum the interference caused to the adjacent channels;
— the technical and practical possibilities of transmitter design;
— the limitation to a permissible value of the shaping or distortion of the signal;

(h) that, however, one must always bear in mind the fact that the three concepts are not independent and that given a specific emission, the knowledge of each one provides partial information on the emitted spectrum; the emission is completely determined only by its entire spectrum;

UNANIMOUSLY RECOMMENDS

1. Definitions

1.0 that in addition to the definition of bandwidth occupied by an emission, given in Chap. 1, Art. 1 No. 58 of the Radio Regulations, and which is quoted for reference in § 1.1 below, the following definitions and explanatory notes should be employed as convenient conventions to facilitate and clarify the consideration of bandwidth problems.

1.1 *Bandwidth occupied by an emission*

The band of frequencies comprising 99% of the total radiated power extended to include any discrete frequency on which the power is at least 0.25% of the total radiated power.

1.2 *Bandwidth necessarily occupied by an emission*

The minimum value of the bandwidth occupied by an emission, sufficient to ensure the transmission of information of required quality at the output of the receiving equipment for the class of emission, the system employed, and for specified technical conditions (see notes 1 & 3).

1.3 *Out-of-band radiation of an emission*

The power radiated by an emission outside the bandwidth necessarily occupied (see note 1). The out-of-band radiation does not include radiations on remote frequencies such as harmonics and parasitic emissions (see notes 2, 3 & 4).

1.4 *Build-up time of the signal*

The time during which the telegraphic current passes from one tenth to nine tenths (or vice versa) of the value reached at the steady state (see note 5).

1.5 *Note* 1. — Such radiation useful for the good functioning of the receiving equipment, as for example, the radiation corresponding to the carrier of reduced-carrier systems should be included in the bandwidth necessarily occupied, and not in the out-of-band radiation.

Note 2. — It is not intended that radiation on frequencies remote from the useful part of the emission, such as radio-frequency harmonics, be included in the defined out-of-band radiation, as these are covered by separate regulations (see App. 4, Radio Regulations).

Note 3. — The bandwidth occupied by an emission which would be considered as perfect from the standpoint of bandwidth economy equals the bandwidth necessarily occupied. In this case the out-of-band radiation generally equals 1% of the total radiated power. For other cases the percentage will, in general, be higher.

Note 4. — The concept of out-of-band radiation gives a convenient means to indicate the relative imperfection of an emission. However, a complete description of the spectrum of the out-of-band radiation is indispensable for the determination of interference caused on adjacent channels.

Note 5. — In the case of asymmetric signals, two different values corresponding to this definition can exist, representing the build-up times at the beginning and end of the signal.

2. Limitations of the emitted spectra

2.0 that, since some present emissions (particularly class A1 emissions) occupy an unduly wide bandwidth, administrations should endeavour, with the minimum practicable delay, to limit the emitted spectra to those shown below for various classes of emission.

2.0.1 The telegraph speed in bauds (later referred to as B) used in the following text is the maximum speed used by the corresponding transmitter. In the case of a transmitter operating at a speed lower than this maximum speed, the build-up time should be increased to keep the occupied bandwidth at a minimum in order to comply with Art. 17, § 2 (No. 398) of the Radio Regulations.

2.1 *Class A1 emissions with fluctuations*

2.1.0 Under conditions where large short-period variations of the received field are present the specifications given below for single-channel, amplitude-modulated, continuous-wave telegraphy (class A1) represent desirable performance that can be obtained from transmitters with adequate input filters and sufficiently linear amplifiers, following that in which keying takes place.

2.1.1 *Bandwidth necessarily occupied*

The bandwidth necessarily occupied is equal to five times the telegraph speed in Bauds with an attenuation of the components at the edges of the band equal to at least 3 db, in comparison with the level of the same components of the spectrum representing a series of equal rectangular dots and spaces at the same telegraph speed. This relative level of -3 db corresponds to an absolute level of 27 db below the level of a continuous mark.

2.1.2 *Spectrum of the out-of-band radiation*

Outside the bandwidth defined above, the envelope of the spectrum should lie below a curve starting at the point $\left(\pm \frac{5B}{2}, -27 \text{ db}\right)$ defined above, and presenting a slope of 30 db per octave and extending over at least one octave, that is out to the points (± 5 B, -57 db). From these points onward, the level of all the components emitted should be below -57 db.

2.1.3 *Build-up time of the signal*

The build-up time of the transmitted signal depends essentially on the shape of the signal at the input of the transmitter, on the exact structure of the filters to which this signal is applied, on filtering and non-linear effects which may take place in the transmitter itself (assuming that the antenna has no influence on the shape of the signal). As a first approximation it can be accepted that a spectrum curve close to the limiting spectrum defined in § 2.1.1 and 2.1.2, corresponds to a build-up time of order of 20% of the initial duration of the telegraph dot, i.e. of the order of $\frac{1}{5B}$.

2.2 *Class A1 emissions, without fluctuations*

For amplitude-modulated, continuous-wave telegraphy, in conditions where short-period variations of the receiver field strength do not affect transmission quality, the bandwidth necessarily occupied can be reduced to three times the keying speed in bauds.

2.3 *Class A2 emissions*

2.3.0 For single-channel modulated telegraphy keyed on both the carrier and the modulating frequency, the percentage of modulation being 100% or less and the modulation frequency higher than twice the keying frequency ($F > B$), the specifications given below represent desirable performance that can be obtained from transmitters with fairly simple input filters and approximately linear stages.

2.3.1 *Spectrum*

Outside a band with a width equal to twice the modulating frequency (referred to as F) plus five times the telegraph speed in bauds, the envelope of the spectrum should lie below a curve starting at the points of abscissae $\pm \left(F + \frac{5B}{2}\right)$ and ordinates -24 db, presenting a slope of 12 db per octave, and extending over at least one octave, that is out to the points of abscissae $\pm$ (F + 5 B) and ordinate -36 db.
From these points onward the level of all the components emitted should be below -36 db.

The reference level is the carrier level during a steady dash.

2.3.2 *Modulation depth*

With a view to reducing the components due to the harmonics of the modulating frequency it is recommended that, in general, the depth of modulation should not exceed 80%.

2.3.3 *Bandwidth necessarily occupied*

The bandwidth necessarily occupied depends on the telegraph speed, on the frequency and depth of modulation and on non-linear effects. It must therefore be determined for each specific case.

2.4 *Class A3 emissions*

The limitations given below for radiotelephone emissions have been deduced from measurements made by different methods. In one of these methods two pure audio-frequency tones of equal amplitude are applied to the input of the transmitter and the amplitude of modulation products outside the normal bandwidth of the transmitter is measured at the output. In other methods the output voltage from a recording of conversational speech, or a white noise voltage, is substituted for the two audio-frequency tones.

These fundamentally different methods do not lead to the same result; however, the known results of measurements are within the limiting spectra specified below.

In the curves defined in § 2.4.1 and 2.4.2, the ordinates represent the energy intercepted by a receiver of a bandwidth practically equal to 3 kc/s, the central frequency of which is tuned to the frequency plotted on the abscissa, as compared with the energy which would be intercepted by the same receiver if it were tuned to the central frequency of the necessary band.

2.4.1 *Class A3 emissions, double-sideband*

2.4.1.1 *Necessary frequency band*

The necessary bandwidth equals twice the highest audio frequency M which it is desired to transmit with a specified small attenuation

2.4.1.2 *Power within the necessary band*

To estimate statistically the distribution of power within the necessary band when no privacy equipment is connected with the transmitter, the distribution shown by the C.C.I.F. for the " commercial circuit psophometer " can be used (Recommendation No. 5, 16th Plenary Assembly, Volume VI); in addition, the relative power level of speech frequencies should be taken into account. In cases where the transmitter is used in connection with a frequency inversion privacy equipment the same data can be used with appropriate frequency inversion of the resulting spectrum.

If a band-splitting privacy equipment is used, it has to be assumed that the statistical distribution of power is uniform within the frequency band.

2.4.1.3 *Power outside the necessary band*

2M being the necessary bandwidth, if a logarithmic abscissa frequency scale and an ordinate amplitude scale in decibels are used, the distribution curve of power outside the necessary band should lie below two straight lines starting from the points ($\pm$ M, 0 db) to the points ($\pm$1.4 M, –20 db). Beyond these points, and down to the level of –60 db, this curve should lie below two straight lines starting from the latter points and presenting a slope of 12 db per octave. Thereafter, the same curve should lie below the level –60 db.

The reference level corresponds to the level of a single pure tone which, when applied to the input of the transmitter, gives the peak modulation of the transmitter.

2.4.2 *Class A3a, A3b, etc. emissions, independent-sidebands and reduced-carrier*

2.4.2.1 *Necessary frequency band*

The necessary bandwidth 2F is equal to the difference of the two radio frequencies defining the limits of the necessary band. These two frequencies correspond to the extreme modulating frequencies which it is desired to transmit with a specified small attenuation in the outer channels of the emission.

2.4.2.2 *Power within the necessary band*

The distribution of power within the necessary band is determined as for double-sideband transmitters. However, one must consider that independent-sideband transmitters are, in general, used with a band-splitting privacy equipment; it has then to be assumed that power distribution is, in general, statistically uniform within each of the sidebands.

2.4.2.3 *Power outside the necessary band*

The power outside the necessary band is dependent on the number and position of the active channels. The curves described below are appropriate when all channels are active simultaneously. When some channels are idle the power outside the necessary band is less. 2F being the necessary bandwidth, if a logarithmic abscissa frequency scale and an ordinate amplitude scale in decibels are used, the distribution curve of power outside the necessary band should lie below two straight lines starting from the points ($\pm$F, 0 db) to the points ($\pm$1.4 F, -30 db).

Beyond these points, and down to the level of -60 db, this curve should lie below two straight lines starting from the latter points and presenting a slope of 12 db per octave. Thereafter, the same curve should lie below the level -60 db.

The reference level corresponds to the level of a single pure tone which, when applied to the input of one of the transmitter sidebands, gives the peak power of the transmitter.

2.5 *Class F1 emissions*

For single-channel, frequency-shift telegraphy (class F1), with or without fluctuations:

2.5.1 *Bandwidth necessarily occupied*

The deviation, or difference, between mark and space frequencies being 2D and m being the modulation index 2D/B, the bandwidths necessary are given by one of the following formulae, the choice depending on the value of m:

$$2.5\ D+0.5\ B \text{ for } 2.5 < m \leqslant 8$$
$$2\ D+2.5\ B \text{ for } 8 \leqslant m \leqslant 20$$

2.5.2 *Spectrum of the out-of-band radiation*

Outside the bandwidth defined above, the envelope of the spectrum should lie below a curve of constant slope in decibels per octave, starting from points situated at the limiting frequencies for the bandwidth necessarily occupied, and at the level of -15 or -20 db, depending on the value of the modulation index, the curve extends to the level of -60 db. The levels are computed by comparison with a zero level corresponding to the amplitude of the emission; the starting ordinates of the curve and its slopes are given in the following table, the entry depending on the modulation index:

Modulation index	Starting ordinates in db	Slope in db per octave
$2.5 < m \leqslant 3$	—15	17
$3 < m \leqslant 8$	—15	25
$8 < m \leqslant 20$	—20	30

On the frequencies more remote from the median frequency than those where the curve reaches the -60 db level, the level of all emitted components should lie below -60 db.

2.5.3 *Build-up time of the signal*

A spectrum curve close to the limiting spectrum described in § 2.5.1 and 2.5.2 corresponds to a build-up time equal to about 8 % of the duration of the initial telegraph dot, i.e. about $\frac{1}{12B}$ provided that an adequate filter is used for signal shaping.

2.5.4 *Bandwidth occupied, in the case of unshaped signals*

Only for comparison purposes with the formulae above, it may be mentioned that for a sequence of equal and rectangular (zero build-up time) mark and space signals, the occupied bandwidths are given by the following formulae:

$$\frac{8}{3}D + \frac{4}{3}B \quad \text{for } 2.5 < m \leqslant 8$$

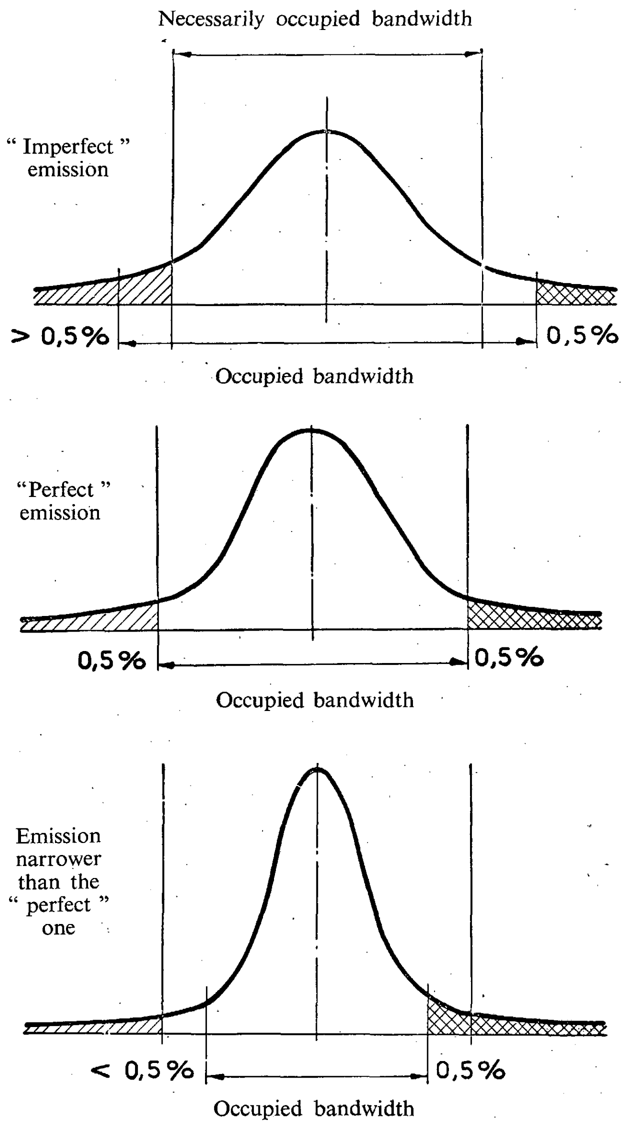
$$2.2\,D + 3.2\,B \quad \text{for } 8 \leqslant m \leqslant 20$$

ANNEX

Examples of spectra for illustration of the definition of necessarily occupied bandwidth

Abscissae: frequencies
Ordinates: power, per unit frequency

The spectra are assumed to be symmetrical



Hatched areas represent the out-of-band radiation (see definition 1.3)
Cross-hatched areas represent radiation outside the occupied band (see definition 1.1)

RECOMMENDATION No. 146

DEFINITION OF THE BANDWIDTH OF EMISSIONS

(Study Programme No. 39, § 3) *

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) the theoretical and practical studies on the bandwidth of emissions made in different countries**;

(b) that the measurement of the bandwidth as defined by the Radio Regulations is difficult, especially at long distances from the transmitter;

(c) that certain methods of direct measurement of bandwidth appear satisfactory, but have not yet been tested for all types of emissions;

(d) that no existing measuring method takes account of any discrete component outside the band comprising 99% of the power;

(e) that it seems advisable to amend the definition of bandwidth occupied to facilitate its measurement;

UNANIMOUSLY RECOMMENDS

1. that the principle of percentage of power should be maintained as the basis of any new definition of the bandwidth occupied by an emission;

2. that any new definition should exclude reference to the discrete components.

RECOMMENDATION No. 147 ***

SPURIOUS RADIATION

(Question No. 1 (I) § A *(b)*)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that Appendix 4 of the Radio Regulations 1947 specifies the maximum level of harmonics and parasitic emissions of all transmitters (except those mentioned in Note 1 of this Appendix) operating in the frequency band 10 to 30 000 kc/s in terms of power supplied to the antenna on the frequency of the harmonic, or of the parasitic, emission;

(b) that Article 17, para. 2, (No. 398), of the Radio Regulations, 1947 states that:

" the bandwidths of emissions, level of radio-frequency harmonics, and non-essential emissions must be kept at the lowest value which the state of technique and the nature of the

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* This Study Programme has been replaced by Study Programme No. 82 (I).

** For example, see Warsaw Docs. Nos. 216, 312, 355 and 405.

*** This Recommendation replaces Recommendation No. 89. Denmark, Norway, Sweden and the United States of America reserved their opinion on this Recommendation.

service permit. Appendices 4 and 5 must be considered as a guide in this respect, until more recent recommendations of the C.C.I.R. are published ";

(c) that measurements of the amount of power at frequencies other than the fundamental frequencies supplied to a transmitting antenna or to a dummy load are useful in the analysis of transmitter performance with reference to purity of emissions under specific conditions, and that such measurements will encourage the use of certain means of reducing spurious radiation;

(d) that the relation between the harmonic power supplied to a transmitting antenna and the field-strength of the corresponding signals at locations away from the transmitter may differ greatly due to such factors as the horizontal and vertical antenna directivity at the unwanted frequencies, propagation over various paths and radiation from parts of the transmitting apparatus other than the antenna proper;

(e) that field-strength measurements of spurious radiation at locations distant from the transmitter are recognised as the direct means of expressing the intensities of interfering signals due to such radiation;

(f) that in dealing with emissions on the fundamental frequency, administrations customarily establish the power supplied to the antenna, and measure the field-strength at a distance to aid in determining when an emission is causing interference with another authorised emission; that a similar procedure would be helpful in dealing with spurious radiation (See Article 13, No. 376, of the Radio Regulations);

RECOMMENDS

1. Terminology and definitions

that the following terms and definitions be used to designate what is regarded as spurious radiation:

1.1 *Spurious radiation*

radiation on a frequency or frequencies which are outside the band occupied by an emission, and the level of which may be reduced without affecting the corresponding transmission of information;

1.2 *Harmonic radiation*

spurious radiation on frequencies which are whole multiples of those comprised in the band occupied;

1.3 *Intermodulation products outside the occupied band*

(a) spurious radiation at frequencies resulting from intermodulation between the fundamental frequency or the harmonic frequencies of an emission and the fundamental frequencies or the harmonic frequencies of one or several other emissions originating from the same or different stations;

(b) spurious radiation at frequencies resulting from intermodulation between several frequencies appearing in the course of generation of the fundamental frequency of one or several emissions, which is not covered by the definition in paragraph *a)* above;

1.4 *Parasitic radiation*

spurious radiation at frequencies which are not in harmonic relation with the fundamental frequency and are not intermodulation products;

2. Application of tolerances

2.1. that the tolerances for spurious radiations continue to be expressed by the power supplied to the antenna at the frequencies of the spurious radiation considered;

2.2. that in the event of the standards of performance in paragraph 3 below being adopted by an Administrative Radio Conference as revised tolerances for Appendix 4 of Radio Regulations a period of three years from the coming into force of the revised Regulations might be necessary to enable all Administrations to achieve these standards for new transmitters and a period of five years for all transmitters;

3. Tolerances for the intensity of spurious radiation

3.1 the following tolerances are realisable on new transmitters with a fundamental frequency between 10 kc/s and 30 Mc/s:

3.1.1 for any spurious radiation the mid-frequency of which lies between 10 kc/s and 60 Mc/s, the mean power supplied to the antenna should be at least 40 db below the power of the fundamental without exceeding the value of 200 mW and without the necessity of reducing this value below 10 mW;

3.1.2 for any spurious radiation, the mid-frequency of which is above 60 Mc/s the figure of 200 mW is replaced by 25 mW, with a possible exception in the case of mobile transmitters;

3.2 for transmitters, the fundamental frequency of which lies between 30 Mc/s and 235 Mc/s, the question remains for study;

4. Methods of measurement of spurious radiation

4.1 *Measurement of power radiated*

that, together with other known methods of measuring the power of spurious radiation, either the substitution method, or a direct power measuring method, (see Report No. 17, London, 1953) should be used, when the transmitter is operated under normal conditions and when connected to its normal antenna or to a dummy load;

4.2 *The substitution method*

that in the substitution method an auxiliary generator of which the output power can be varied is employed and its frequency is adjusted to be equal to the mean frequency of the spurious radiation in question. This auxiliary generator is used as follows:

the generator is substituted for the radio transmitter and is adjusted in power output and internal impedance until it produces the same field on the spurious radiation frequency as was produced by the radio transmitter, both as to intensity and polarisation. This field is measured by means of a radio receiver tuned to the spurious radiation and located at a distance of several wavelengths from the transmitting antenna. When a dummy load is used, an indicator coupled to the load is required. Under these conditions, the power delivered by the generator is equal to that which was originally delivered by the transmitter in question. In order to obtain the same conditions with the generator, account must be taken of any stray coupling from the original transmitter to the radiating system and of any direct radiation from the transmitter or from feeder lines or other apparatus that may become excited by direct coupling. It is also necessary to take into account the possibility of the power at a spurious radiation being supplied in a push-pull or push-push mode or combination of both. More than one generator may be necessary when the method of excitation is complex. It is further necessary to establish the impedance of the feeder input circuit at the spurious radiation frequency so that the power will not be inaccurately measured. It is advisable that several sets of measurements be made when using different receiver locations;

5. Field-strength measurements

that field-strength measurements of spurious radiation at locations distant from the transmitter should be the direct means of expressing the intensity of this interfering signal;

6. Radiation from parts of the transmitting systems other than the antenna

that the power of spurious radiation from any part of the system other than from the antenna should not have an effect greater than that due to the maximum power specified for the radiation of spurious frequencies from the antenna;

7. Further improvements

that administrations and private operating agencies should continue to improve the degree of suppression of spurious radiation where this is economically possible in order to reduce interference to other services to a greater extent than that provided for in the Table of Tolerances in App. 4 of the Radio Regulations, by, for example:

— the use of low-pass or other output filters;
— suitable coupling circuits;
— screening of various stages in transmitters, filters and other parts of the equipment, which otherwise might emit spurious radiations directly or by coupling.

RECOMMENDATION No. 148 *

FREQUENCY STABILISATION OF TRANSMITTERS

(Study Programme No. 3 (I))

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that in certain frequency bands a large number of transmitters at present in use are more stable than is required by App. 3 of the Radio Regulations, Atlantic City, 1947;

(b) that it seems possible and desirable that new transmitters for these frequency bands should comply with more stringent tolerances;

(c) that the additional cost of ensuring that these new transmitters comply with the new tolerances is small compared with the total cost and operating expenses of the equipment;

RECOMMENDS

1. that the following standards of performance are realisable on new transmitters and could be considered at the next Administrative Radio Conference in any revision of App. 3 of the Radio Regulations, Atlantic City, 1947; where specific changes are not made in paragraphs 1.1, 1.2, 1.3, 1.4 and 1.5 below, it is recommended that the tolerances of App. 3 of the Radio Regulations, Atlantic City, 1947, should be retained:

1.1 *in frequency band B* (535 kc/s-1605 kc/s), the tolerance should be 10 c/s;

1.2 *in band D* (4000 kc/s-30 000 kc/s):

1.2.1 for fixed stations with powers greater than 500 Watts the tolerance should be 0.0015%;

1.2.2 for fixed stations with powers of 500 Watts or less the tolerance should be 0.005%;

1.2.3 for coastal and aeronautical stations with powers greater than 500 Watts but not exceeding 5 kW the tolerance should be 0.005%;

1.2.4 for coastal and aeronautical stations with powers greater than 5 kW the tolerance should be 0.0015%;

1.2.5 for broadcasting stations the tolerance should be 0.0015%;

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* This Recommendation replaces Recommendation No. 90. The Republic of India reserved its opinion on this Recommendation.

1.3 *In band E* (30 Mc/s-100 Mc/s):

1.3.1 for fixed stations with powers of 200 Watts or less the tolerance should be 0.02%;

1.3.2 for fixed stations with powers greater than 200 Watts the tolerance should be 0.003%;

1.3.3 for television broadcasting stations including sound and vision transmitters the tolerance should be 1000 c/s;

1.3.4 for broadcasting stations other than television the tolerance should be 0.002%;

1.3.5 for wide-band radio relay systems the tolerance should be 0.02 %;

1.3.6 for land and mobile stations with powers of 5 Watts or less the tolerance should be 0.005%;

1.3.7 for land and mobile stations with powers greater than 5 Watts the tolerance should be 0.002%;

1.4 *In band F* (100 Mc/s-500 Mc/s):

1.4.1 for mobile ship stations the tolerance should be 0.002% on the frequency of 156.8 Mc/s and neighbouring frequencies, and 0.005% in other parts of this band;

1.4.2 for land and mobile stations (ship stations excluded) the tolerance should be 0.002%;

1.4.3 for wide-band radio relay systems the tolerance should be 0.01%;

1.4.4 for television broadcasting stations including sound and vision transmitters the tolerance should be 1000 c/s;

1.4.5 for broadcasting stations other than television the tolerance should be 0.002%;

1.5 *In band G* (500 Mc/s-10 500 Mc/s):

for wide-band radio relay systems the tolerance should be 0.05% for the next few years and 0.03% thereafter;

2. that the above tolerances are applicable to those stations which might cause international interference or which are used in international services;

3. that in the event of the above standards of performance being adopted by an Administrative Radio Conference, as revised tolerances for App. 3 of the Radio Regulations, Atlantic City, 1947, a period of three years from the coming into force of the revised Regulations might be necessary to enable all administrations to achieve these standards for new transmitters and five years for all transmitters. Nevertheless, in order to facilitate international interconnection of wide-band radio relay systems, administrations and private operating agencies are recommended to apply the tolerances laid down in paragraphs b, 1.3.5, 1.4.3 and 1.5 without waiting for the adoption of these figures by an Administrative Radio Conference.

RECOMMENDATION No. 149 *

ARRANGEMENT OF CHANNELS IN MULTI-CHANNEL RADIOTELEPHONE TRANSMITTERS FOR LONG-RANGE CIRCUITS OPERATING ON FREQUENCIES BELOW ABOUT 30 Mc/s

(Question No. 46)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the lack of uniformity in the arrangement and designation of the channels in multi-channel transmitters for long-range circuits operating on frequencies below about 30 Mc/s may give rise to certain difficulties when one transmitting station has to work with several receiving stations;

(b) that, since it is necessary to economise in the use of the radio spectrum when considering inter-continental circuits consisting mainly of single long-distance radio links operating on frequencies less than 30 Mc/s, it is desirable:

— to use independent-sideband transmissions to the maximum extent possible;
— to transmit a band less than the 300 to 3400 c/s recommended by the C.C.I.F. for land-line circuits;
— to reduce the upper frequency to 3000 c/s below but to not less than 2600 c/s, except in special circumstances;

(c) that there are already in operation international multichannel radiotelephone circuits in which the bandwidth allocated to each channel is 3000 c/s actually transmitting a speech band of 250 to 3000 c/s;

(d) that, in general, the outer channels are liable to cause and receive more interference to and from stations operating on adjacent assigned frequencies; the outer channels being those located furthest from the assigned frequency;

(e) that there are numerous transmitters in service which, when operated on a twin-channel basis, give rise to excessive cross-talk unless one of the channels is placed away from the carrier;

(f) that there are transmitters in service which permit the addition of a third channel when it is desired to provide additional traffic capacity;

UNANIMOUSLY RECOMMENDS

1. that standard channel arrangements should be adopted for multi-channel radiotelephone systems;

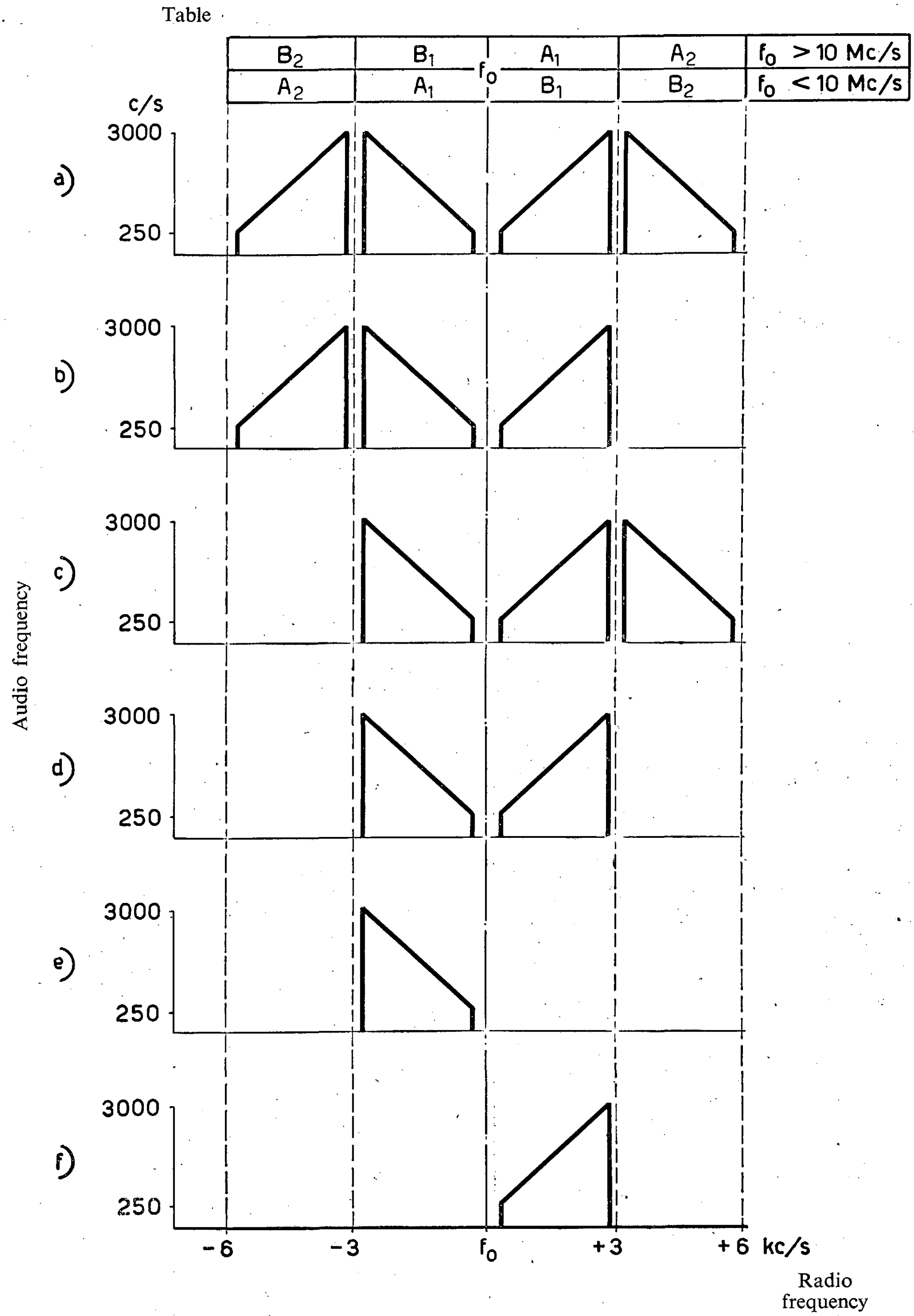
2. that the effective speech channel allocation should be 3000 c/s;

3. that the transmitted band in each speech channel should be from 250 to 3000 c/s;

4. that in four-channel systems the channel arrangement should be as shown in Fig. 1 *a)*;

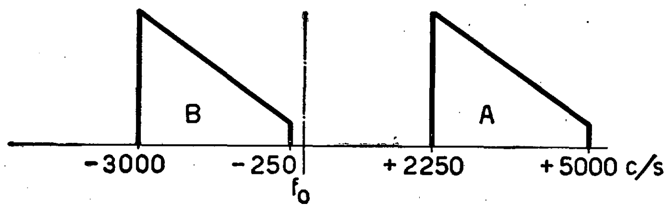
5. that in four-channel systems the channel designation should be as shown in the upper part of the Table when the reference frequency f_o corresponding to the reduced carrier is above 10 Mc/s and in the lower part when below 10 Mc/s. The same table shall be used when less than four channels are employed;

* This Recommendation replaces Recommendation No. 91.

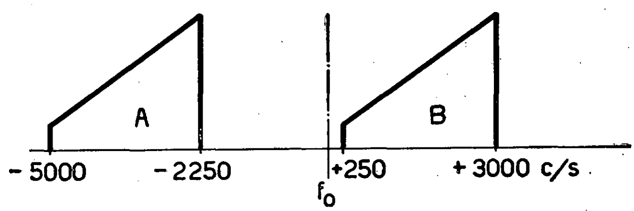


These figures represent the relationship between the audio frequencies and the radio frequencies for the various channel arrangements

FIGURE 1

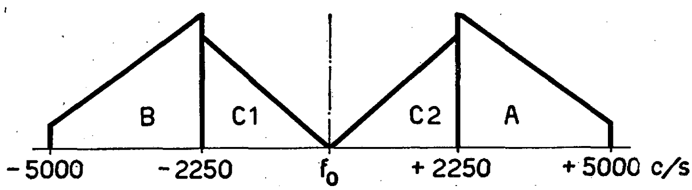


Reference frequency above 10 Mc/s

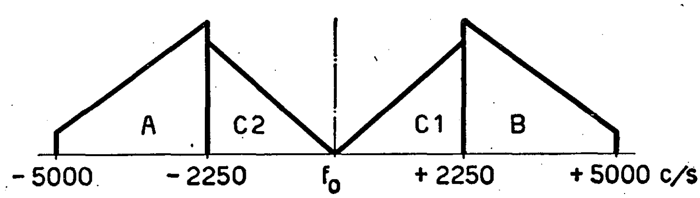


Reference frequency below 10 Mc/s

FIGURE 2



Reference frequency above 10 Mc/s



Reference frequency below 10 Mc/s

It is necessary that the subdivision of channel C into two parts C1 and C2 as well as the arrangement of these parts should be agreed upon by operating organisations.

FIGURE 3

6. that when less than four channels are used the channels nearest to the carrier should be selected according to the arrangements shown in Figs. 1 *b), c), d), e)* or *f)*;

7. that with some transmitters in service, which do not give satisfactory operation with the arrangement shown in Fig. 1 *d)*, a channelling arrangement such as that shown in Fig. 2 may be used to minimise cross-talk;

8. that with some transmitters in service, which do not give satisfactory operation with the arrangement shown in Figs. 1 *b)* or 1 *c)*, a third channel may be provided as shown in Fig. 3;

9. that when it is desirable to standardise the arrangements of radiotelegraph channels a new question should be raised.

RECOMMENDATION No. 150 *

FREQUENCY-SHIFT KEYING

(Question No. 20 (I))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that frequency-shift keying is employed in radio telegraphy in the fixed service and that its use may be extended to the mobile service;

(b) that it is desirable to adapt the frequency shift used to the telegraph speed;

(c) that traffic interruptions should be reduced to a minimum by avoiding frequent changes of the shift employed;

(d) that it is often necessary to employ the same radio transmitter to work with more than one receiving station;

(e) that it is desirable to standardise the main operating characteristics of systems employing frequency-shift keying;

(f) that various technical factors influence the choice of operating characteristics in such systems, in particular:
- — the economy of bandwidth and the consequent need to control the shape of the transmitted signals;
- — the signal distortion due to propagation conditions;
- — the instability of the characteristics of certain transmitter and receiver elements (such as oscillators, filters or discriminators); this instability being one of the reasons for the relatively large shift employed in many existing equipments;

(g) that difficulties can arise from the use of terms " mark " and " space " and also that the C.C.I.T., at its VIIth Plenary Assembly, issued Recommendation No. I.4 introducing new terms;

UNANIMOUSLY RECOMMENDS

1. that it is too early to standardise the actual values of frequency shift but that every effort should be made to achieve this as quickly as possible for emissions using only two frequencies, one for mark and one for space; that to assist in this, the characteristics shown below should be used as far as possible;

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* This Recommendation replaces Recommendation No. 92.

2. that the value of the frequency shift employed should be the lowest compatible with the maximum telegraph speed regularly used, the propagation conditions and the equipment stability;

3. that for frequency-shift systems working on two conditions only (i.e. single-channel and time-division multiplex systems) and operating between about 3 Mc/s and 30 Mc/s the preferred values of frequency shift are 200 c/s, 400 c/s and 500 c/s. *

4. that the values 140 c/s, 280 c/s and 560 c/s may be used provisionally but 560 c/s should not be adopted for new systems.

5. that the value of the frequency shift should, if possible, be maintained within ±3% of its nominal value and, in any case, within ±10%;

6. that for circuits employing the Morse code the marking frequency should be the higher frequency and the spacing frequency the lower frequency.

Note : For teleprinter circuits or those employing methods of multiplexing such as those described in Document No. 359 of Warsaw, it is left to the using organisations, while awaiting the results of further study, to agree among themselves on the significance of the emitted frequencies.

RECOMMENDATION No. 151 **

TELEGRAPHIC DISTORTION

(Question No. 18 (I))

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

that a partial answer to Question No. 18 (I) of the C.C.I.R. is contained in Recommendation B.1 of the C.C.I.T.;

UNANIMOUSLY RECOMMENDS

1. that Recommendation No. B. 1 revised, proposed by the C.C.I.T. and notified to the VIIIth Plenary Assembly of the C.C.I.R. in Document No. 309 (Warsaw, 1956) should be adopted by the C.C.I.R.

2. that the studies of Question No. 18 (I) should be continued.

Note : The VIIIth Plenary Assembly of the C.C.I.T. decided to incorporate the definitions of their Recommendation B.1 in the *Draft list of essential telegraph terms* (July, 1955) and in its *Annex*. ***

* For long-distance communication see Question No. 139 (VI).

** This Recommendation replaces Recommendation No. 93.

*** The draft list contains all the terms in Recommendation B.1 whose definitions have not been modified. The annex contains the definitions of the terms in the draft list which were modified by the VIIIth Plenary Assembly of the C.C.I.T., together with any new definitions introduced by the Plenary Assembly.

RECOMMENDATION No. 152

FOUR-FREQUENCY DIPLEX SYSTEMS

(Question No. 20 (I))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that there are in use in the fixed radiotelegraph services operating between 2 Mc/s and 27 Mc/s, four-frequency diplex (or twinplex) systems in which each of four frequencies is used to transmit one of the four possible combinations of mark and space signals corresponding to two telegraph channels; it being understood that either or both of the two telegraph channels may be sub-channelled by time-division methods and that the use of such systems may be extended;

(b) that it is desirable to standardise the main characteristics of four-frequency diplex systems;

(c) that it may sometimes be necessary to employ the same radio transmitter to work with more than one receiving station;

(d) that circuit interruptions should be reduced to a minimum by avoiding frequent changes of the spacing between adjacent frequencies and of the coding employed;

(e) that various technical factors influence the choice of operating characteristics in such systems, in particular:

— the economy of bandwidth and the consequent need to control the shape of the transmitted signals;

— a relatively wide spacing between adjacent frequencies may be necessary for high telegraph speeds;

— the signal distortion due to propagation conditions;

— the instability of the characteristics of certain receiver and transmitter elements such as oscillators, filters, or discriminators;

(f) that many existing four-frequency diplex systems each use one of four values of spacing between adjacent frequencies with corresponding telegraph speeds;

UNANIMOUSLY RECOMMENDS

1. that the following preferred values shall be adopted for the spacing between adjacent frequencies:

Spacing between adjacent frequencies (c/s)	Nominal telegraph speed of each channel (bauds)
1000	over 300
500 *	200 to 300
400 *	100 to 200
200 or 250	below 100

* lower telegraph speeds may be used with both these spacings at present.

2. that the value of the frequency separation between adjacent frequencies employed should be the lowest of the preferred values compatible with the maximum telegraph speeds regularly used, the propagation conditions and the equipment stability;

3. that in cases where the two channels are not synchronised it is desirable to limit the maximum rate of change of frequency in order to minimise the bandwidth of the emission;

4. that in order to designate this type of emission, the classification F6 shall be used. (Radio Regulations, Atlantic City, 1947, Chap. 2, Art. 2, Section 1, refers).

RECOMMENDATION No. 153

ARRANGEMENT OF CHANNELS IN MULTI-CHANNEL RADIOTELEGRAPH SYSTEMS FOR LONG-RANGE CIRCUITS OPERATING ON FREQUENCIES BELOW ABOUT 30 Mc/s

(Question No. 74 (I))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the lack of uniformity in the arrangement and designation of the channels in multi-channel radiotelegraph systems for long-range circuits operating on frequencies below about 30 Mc/s may give rise to certain difficulties when one transmitting station has to work with several receiving stations;

(b) that the increasing use of multi-channel telegraph systems makes it desirable to adopt a uniform designation of channels in such systems:

UNANIMOUSLY RECOMMENDS

1. that the groups of systems should be designated by letters, as follows:

time-division multiplex	cap. letter T
frequency-division multiplex with constant arrangement of significant conditions	cap. letter U
frequency-division multiplex with variable arrangement of significant conditions	cap. letter V
combination of multiplex processes	combination of the above mentioned letters.

2. when a multi-channel telegraph signal is applied to a multi-channel telephone transmitter the designation of the telephone channel should come first in the sequence and should be in accordance with Recommendation No. 149;

3. that in time-division systems the telegraph channels should be designated by capital letters A, B, C, D, etc.; in the case of subdivision, the subchannels should be designated by A1, A2, A3, A4, B1, B2, B3, B4, etc.;

4. that in frequency-division systems the telegraph channels should be designated by figures;

5. that in a combination of multi-channel processes the telegraph channels should be designated by a letter and figure sequence.

For example :

When using a frequency-division system with constant frequency arrangement of significant conditions, indicated by letter U, and modulating the 3rd channel of this latter system with a time-division multiplex (letter T), channel B of this latter system would be indicated by

" U3TB ".

In the case where channel B of the time-division system is subdivided and sub-channel 2 is in use, the designation would be

" U3TB2 ".

If the above mentioned system is applied to channel B of an independent-sideband telephone transmitter with reduced carrier, the designations would be

" BU3TB or BU3TB2 ".

RECOMMENDATION No. 154 *

NOISE AND SENSITIVITY OF RECEIVERS

(Geneva, 1951 — London, 1953 — Warsaw, 1956)

The C.C.I.R.,

CONSIDERING

(a) that the sensitivity of a receiver is a measure of its ability to receive weak signals and reproduce them with usable strength and acceptable quality ;

(b) that the following parameters, which are determined by the particular service for which the receiver is used, are of special importance in relation to the sensitivity:
- necessary output level,
- necessary overall signal band,
- necessary signal-to-noise ratio at the output;

(c) that the following parameters relating to the internal noise of the receiver, which are determined by the receiver design, are also of importance in relation to the sensitivity of the receiver:
- the level of the internal noise, as defined e.g. by the noise factor,
- the width of the effective overall noise band, which is not necessarily identical with the width of the signal band **;

(d) that, in many cases, in order to economise in transmitted power, it is desirable that the sensitivity shall be as great as economic and technical considerations permit and is justified by the external noise level;

(e) that the conditions for obtaining a high sensitivity may conflict with those for obtaining good protection against interfering signals **;

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* This Recommendation replaces Recommendation No. 94. The Republic of India reserved its opinion on this Recommendation.

** See Recommendation No. 155.

(f) that Question No. 123 (II) asks for data on noise factor and sensitivity for the various types of receivers used for the reception of different classes of emission in the different services;

(g) that for the purpose of presenting, comparing, and using data on the sensitivity of receivers, it is desirable to define the following terms:

— maximum usable (noise-limited) sensitivity;
— maximum usable (gain-limited) sensitivity;
— reference sensitivity;
— noise factor;

(h) that values for noise factor are often particularly useful since they are more uniform than values of maximum usable sensitivity for the various types of receivers used for the reception of different classes of emission in the different services, and indicate the degree of improvement in maximum usable sensitivity which is theoretically possible, other factors remaining unchanged;

(i) that the noise factor is useful only for a linear receiver or for the linear part of the receiver, since for a non-linear receiver the noise factor is dependent on the signal input level;

(j) that the reference sensitivity is chiefly of value in comparing linear receivers;

(k) that it is desirable to define a "linear" receiver;

(l) that in the case of radiotelegraphy receivers:

— a non-linear relation between the input signal level and the output signal level, due, for example, to the use of a non-linear detector or discriminator or a telegraph shaping circuit, changes the effect of noise from an amplitude variation into a variation of the duration of the telegraph signal elements at the output of the receiver (signal distortion);
— in addition the effect of noise may cause mutilation of the signals by splits or extras;
— the foregoing considerations make it desirable to define, in addition to the terms contained in *(g)*, receiver sensitivity in connection with signal distortion;

(m) that in the case of sound broadcast and television receivers, it is desirable to define sensitivity not only for a reasonably good output signal, but also for any usable output signal;

RECOMMENDS

1. that a *linear* receiver should be defined as one operating in such a manner that the signal-to-noise ratio at the output is proportional to the signal level at the input, and to the degree of modulation;

2. that the *noise factor* should be defined as follows: the noise factor is the ratio of noise power measured at the output of the receiver to the noise power which would be present at the output if the thermal noise due to the resistive component of the source impedance were the only source of noise in the system;

3. that the width of the *effective overall noise band* should be defined as the width of a rectangular frequency response curve having a height equal to the maximum height of the receiver frequency response curve and corresponding to the same total noise power *;

4. that the *maximum usable sensitivity* should be defined as the minimum input signal (expressed as the e.m.f. of the unmodulated carrier) which must be applied in series with the specified source impedance (dummy antenna) to the input of the receiver in order to obtain at the output the signal level and the signal-to-noise ratio necessary for normal operation when the normal degree of modulation ** is applied to the carrier;

* See Doc. No. 3 (Geneva, 1951).
** A1 class of modulation is considered as 100% modulated.

5. that the maximum usable sensitivity as defined above should be described as " noise limited ", and that if the gain is insufficient, the maximum usable sensitivity should be described as " gain limited "; in the latter case the sensitivity is measured as the minimum input required to obtain the same signal level, the gain being adjusted to a maximum value without regard to the output noise level;

6. that, for the purpose of presenting and comparing data for particular classes of receivers and classes of emission for the different services (normally to be noise-limited cases), and for a particular frequency range, the *reference sensitivity* should be defined as the maximum usable sensitivity for specified values of:

— signal-to-noise ratio,
— receiver bandwidth,
— degree of modulation,
— source impedance (dummy antenna).

Within the linear range the maximum usable sensitivity for any of these conditions should be derived from the reference sensitivity (the noise factor being considered as constant), and vice versa (see Ann. II);

7. that in case of uncertainty with regard to terms of the formulae relating noise factor and reference sensitivity (see Ann. II) e.g. the effective overall noise band, independently measured values for these two quantities should be given;

8. that values for the maximum usable sensitivity and for the reference sensitivity should be considered in connection with the values for the one-signal and two-signal selectivity *;

9. that, since the reference sensitivity is of particular value for a receiver working in a linear condition, for the markedly non-linear condition only the maximum usable sensitivity and the noise factor for the normal operational condition should be given;

10. that, in the case of telegraphy receivers:

10.1 a *maximum usable sensitivity* should be defined as the minimum input signal (expressed as the e.m.f. of the unmodulated carrier) which must be applied, in series with the specified source impedance (dummy antenna), to the input of the receiver in order to obtain at the output the desired signal level and the amount of signal distortion or mutilation permissible in normal operation; the maximum usable sensitivity as defined above should be described as " distortion limited ";

10.2 defined methods for measuring signal distortion and mutilation should be used **;

10.3 *** for the purpose of comparing and presenting data a *reference sensitivity* for signal distortion and mutilation should be defined as the maximum usable sensitivity for specified values of:

— the amount of signal distortion or mutilation with a specified probability of occurrence,
— the receiver bandwidth,
— the frequency shift in the case of Fl transmissions,
— the source impedance (dummy antenna);

11. that in the case of sound broadcast and television receivers:

11.1 a *maximum sensitivity* should be defined as the minimum input signal applied, in series with the specified source impedance (dummy antenna), to the input of the receiver for which any usable signal with a specified output level can be obtained;

11.2 measurements of sensitivity be made in conformity with Recommendations Nos. 157 and 158;

12. that, since measured characteristics vary widely from one receiver to another, measurements should be made as far as possible on several receivers of the same type, and the values given

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* See Recommendation No. 155
** See Doc. No. 227 (Warsaw).
*** See Annex II, para. 5.

for the type of receiver under consideration should be stated statistically (mean value, standard deviation);

13. that, when a psophometric weighting network is used for sensitivity measurements, this fact should be stated and the response curve given.

Note. — The Annexes give for reference purposes the noise and sensitivity values obtained for several types of receiver in current use in certain countries, based on data and information given in Recommendation No. 94 and Docs. Nos 7, 161, 199, 215, 317 and 398 of Warsaw. The data were collected as part of the studies required by Question No. 76.

ANNEX I

Classification scheme for receivers

	Frequency sub-divisions
1. *Telegraphy* A1, A2, F1 — Fixed service; General purpose; Mobile service	30 - 600 kc/s 1 600 - 30 000 kc/s 30 - 300 Mc/s
2. *Telephony* A3 — Fixed service; General purpose; Mobile service A3b — Fixed service F3 — Fixed service; General purpose; Mobile service	30 - 600 kc/s 1 600 - 30 000 kc/s 30 - 300 Mc/s
3. *Sound broadcasting* A3 F3	150 - 300 kc/s 500 - 1 600 kc/s 1 600 - 30 000 kc/s 30 - 100 Mc/s 100 - 300 Mc/s 300 - 1 000 Mc/s
4. *Television* A5 — Vision A3, F3 — Sound	30 - 100 Mc/s 100 - 300 Mc/s 300 - 1 000 Mc/s

ANNEX II

Formulae relating noise factor and sensitivity of linear receivers

(See § 2 and 3 of this Recommendation)

1. *A1, A2, A3 emissions (amplitude modulation).*

$$E^2 = 8kT \frac{BRn}{m^2} F \times 10^{12} \qquad (1)^*$$

where:

E = e.m.f. of the carrier in series with the equivalent series resistance of the source, measured in microvolts;

* See Recommendation No. 41.

F = noise factor (power ratio);

R = source (dummy antenna) equivalent resistance in ohms;

n = signal-to-noise power ratio at the output;

m = degree of modulation (modulation considered sinusoidal). For Al class of emission, take m = 1;

k = Boltzmann constant = 1.37×10^{-23} Joules/degree K;

T = absolute temperature in degrees K (T is commonly taken as 293° K, then $kT \approx 400 \times 10^{-23}$ Joules);

B = width of the effective overall noise band in c/s, taken as the smaller of the two following quantities:

(a) the post-detection bandwidth;

(b) *half* the predetection bandwidth *.

2. *A 3 b emissions (single-sideband amplitude-modulation).*

$$E^2 = 4kTBR\ n\ F \times 10^{12} \qquad (2)\ **$$

where

E = e.m.f. of the sideband component in series with the equivalent series resistance of the source, measured in microvolts

F, R, n, k and T as described in para. 1;

B = width of the effective overall noise band in c/s taken as the smaller of the two following quantities:

(a) the post-detection bandwidth;

(b) the *full predetection bandwidth* *

3. *F_1, F_3 emissions (frequency-modulation)*

$$E^2 = 8kT \frac{BRn}{q^2} F \times 10^{12} \qquad (3)\ ***$$

where:

$$q^2 = \frac{3}{4} \frac{D^2}{B^2}$$

E, F, R, n, k and T as described in para. 1;

D = frequency shift in telegraphy or peak-to-peak value of the frequency deviations in telephony (modulation considered sinusoidal);

B = width of the effective overall post-detection noise band *

Note. — Formula (3) is applicable only in case of a receiver of perfect design and working under idealised conditions, that is with:

(a) linear operation :

the carrier in the limiter being at such a level with regard to the noise that linear operation is ensured and the discriminator being linear,

* In some cases, it may be sufficient to approximate the bandwidth by taking limiting responses 6 db below the maximum response; if a more accurate measurement of bandwidth is required, the width of the effective overall noise band may be determined in each case, as explained in para. 3 of this Recommendation.

** See Recommendation No. 94.

*** See Docs. Nos. 121 and 235 (London).

(b) *a perfect limiter* (removing all spurious amplitude modulation),

(c) *the receiver noise* mainly produced in the early stages of the receiver.

Also—that uncertainty with regard to B (the width of the effective overall noise band) entering to the third power into formula (3) may to a large extent affect calculations.

The usefulness of formula (3) in particular for calculating the noise factor from the measured reference sensitivity and vice versa seems to be greatly reduced (see § 9 of this Recommendation and § 4 of this Annex) *

4. *Reference sensitivity* (see § 5 of this Recommendation).
The reference sensitivity may be calculated from the noise factor (see Ann. III) by means of formulae (1) to (3) above or the simplified formula (4) give below:

$$E^2 = C \times F \qquad (4)$$

Typical reference values for B, R, n, m and D are given in the following table, together with the corresponding values of the multiplying factor C used in formula (4). For ease of computation the values of C given in the table are in decibels.
While formulae (1) to (4) can also be used to calculate the noise factor from the measured sensitivity, this procedure must be employed with caution because possible uncertainties in the various parameters (e.g., the effective overall noise band) may lead to less precise values for F than can be obtained by direct measurement (see § 1.2. Ann. IV).

5. *Measurement of reference sensitivity of telegraphy receivers in case of signal distortion or mutilation.*
The reference values for B and R are contained in Table I, the shift in case of F_1 should be taken as 400 c/s,
the input signal should be modulated by a square wave at 50 bauds with the amount of distortion or mutilation produced in the receiver taken as the greater of the values corresponding to:

— 20% distortion with a probability of 1 in 1000;

— one split or extra in 10^3 elements **

Note.—An indication of the critical input level for " distortion limiter " sensitivity in the case of an input signal of the printer type can be obtained by reducing the input level and observing the appearance of wrong letters in the reproduced text. ***

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* See Doc. No. 199 (Warsaw).
** See Doc. No. 227 (Warsaw).
*** See Doc. No. 2 (Warsaw).

TABLE I

Typical reference values for parameters used in calculating and measuring reference sensitivity

Class of emission	Service	Effective overall noise band c/s	Source resistance (ohms)	Output-signal-to-noise power ratio (db)	Degree of modulation	Frequency shift (for F_1) peak deviation (for F_3) c/s	10 log C
A1	Fixed	100	75	20	1	—	—16.2
		300	75	20	1	—	—11.4
	General purpose	1000	75	20	1	—	— 6.2
	Mobile	1000	75	20	1	—	— 6.2
A2	Fixed	100	75	20	0.3	—	—5.7(²)—16.2(³)
		300	75	20	0.3	—	—0.9 —11.4
	General purpose	1000	75	20	0.3	—	+4.3 — 6.2
	Mobile	1000	75	20	0.3	—	+4.3 — 6.2
A3	Fixed General purpose Mobile	3000	75	20	0.3	—	+ 9.1
	Sound-broadcast (MF), domestic use	5000	dummy antenna (¹)	20	0.3	—	—
	Sound-broadcast (HF) — domestic use	5000	dummy antenna (¹)	20	0.3	—	+18.3
	Sound-broadcast (HF) — professional use	5000	75	20	0.3	—	+11.1
A3b	Fixed	3000	75	20	—	—	— 4.4
F1	Fixed	100	75	20	—	100	—15.0
		100	75	20	—	400	—27.0
		300	75	20	—	100	— 0.7
		300	75	20	—	400	—12.7
F3	Fixed General purpose Mobile	3000	75	20	—	±4500 (⁴)	— 9.7
	Sound broadcast	5000	75	20	—	±22500 (⁴)	—17.0

(¹) The values of the elements of the dummy antenna are shown in Fig. 1.

(²) Without IF oscillator.

(³) With IF oscillator.

(⁴) 30% of reference peak deviation
— telephony 15 kc/s.
— sound broadcasting 75 kc/s.

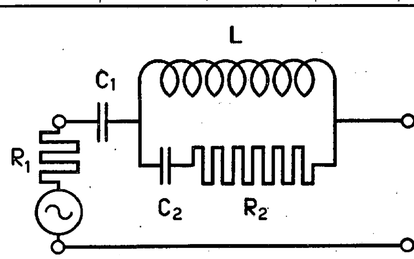

Figure 1

Dummy antenna
C_1 = 125 pF
C_2 = 400 pF
L = 20 μH
R_1 = 80 Ω
R_2 = 320 Ω
Q_L > 15 (at 1 Mc/s)

ANNEX III

General considerations relating to the noise factor of receivers

In a well designed receiver, noise originating in the receiver is mainly due to the random voltages (thermal and shot-noise) generated in the early stages of the receiver, including that portion of the aerial circuit contained within the receiver.

Representative values of noise factor for good modern receivers, which are especially designed to have low noise factors, are given below:

Table II

Frequency Mc/s	Noise Factor	
	Power Ratio	Decibels
up to 100	2.5	4.0
200	3.5	5.4
500	5.5	7.4
1 000	8.0	9.0
2 000	11.2	10.5
5 000	18.0	12.5
10 000	25.0	14.0

When, however, either the external noise level or the input signal level is high, the receiver noise factor becomes less important. For this reason, some receivers (e.g., many broadcast receivers) are not designed to have the best possible values of reference sensitivity or of noise factor (see § 4 of this Recommendation).

The measurement of noise factor is generally best carried out by means of the noise-generator method (particularly for frequencies above 30 Mc/s) (see Doc. No. 117, London).

When the receiver contains a non-linear element (e.g., a detector, limiter or discriminator), it is desirable that overall measurements of noise factor be made under conditions of linear operation, such as may be obtained by simultaneously injecting a carrier at an appropriate level and frequency (see Docs. Nos. 197 and 235, London).

ANNEX IV

Representative values for the noise factor and reference sensitivity of receivers (excluding television receivers)

1. *Introduction.*

1.1 In the following tables an attempt has been made to present in a systematic way representative data for noise and sensitivity characteristics of the various classes of receivers. In order to facilitate the use of these data and at the same time to reduce the amount of data presented, in general only three figures (called for convenience " maximum ", " mean ", and " minimum " values) have been given for each characteristic for a number of similar receivers in each class. The terms *maximum, mean* and *minimum* refer to *values expressed in decibels* for sensitivity or noise factor according to the column. It is important to note therefore, that for a given case, the *maximum value* in the sensitivity column indicates a poorer *sensitivity* than that of the *minimum* value. For some medium-frequency sound broadcasting receivers, statistical values (mean value and standard deviation) are given.

1.2 It was found that the values for maximum usable sensitivity, reference sensitivity and noise factor, obtained from the different sources, were not always consistent with the formulae (1) to (4) in Ann. II. As the values for noise factor were considered more reliable in such cases, these were taken as the basic information, and the values for reference sensitivity given in the tables in Ann. IV were derived from those for the noise factor by the use of formula (4) in Ann. II.

2. *Notes on Tables III to V*

Column No.

(1), (2), (3) *Receivers* are tabulated in terms of the class of emission, service and frequency range, respectively.

(4) See § 1.1 of this Annex.

(5) *Reference sensitivity.* See § 5 and Ann. II, § 4 of this Recommendation; the values for the reference sensitivity given in the tables assume the reference values for overall noise-band, source resistance, output signal-to-noise ratio and degree of modulation (frequency-shift or deviation in frequency-modulation receivers), given in Table I of Ann. II.

(6) *Noise Factor.* See § 2 and Ann. II and III of this Recommendation.

(7) *Reference bandwidth.* See Ann. II, Table 1 of this Recommendation.

(8) *Remarks.* This column contains information on the number of receivers on which the representative values for noise and sensitivity are based and, when possible, some indication of the spread of the data.

TABLE III

Reference sensitivity and noise factor for radiotelegraphy receivers *

Class of emission	Service	Frequency range in kc/s		Reference sensitivity (db rel. to 1 μV)	Noise factor (db)	Reference bandwidth (c/s)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A1	Fixed	1 600-30 000	Max. Mean Min.	−6.2 −9.2 −14.2	10 7 2	100	Many receivers tested
	General purpose	1 600-30 000	Max. Mean Min.	+7.8 +2.8 −1.2	14 9 5	1000	Several receivers tested
	Mobile	1 600-30 000	Max. Mean Min.	+11.3 +5.8 +0.3	17.5 12 6.5	1000	Few receivers tested
F1	Fixed	1 600-30 000	Max. Mean Min.	−17 −20 −23	10 7 4	100	Reference frequency shift = 400 c/s Few receivers tested
	General purpose	1 600-30 000	Mean	−18	9	100	

* See Annex IV of Recommendation No. 94 (London) and Docs. Nos. 7 and 199 (Warsaw).

TABLE IV

Reference sensitivity and noise factor for radiotelephony receivers *

Class of emission	Service	Frequency range in Mc/s		Reference sensitivity (db rel. to 1 μV)	Noise factor (db)	Reference bandwidth (c/s)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A3	Fixed	1.6-30	Max. Mean Min.	+19.1 +16.1 +11.1	10 7 2	3000	Several receivers tested
	General purpose	1.6-30	Max. Mean Min.	+23.1 +17.1 +11.1	14 8 2	3000	Several receivers tested
	General purpose	30-300	Max. Mean Min.	+29.1 +18.6 +11.1	20 9.5 2	3000	Few receivers tested Frequency range=20-155 Mc/s
	Mobile	30-300	Max. Mean Min.	+22.6 +18.5 +15.1	13.5 9.4 6	3000	Several receivers tested
A3b	Fixed	1.6-30	Max. Mean Min.	+5.6 +2.6 −0.4	10 7 4	3000	Several receivers tested
F3	Fixed	30-300	Max. Mean Min.	+5.3 +1.3 −1.7	15 11 8	3000	Few receivers tested Frequency range=80-200 Mc/s
	General purpose	30-300	Max. Mean Min.	+2.3 −2.7 −7.7	12 7 2	3000	1 receiver tested Frequency range=19-165 Mc/s
	Mobile **	30-300	Max. Mean Min.	+7.3 +0.8 −3.7	17 10.5 6	3000	Many receivers tested Frequency range=60-200 Mc/s

* See Annex IV of Recommendation No. 94 (London) and Docs. Nos. 7, 161, 199, and 317 (Warsaw).
** See also Doc. No. 445 (Warsaw).

[redacted]

TABLE V

Reference sensitivity and noise factor for sound-broadcast receivers *

Class of emission	Service	Frequency range in kc/s		Reference sensitivity (rel. to 1 μV)	Noise factor (db)	Reference bandwidth (c/s)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A3	Sound-broadcasting	500- 1 600	Mean	+35.5	24	5000	Mass-production receivers ** Standard deviation = 3.5 db Source imp. = dummy antenna
		1 600- 30 000	Mean	+38.7	20.4	5000	Mass-production receivers ** Source imp. = dummy antenna (400 ohms)
		1 600- 30 000	Max.	+32.1	21	5000	Several receivers tested, one RF stage Source imp. = 75 ohms
			Mean	+25	13.9		
			Min.	+17.1	6		
		in Mc/s 30-300	Mean	+19.1	8	5000	
F3		30-300	Mean	+ 1.5	18.5	5000	Many receivers tested Standard deviation = 5.5 db ***

* See Annex IV of Recommendation No. 94 (London).
** See Doc. No. 398 (Warsaw).
*** See Docs. Nos. 7, 161, and 199 (Warsaw).

ANNEX V

REPRESENTATIVE VALUES FOR THE REFERENCE SENSITIVITY AND NOISE FACTOR OF TELEVISION RECEIVERS

1. *Introduction.*

1.1 The methods of test of television receivers have not, as yet, been fully standardised in the various countries and the data given in this Annex and the relevant documents must be regarded as tentative until such standardisation is more complete.*

1.2 The Tables given below contain representative values for the sensitivity of the vision and sound channels of typical television receivers, as required by Question No. 76.**
The data given in the Tables are deduced from information contained in Documents Nos. 116 and 118 (London) and Documents Nos. 199, 215 and 398 of Warsaw.

2. *Notes on Table VI* (405-line system)

Column No.

(1), (2), (3), (6) The significance of these columns is the same as in the case of the columns with corresponding titles in Ann. IV.

(4) In the case of the vision channel the reference sensitivity has been taken as the larger of the input signal levels required to produce at the output:

(a) a vision signal output level of 20 V (peak-to-peak, black-to-white picture signal), or

(b) a vision signal-to-noise ratio of 12 db (peak-to-peak values of vision signal and noise).

If the gain is insufficient to enable *(a)* and *(b)* to be simultaneously satisfied, the receiver is referred to as gain-limited; otherwise it is noise-limited.

TABLE VI

Reference sensitivity and noise factor for television receivers (405-line system)

Frequency range in Mc/s	Class of emission		Reference sensitivity (db rel. to 1 μV)			Noise factor (db)	Remarks
			Noise-limited	Gain-limited	All types		
(1)	(2)	(3)	(4)			(5)	(6)
30-100	A5 (vision)	Max.	56	57	57	14	9 receivers tested (7 noise-limited, 2 gain-limited); synchronisation satisfactory in all cases (405-line system)
		Mean	46	54	48	8	
		Min.	42	51	42	5	
	A3 (sound)	Max.	28	35	35	13	9 receivers tested (4 noise-limited, 5 gain-limited)
		Mean	22	27	25	9	
		Min.	18	20	18	6	

* See Recommendations Nos. 157 and 158.
** This Question has been replaced by Question No. 123 (II).

The sensitivity is stated as the r.m.s. value of the input carrier corresponding to peak white modulation (positive modulation system); for test purposes a carrier sinusoidally modulated to a depth of 50%, corresponding to a black to white picture signal in a system with 70/30 picture/synchronising-pulse amplitude ratio, is assumed.

The following reference values are also assumed:

Source resistance	75 ohms
Width of overall effective noise band	3 Mc/s

In the case of the sound channel the reference values for the output signal/noise ratio, the width of the overall effective noise band and the modulation of the test signal are the same as for sound broadcasting receivers (see Table 1, Ann. II).

3. *Notes on Tables VII and VIII* (625-line system).

Column No.

(1), (2), (3), (6) The significance of these columns is the same as in the columns with the corresponding titles in Annex IV.

(4), (5) In the case of the vision channel the sensitivity has been taken as the input signal required to produce at the output:

(a) a vision signal output level of 20V (peak-to-peak, black-to-white picture signal) (Table VII).
or standard image of maximum subjective brightness of white = 20 nits (6 ft. lamberts) and maximum contrast = 10 (Table VIII).

(b) a vision signal-to-noise ratio of appr. 20 db (peak-to-peak values of vision signal and noise), a 20 db signal-to-noise ratio being considered as a value for a good picture (noise just visible).

If the gain is insufficient to enable *(a)* and *(b)* to be simultaneously satisfied, the receiver is referred to as " gain-limited ", otherwise it is " noise-limited ".

If on the other hand, *(a)* being satisfied, *(b)* is the signal-to-noise ration for " any usable " picture, the sensitivity should be described as " maximum sensitivity ".*

The sensitivity is stated as the r.m.s. value of the input carrier, sinusoidally modulated to a depth of approx. 85%. The following reference values are assumed:

source impedance	75 ohms
width of the effective noise band	4.6 Mc/s for 625 lines

In the case of the sound channel the reference values for the output signal-to-noise ratio, the width of the effective overall noise band, the degree of modulation and, for frequency modulation, the deviation, are the same as for F_3 sound broadcast receivers. (See Table I, Annex II).

4. *Notes on Table IX* (819-line system)

Column. No.

(1), (2), (3), (7) The significance of these columns is the same as in the columns with the corresponding titles in Annex IV.

(4), (5), (6) See para. 3 of Annex V with:

(a) a vision signal output level of 33.3 V (peak-to-peak);

(b) a vision signal-to-noise ratio of 14 db (peak-to-peak values of signal and noise).

The sensitivity is stated as the r.m.s. value of the input carrier, square-modulated to a depth of 100% at 5000 c/s.

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* See § 11 of this Recommendation on page 123.

TABLE VII

*Reference sensitivity and noise factor for television receivers * (625-line system, 5 Mc/s video band)*

Frequency range Mc/s	Class of emission		Maximum usable sensitivity (noise limited)	Maximum sensitivity	Remarks
			db rel. to 1 μV		
(1)	(2)	(3)	(4)	(5)	(6)
61-68	A5 (vision)	mean	43	36	Mass production receivers
174-216			49	44	
61-68	F3 (sound)	mean	34.5		
174-216			40.5		

TABLE VIII

*Reference sensitivity and noise factor for television receivers ** (625-line system, 6 Mc/s video band)*

Frequency range Mc/s	Class of emission		Maximum usable sensitivity (noise limited)	Maximum usable sensitivity (gain limited)	Remarks
			db rel. to 1 μV		
(1)	(2)	(3)	(4)	(5)	(6)
41-68	A5 (vision)	mean	56	50	Few receivers tested. Receivers of different type and design

TABLE IX

Reference sensitivity and noise factor for television receivers (819-line system)

Frequency range Mc/s	Class of emission		Maximum usable sensitivity (noise limited)	Maximum usable sensitivity (gain limited)	Maximum sensitivity	Noise factor
			db rel. to 1 μV			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
162-216	A5 (vision)	mean	43	57	33	8

* Doc No. 398 (Warsaw).
** Doc. No. 215 (Warsaw).

RECOMMENDATION No. 155 *

SELECTIVITY OF RECEIVERS

The C.C.I.R., (London, 1953—Warsaw, 1956)

CONSIDERING

(a) that the selectivity of a receiver is a measure of its ability to discriminate between a desired signal to which the receiver is tuned and undesired signals;

(b) that economy in the use of the radio spectrum requires the maximum selectivity compatible with the technical and economic considerations relating to the particular class of receiver;

(c) that the single-signal selectivity method is used to express the performance of certain characteristics of the receiver. The measurements are made with sufficiently low levels of input to avoid non-linearity (e.g. overloading) affecting the results; automatic gain control, automatic frequency control, etc., being rendered inoperative;

(d) that the two-signal selectivity method should be the general method for measuring the selectivity. Sometimes the non-linear effects are numerous, then it will be necessary to select the most representative cases in order to simplify the measurements;

(e) that defined methods of single-signal and two-signal selectivity measurements are desirable to permit comparison of receivers;

RECOMMENDS

1. that the pass-band of the receiver shall be no wider than is essential for the transmission of the necessary modulation of the desired signal without significant distortion (see § 1.2 of Recommendation No. 145), together with an allowance for the unavoidable instabilities of the frequencies of the transmitter and of the receiver;

2. in establishing the required attenuation slope of a receiver account should be taken of:

2.1 the unavoidable spread of the spectrum of signals in adjacent channels (see § 2 of Recommendation No. 145);

2.2 the limitation of the selectivity of the receiver by unavoidable amplitude non-linearity, e.g. cross-modulation;

2.3 the fact that an excessively large attenuation-slope may lead to serious distortion of the phase/frequency characteristic in the pass-band;

3. that the filters which determine the selectivity shall be included as near as possible to the receiver input, and the valve stages preceding the filters shall be sufficiently linear, in order to avoid significant loss of selectivity, e.g. by cross-modulation of the desired signal by strong undesired signals;

4. that for the purpose of studying the single-signal selectivity, the following definitions are recommended:

4.1 *pass-band:* the pass-band is the band of frequencies limited by the two frequencies for which the attenuation exceeds that of the most favoured frequency by some agreed value; in general this value is 6 db, except for high-quality radiotelephony receivers where the value is 2 db;

4.2 *attenuation-slope:* the attenuation-slope on each side of the passband is the ratio:

— of the difference of attenuation obtained for frequencies beyond the pass-band,
— to the difference between these frequencies;

* This Recommendation replaces Recommendation No. 95. The Republic of India reserved its opinion on this Recommendation.

4.3 *image-response ratio :* the image-response ratio is the ratio:

— of the input signal level at the image frequency required to produce a specified output from the receiver,

— to the level of the desired signal required to produce the same output.

The image frequency is the desired signal frequency plus or minus twice the intermediate frequency, according to whether the frequency-change oscillator is higher or lower in frequency than the desired signal frequency respectively.

If the receiver incorporates more than one frequency change there will be more than one image frequency, and for each of these there will be a corresponding image-response ratio;

4.4 *intermediate-frequency response ratio :* the intermediate-frequency response ratio is the ratio:

— of the level of a signal at the intermediate frequency applied to the receiver input and which produces a specified output from the receiver,

— to the level of the desired signal required to produce the same output;

4.5 other spurious responses can occur when the intermediate frequency arises as the sum or the difference of the frequency of an interfering signal and a harmonic of the local oscillator frequency, etc.,

spurious-response ratio : the spurious-response ratio is the ratio:

— of the input level at the interfering frequency required to produce a specified output from the receiver,

— to the level of the desired signal to produce the same output;

5. that single-signal measurements be made of the pass-band, the attenuation slope, the image-response, the intermediate-frequency response and other spurious-response ratios as defined above.

In the case of the attenuation-slope sufficient indication is generally obtained by considering the frequency difference corresponding to attenuations of 20, 40, 60 and if possible 80 db, reckoned from the limit frequencies of the pass-band. When the values thus obtained are essentially equal for the two sides of the pass-band it is sufficient to give mean values.

For some purposes it is of interest to know the bandwidth at fixed levels corresponding to the above-mentioned attenuations of 20, 40, 60 db. These figures can easily be reduced from the pass-band and the attenuation-slopes at the different levels.

Since, when plotted in decibels to a logarithmic scale of frequency, the sides of the selectivity characteristics are often almost straight beyond a certain frequency difference relative to the mid-band frequency, the attenuation outside the pass-band can also be expressed as the slope of the attenuation/frequency characteristic, in decibels per octave of the frequency difference (see Fig. 1 Recommendation No. 95, London, page 107). The frequency and attenuation at the starting point of such a slope, relative to the mid-band frequency, should be stated;

6. that for the purpose of studying the selectivity in the non-linear region with *two or more input signals* the following definitions are recommended:

6.1 *effective selectivity :* the effective selectivity is the ability of the receiver to discriminate between the desired signal (to which the receiver is tuned) and an undesired signal (having a frequency generally outside the pass-band) the level of which is such as to produce non-linear effects, both desired and undesired signals acting simultaneously and one or both being modulated. The effective selectivity can be measured by the blocking, cross-modulation and inter-modulation characteristics defined below;

6.2 *blocking :* blocking is defined as the level of an undesired signal on a near-by frequency, e.g. in an adjacent channel, which results in a given change (generally a reduction), e.g. 3db, in the output due to a modulated * desired signal of specified level applied to the receiver input;

* Except for A1 signals when an unmodulated carrier is used.

6.3 *cross-modulation :* cross-modulation is defined as the level of a modulated undesired signal on a frequency near to an unmodulated desired signal (e.g. in an adjacent channel), which results in an output from the receiver of a specified amount, (e.g. 20 db *), below that which would be obtained if the desired signal were modulated;

6.4 *inter-modulation :* inter-modulation is defined as the levels of two undesired signals which produce at the receiver output a given level (e.g. 20 db *) below that corresponding to the normal input signal, when the frequencies of these two undesired signals have :

— a difference equal to the intermediate frequency,

— a sum or difference equal to the frequency of the desired signal,

the two interfering signals being simultaneously applied.

In general the signals are equal in level, one being modulated and the other unmodulated, and both frequencies are simultaneously adjusted so that the level of the inter-modulation product is a maximum. The gain of the receiver when measuring the inter-modulation performance should be that corresponding to the specified input and output levels of the desired signal.

Other orders of inter-modulation product may occur in practice; those selected are generally sufficient to specify the performance in respect of inter-modulation;

7. that in order to express the selectivity in the non-linear region, it is desirable that two-signal measurements be made of the effective selectivity in terms of the blocking, cross-modulation and inter-modulation characteristics as defined above.

Note. — Annex I gives representative values for the selectivity of a limited number of receivers (excluding television receivers) and is based on data and information given in the Annex to Recommendation No. 95 and Docs. Nos. 137, 318, 398 and 488 of Warsaw.

Annex II gives representative values for the selectivity of television receivers and is based on data given in the Annex to Recommendation No. 95 and Docs. Nos. 137, 398, and 488 of Warsaw. The data given in Annexes I and II were collected as part of studies required by Study Programme No. 42.

ANNEX I

Selectivity of receivers, excluding television receivers

1. *General.*

In the following tables an attempt has been made to present in a systematic way representative data for the selectivity characteristics of the various classes of receiver. In order to facilitate the use of these data and at the same time to reduce the amount of data presented, only three figures (called for convenience "maximum", "mean" and "minimum" values) have been given for each characteristic for a number of similar receivers of each class. That means, that the mean value is taken as a result of figures given either for a larger number of receivers of the same type or for different types of receivers and for different frequencies within the indicated range (Col. 3). In most cases, however, the actual frequency range is less than the full indicated range. It should be noted, however, that in many cases, because of the small number of receivers (indicated in the " Remarks " columns of the tables), these figures have not a precise statistical significance.

Only limited data, and in some cases no data, are available for certain classes of receiver. It is hoped that, nevertheless, the incomplete data given in the tables will be of value to the users and that it will be possible to add to these data in the future.

* Other values may be desirable for certain special classes of receivers.

2. *Notes to the tables*

2.1 *Single-signal selectivity*

Column No.

(1), (2), (3) Receivers are tabulated in terms of the class of emission, class of receiver and frequency range respectively, according to the " Classification Scheme for Receivers ", contained in Annex I of Recommendation No. 154.

(4) See paragraph 1 above (General).

(5) See paragraph 4.1 of this Recommendation.

(6) See paragraphs 4.2 and 5 of this Recommendation.

(7) See paragraph 5 and Fig. 1 of this Recommendation. The " ultimate slope " is the value, generally constant, that the attenuation slope attains at frequencies remote from the pass-band. The frequency and attenuation at the starting point of such a slope, relative to the mid-band frequency, should be stated.

(8) See paragraph 4.3 of this Recommendation.

(9) See paragraph 4.4 of this Recommendation.

(10) This column shows the number of receivers on which the representative values for the single-signal selectivity are based, and, when possible, some indication of the spread of the data.

2.2. *Two-signal selectivity*

Column No.

(1), (2), (3) See Section 2.1 above.

(4) Frequency difference between the desired signal (F_d) and the undesired signal (F_n).

(5) See paragraph 1 above (General).

(6) See paragraph 6.2 of this Recommendation.

(7) See paragraph 6.3 of this Recommendation.

(8) See paragraph 6.4 of this Recommendation.

(9) This column shows the number of receivers on which representative values for the two-signal selectivity are based, and the values for the ratios of the desired to the undesired signal at the receiver output (in cross-modulation and inter-modulation tests) when these differ from those suggested in paragraphs 6.3 and 6.4 of this Recommendation.

ANNEX II

Selectivity of television receivers

General.

The methods of test of television receivers have not, as yet, been fully standardised in the various countries and the data given in this Annex and the relevant documents must be regarded as tentative until such standardisation is more complete (See Table VII, page 146).

The table contains representative values for the single-signal selectivity of the vision and sound channels of typical television receivers (405 and 625 line systems only).

TABLE I

Single-signal selectivity of radiotelegraphy receivers

Class of emission	Service	Frequency range in Mc/s		RF and IF passband in kc/s	Attenuation slope in db/kc/s from edge of passband: 26 db	46 db	66 db	86 db	Ultimate slope in db/octave	Image response ratio in db	IF response ratio in db	Remarks
(1)	(2)	(3)	(4)	(5)	(6)				(7)	(8)	(9)	(10)
A1	Fixed	1.6 - 30		1.1	165	200	200	200	—	113/83	—	1 receiver tested
		1.6 - 30		0.4	108	135	144	130	—	100	100	—
				1.2	130	164	183	210	—	100	100	
	General purpose	1.6 - 30	Max.	4.7	28	28	28	—	—	119/53	110	6 receivers tested
			Mean	1.4	16	15	15	—	—	73/28	90	
			Min.	0.2	10	10	8	—	—	41/7	80	
		0.03-30	Max.	3.8	10.5	10.0				100	110	3 receivers tested (different types)
			Mean	3.2	8.9	7.4	—	—	—			
			Min.	2.4	6.7	6.5				31	52	

Table II

Single-signal selectivity of radiotelephony receivers

Class of emission	Service	Frequency range in Mc/s		RF and IF passband in kc/s	Attenuation-slope in db/kc/s From edge of passband				Ultimate slope in db/octave	Image response ratio in db	IF response in db	Remarks
					26 db	46 db	66 db	86 db				
(1)	(2)	(3)	(4)	(5)	(6)				(7)	(8)	(9)	(10)
A3	Fixed	1.6-30		6	22	23	26.5	28	—	>70	>100	—
	General purpose	1.6-30	Max.	6.8	12	11	11	—	—	119/53	>110	7 receivers tested
			Mean	5.3	8.5	8	8	—	—	73/28	>90	
			Min.	4.0	5	4	4	—	—	41/7	>80	
		0.03-30	Max.	9.4	10.5	10.7	—	—	—	>100	>100	4 receivers (of different types) tested
			Mean	6.1	9.1	9.3	—	—	—			
			Min.	4.3	7.1	6.5	—	—	—	30	81	
		30-300	Max.	52	1.25	1.5	1.5	1.5		100	100	3 groups of 2 receivers (of different types) tested
			Mean	34	1.1	1.2	—	—	—	63	90	
			Min.	16.5	0.84	0.9	0.9	0.9		22	82	
	Mobile	30-300	Max.	65	5	4.4	3.6	3	—	100	109	3 groups of 4 receivers (of different types) tested
			Mean	37	3.2	2.7	2.3	1.4	—			
			Min.	22	1.5	1.1	1.5	1.1	—	60	90	
A3b	Fixed	1.6-30	Max.	6.4	240	240	240	100	—	115/85	>110	4 receivers tested for cols. (5) and (6); 3 rec. tested for cols. (8), (9)
			Mean	6.15	100	114	118	70	—	112/84	>95	
			Min.	6.0	12	12	12	10	—	110/82	>80	
		1.6-30	Max.	7.3	45	—	—	—	—	115	126	23 receivers tested of 4 different types
			Mean	6.9	—	—	—	—	—			
			Min.	6.1	13.3	—	—	—	—	61	60	
F3	Fixed	30-300		900	0.35	0.35	0.35	—	200	60	80	20 receivers (same type) tested; designed for 24 channel FM-system
		30-300		2100	0.02	0.02	—	—	—	58	>100	
	General purpose	30-300		40	0.8	0.8	—	—	—	90/44	>100	—
	Mobile		Max.	52	5.2	5.2	5.2	5.2	53 *	96		13 receivers tested (of different types) * cols. (7) and (9); 2 receivers tested. Portable receiver; 25 receivers tested of 2 types
		30-300	Mean	33	2.5	2.8	3.1	3.3		92	100 *	
			Min.	21	1.4	1.7	1.1	1.1	118 *	76		
		30-300		55	1.2	1.2	1.2	1.1	47	70	80	
P	Fixed	2100-2300		5000	0.009	0.009	0.009	0.009	22	50	100	1 receiver tested (prototype of 24 channel PPM-system)

* See also Doc. No. 446.

TABLE III

Single-signal selectivity of sound-broadcast receivers

Class of emission	Frequency range in Mc/s		RF and IF passband in kc/s	Attenuation slope in db/kc/s from edge of passband				Ultimate slope in db/octave	Image response ratio in db	IF response ratio in db	Remarks
				26 db	46 db	66 db	86 db				
(1)	(3)	(4)	(5)	(6)				(7)	(8)	(9)	(10)
A3	1.6-30	Max.	13.3	4.5	3.75	—	—	—	44	120	10 receivers tested
		Mean	8.05	3.6	3.1	—	—	—	25	90	
		Min.	4.0	2.5	2.1	—	—	—	9	57	
	0.5-30	Max.	17.0	5.6	5.3	—	—	—	78	100	3 receivers tested (of different types)
		Mean	10.2	4.3	3.9	—	—	—	28	96	
		Min.	5.9	3.3	2.9	—	—	—	22	68	
	0.5-30	Max.	3.8								Mean values (taken from a curve); 356 receivers tested
		Mean	5.5	4.5	4.2	3.4	—	—	—	—	
		Min.	5.3								

TABLE IV

Two-signal selectivity of radiotelegraphy receivers

Class of emission	Service	Frequency range in Mc/s	F_d-F_n (kc/s)		Blocking Level of undesired signal (db rel. to 1 μV) for level of desired signal (db rel. to 1 μV) of:				Cross-modulation Level of undesired signal (db rel. to 1 μV) for level of desired signal (db rel. to 1 μV) of:				Inter-modulation				Remarks
					+20	+40	+60	+80	+20	+40	+60	+80	F_d (Mc/s)	Level of undesired signal (db rel. to 1 μV): $F_n' - F_n'' = F_{if}$	$F_n' - F_n'' = F_d$	$F_n' + F_n'' = F_d$	
(1)	(2)	(3)	(4)	(5)	(6)				(7)				(8)				(9)
A1	Fixed	1.6-30	10	—	90	105	115	120	—	—	—	—	—	—	—	—	1 receiver tested
A1	Fixed	1.6-30	20	Max.	72	80	88	93	69	77	84	89	10	>120	97	115	3 receivers tested; col. 8, level of desired signal: + 40 db rel. to 1μV.
				Mean	69	77	85	91	64	73	81	87		>110	90	110	
				Min.	66	73	80	87	63	71	79	85		101	85	104	
A1	General purpose	0.03-300	10	Max.	—	106	115	123	—	90	101	113	1	100	90	100	3 receivers of different types tested at two frequencies. Col. 8, standard output and 20 db signal-to-noise ratio
				Mean	—	81	101	115	—	77	91	104	10	79	81	87	
				Min.	—	70	86	104	—	59	83	100		64	72	80	
F1	Fixed	1.6-30	20	Max.	102	113	>120	>120	96	>120	>120	>120	10	>120	91	104	9 receivers tested; col. 8, level of desired signal: + 40 db rel. to 1μV.
				Mean	94	102	>111	>115	87	>120	>120	>120		>107	86	95	
				Min.	85	88	94	102	89	>120	>120	>120		101	80	86	

TABLE V

Two-signal selectivity of radiotelephony receivers

Class of emission	Service	Frequency range in Mc/s	$F_d - F_n$ (kc/s)		Blocking: Level of undesired signal (db rel. to 1 μV) for level of desired signal (db rel. to 1 μV) of: +20	+40	+60	+80	Cross-modulation: Level of undesired signal (db rel. to 1 μV) for level of desired signal (db rel. to 1 μV) of: +20	+40	+60	+80	F_d (Mc/s)	Inter-modulation: Level of undesired signal (db rel. to 1 μV): $F'_n - F''_n = F_{if}$	$F'_n - F''_n = F_d$	$F'_n + F''_n = F_d$	Remarks
(1)	(2)	(3)	(4)	(5)	(6)				(7)					(8)			(9)
A3	Fixed	1.6-30	18	Max.	92	96	101	106	60	74	81	89					
				Mean	87	93	97	101	57	64	68	76	10	—	—	—	
				Min.	74	88	94	96	54	56	60	68					4 receivers tested
			36	Max.	98	102	105	112	62	80	88	86					
				Mean	97	99	103	107	60	68	72	77		—	—	—	
				Min.	94	96	100	102	56	60	65	72					
	General purpose	1.6-30	10	Max.	86	> 120	> 120	> 120	—	93	106	115		93	82	93	
				Mean	75	95	108	117	—	81	94	101	10	> 70	> 71	> 80	6 receivers tested for cols. 6 and 7;
				Min.	66	78	94	111	—	61	79	78		43	60	> 60	4 receivers tested for col. 8
		0.03-30	10	Max.	—	119	126	126	—	109	115	121	1	100	90	100	4 receivers tested, of different types at two frequencies
				Mean	—	87	107	120	—	86	93	97	10	85	77	93	
				Min.	—	61	90	108	—	72	79	85		63	65	80	
			30		—	39	67	108	—	36	51	66	20	82	84	90	1 receiver tested
		30-300	50		—	62	84	102	—	48	75	84	25	90	81	96	1 receiver tested
			500		> 100	> 100	100	—	92	> 100	> 100	—	—	—	—	—	1 receiver tested
	Mobile	0.03-0.6	10		102	112	127	—	—	—	109	114	—	—	—	—	1 receiver tested
		0.03-30	10		—	—	—	—	—	77	89	—	—	—	—	—	2 receivers tested
		30-300	50	—	—	—	100	—	—	—	—	—	—	—	—	—	2 receivers tested;
			1000	—	—	—	—	—	—	—	100*	—	—	—	—	—	* output level 40 db below standard value
A3b	Fixed	1.6-30	10	Max.	72	90	110	110	76	92	105	115		> 94	94	> 94	3 receivers tested for cols. 6 and 7; 1 receiver for col. 8 (measured at 3 frequencies)
				Mean	70	89	105	115	72	87	101	105		> 92	90	> 94	
				Min.	69	86	104	100	64	84	97	96		89	88	> 94	
		1.6-30	10	Max.	78	103	118	116	91	94	106	110		106	109	103	23 receivers tested (4 different types, measured at 4 frequencies)
				Mean	70	90	110	111	74	84	101	102		95	93	93	
				Min.	62	77	102	105	60	75	93	95		75	90	88	
		1.6-30	18	Max.	94	105	113	120	73	84	89	94		—	—	—	7 receivers tested
				Mean	88	99	107	113	64	76	82	82		—	—	—	
				Min.	68	79	95	108	52	66	74	72		—	—	—	
		1.6-30	36	Max.	107	114	120	120	86	94	95	96		—	—	—	
				Mean	99	106	112	116	78	87	86	86		—	—	—	
				Min.	82	91	108	111	67	83	74	74		—	—	—	
F3	Fixed	30-300		—	—	—	—	—	—	—	—	—	160	> 94	> 94	> 94	1 receiver tested
	Mobile	30-300		—	—	—	—	—	—	—	—	—	77.4	96	87	81	1 receiver tested

TABLE VI

Two-signal selectivity of sound-broadcast receivers

Class of emission	Service	Frequency range in Mc/s	$F_d - F_n$ kc/s		Blocking. Level of undesired signal (db rel. to 1 μV) for level of desired signal (db rel. to 1 μV) of:				Cross-modulation. Level of undesired signal (db rel. to 1 μV) for level of desired signal (db rel. to 1 μV) of:				Inter-modulation				Remarks
													F_d (Mc/s)	Level of undesired signal (db rel. to 1 μV)			
					+20	+40	+60	+80	+20	+40	+60	+80		$F'_n - F''_n = F_{if}$	$F'_n - F''_n = F_d$	$F'_n + F''_n = F_d$	
(1)	(2)	(3)	(4)	(5)	(6)				(7)				(8)				(9)
A3		0.5-1.6	10	Max. Mean Min.	— — —	72 67 64	88 86 85	107 104 102	— — —	61 55 50	85 79 73	115 101 93	1	>90 78 58	>90 72 53	>90 76 61	3 receivers tested for cols. 6 and 7; 7 receivers tested for col. 8
	Sound broadcasting	0.5-30	10	Max. Mean Min.	— — —	79 64 50	96 83 68	114 102 85	— — —	76 68 54	99 86 72	115 104 94		90 70 51	78 70 63	90 82 70	3 receivers tested of different types at 3 frequencies; col. 8, standard output and 20 db signal-to-noise ratio
F3		30-300	300		—	—	—	—	46	65	80	90	—	—	—	—	several receivers tested
	Sound broadcasting	30-300	300		—	—	—	—	40	52	60	80	—	—	—	—	several receivers tested; output level of undesired signal 40 db below level of desired signal

Table VII

Single-signal selectivity of television receivers

Class of emission	Frequency range in Mc/s		Attenuation in decibels, relative to maximum response, at the frequency shown below in Mc/s, relative to vision carrier frequency *																Remarks
			−7	−6.5	−6	−5.5	−5	−4.5	−4	−3.5	−3	−2.5	−2	−1	0	+0.5	+1	+1.5	
(1)	(3)	(5)	(6)																(10)
			a) 405-line system																
										Sound carrier					Vision carrier				
A5 (vision)	30-100	Max.					>60	>60	>60	54	20	5	1	0	9	27	46		4 receivers tested
		Mean					>60	>60	>60	40	15	3	0	0	6	23	41		
		Min.					40	18	32	36	10	1	0	0	4	20	37		
	30-300	Max.					>50	>50	>50	>60	46	24	6	2	6	18	40		5 receivers tested
		Mean					>40	>40	>37	>50	24	9	2	1	4	13	30		
		Min.					26	26	25	45	6	1	0	0	0	6	17		
		Max.					42	36	35	>50	29	13	4	4	2	15	23		3 receivers tested
		Mean					37	29	28	>50	20	8	1	2	2	10	21		
		Min.					35	25	25	>50	8	1	0	0	0	6	17		
			b) 625-line system																
			Adjacent vision carrier			Sound carrier									Vision carrier			Adjacent sound carrier	
A5 (vision)	100-300	Max.	56	38	36	40	12		5		3		1.4	2.5	—	21		45	4 receivers of different types tested
		Mean	43	31	25	23	7.7		1.2		0.7		0.7	0.9	6	14		40	
		Min.	33	27	12	15	5		0		0		0	0	—	10		32	
	30-300	Mean	40	23	26	28	16		0.5		0		0	1.5	7.5	16		28	20 receivers tested, each on 5 channels (figures taken from a curve)

* In the case of the 625-line system, the sign of the frequency difference must be changed, since the vision carrier is lower in frequency than its accompanying sound carrier.

RECOMMENDATION No. 156 *

FREQUENCY STABILITY OF RECEIVERS

(Study Programme No. 5)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that, in practice, the pass-band of receivers (§ 1 of Recommendation No. 145), is often increased beyond that essential for the transmission of the modulation of the desired signal without significant distortion;

(b) that the reasons for this increase in the pass-band width, in the most usual order of importance, are:

- — the frequency instability of the receiver frequency-change oscillators,
- — the inaccuracies in resetting these oscillators to a desired frequency,
- — the instability of the receiver filters,
- — and the instability of the frequency of received signals;

(c) that, in order to achieve the greatest economy in the use of the radio spectrum, it is desirable to keep to a minimum the increase of pass-band necessitated by the foregoing causes;

UNANIMOUSLY RECOMMENDS

1. that, in cases where economic considerations prevent the use of more effective frequency stabilising devices, e.g., in some general-purpose communication receivers and broadcast receivers, attention should, as far as possible, be given to:

- — the stability of the inductors and capacitors against temperature variations and mechanical shock,
- — the stability of the oscillator circuit,
- — the use of temperature-compensating components (e.g., negative temperature coefficient capacitors),
- — the protection of the frequency-controlling components from the effects of humidity (e.g., by means of protective coatings),
- — the protection of the frequency-controlling components against excessive temperature rise by adequate natural ventilation and suitable positioning of the components,
- — the reduction of the thermal time-constant in the case of receivers that are frequently switched on and off;

2. that, in cases where operation over a frequency band is required with a better degree of stability than that afforded by the methods referred to in § 1 (e.g., in good quality communication receivers), consideration may be given to the use of variable-frequency oscillators contained in constant-temperature compartments, hermetically sealed to avoid frequency instability which would be caused by changes of humidity or by chemical action of the atmosphere;

3. that, in cases where a still better degree of stability is required, it is advantageous to age the frequency-controlling components (especially inductors and capacitors) by subjecting them to repeated temperature cycles;

4. that, in cases where fixed-frequency operation (with its resulting simplicity) is required together with the highest degree of stability (i.e. for high-grade communication services), high-

* This Recommendation replaces Recommendation No. 96.

stability frequency-controlling components such as quartz crystals should be employed using, if necessary, the constant-temperature hermetically-sealed compartments referred to in § 2 above;

5. that, in cases where the instability of the frequency-change oscillator would otherwise be such as to require an appreciable increase in the width of the receiver pass-band, an automatic frequency control is desirable to reduce the frequency variation of the intermediate-frequency signal to a sufficiently small fraction of the width of the pass-band;

6. that, to minimise the effect of other circuits on the stability of the oscillator, it is desirable to use a separate valve for the oscillator rather than a dual-purpose valve;

7 that, to obtain the highest frequency stability from the frequency-change oscillator, it is desirable that the H.T. and heater supplies to this valve should be separately stabilised;

8. that, in cases where the instability of the frequency-change oscillator would otherwise be such as to require an appreciable percentage increase in the width of the receiver pass-band, an automatic frequency control is desirable to reduce the frequency variation of the intermediate-frequency signal to a sufficiently small fraction of the width of the passband;

9. that, in cases where a high degree of synchronisation is required (e.g., systems employing a partially suppressed pilot-carrier), it is desirable to use a more accurate automatic frequency control capable of correcting the frequency of a local oscillator in the receiver so that the intermediate-frequency carrier is within a few cycles per second of the frequency of another oscillator used to demodulate the signal;

10. that, particularly in single-sideband receivers where sudden jumps of the oscillator frequency can cause failure of the A.F.C., it is desirable to prevent such jumps. These jumps may be due to creeping of an inductor winding relative to its supporting former, and it is therefore desirable to take such steps, as, for example, to use rigid self-supporting coils or windings consisting of metal deposited on a ceramic former;

11. that consideration be given to reducing to a minimum the frequency instability, caused by changes of humidity and temperature, of the receiver filters (electrical or mechanical) by applying methods similar to those referred to in § 1 and 2 above, and by the use of high-stability components such as quartz crystal resonators where technical and economic considerations permit;

12. that, in order to reduce to a minimum frequency variations due to mechanical shock and vibration, due attention should be paid to the mechanical design of the receiver oscillators and filters and, in the case of variable-frequency oscillators, to the resetting accuracy of the variable capacitors or inductors and the frequency-range changeover switches employed;

13. that, because in multiband receivers the frequency-range changeover switches associated with the oscillating circuits often introduce frequency instability, it is desirable to avoid the use of such switches by employing a single-range oscillator followed by frequency multiplying circuits.

Note.—The Annex gives the typical stability values obtained for various types of receivers in certain countries, based on data given in Recommendation No. 96 together with additional information contained in Docs. Nos. 3, 119, 158, 159, 160, 394 and 398 (Warsaw, 1956).

The assembly of this information constitutes a partial reply to Question No. 77.

ANNEX

1. *General.*

In the following tables an attempt has been made to present in a systematic way representative data for the frequency-instability (generally of the frequency-change oscillators) for various classes of receiver. In order to facilitate the use of these data, and at the same time to reduce the amount of data presented, only three figures (maximum, mean and minimum values) have been given for each characteristic for a number of similar receivers in each class. It should be noted, however, that in some cases, because of the small number of receivers tested (as indicated in the Remarks column) these figures have no precise statistical significance.

Only limited data are available for certain classes of receiver, particularly television receivers and other receivers for frequencies above about 30 Mc/s approximately.

The following general conclusions may be drawn from the data so far obtained:

(a) there is a very wide variation in the figures obtained even for the same type of receiver;

(b) most receivers reach their working temperature within one hour after switching on although the use of a thermostatically controlled compartment may have the effect of prolonging the period needed for warming-up;

(c) little information is available on the instability due to a 20% mains voltage variation or to wide ranges of temperature variation.

2. *Notes on the tables*

Column No.

(1) The suffix (L) signifies that the information was extracted from the documents of London (1953); (W) that it was extracted from the documents of Warsaw (1956). Where the information is a combination of that from both sources, the suffix (L W) is used.

(2), (3) The class of emission and type of service are quoted in accordance with Annex 1 of Recommendation No. 154.

(4) The frequency range quoted is that covering the data given in the appropriate documents but does not in all cases correspond to the preferred ranges quoted in Annex 1 of Recommendation No. 154.

(5) This column indicates the type of frequency-change oscillator(s) used in the receiver, e.g. LC- controlled, quartz crystal controlled, frequency synthesiser, double frequency changer, etc. In many cases sufficient information regarding this point was not available.

(6) See paragraph 1—General, above.

(7) Frequency-drift during the warming-up period is indicated, without regard to sign, in parts in 10^6 at 1, 10, 30, 60 and 120 minutes after switching on, the value at 60 minutes being used as the reference datum. These figures are given as being of the greatest importance when considering permissible channel spacings. A knowledge of the sign of the drift would be of interest to the designers of receivers since a change of sign during the warming up period would indicate some measure of self-compensation in the receiver, different parts of the receiver having different thermal time constants. The inclusion of this information would, however, make the table too complicated and is considered unnecessary for the purposes of the C.C.I.R.

(8) The frequency variation is that due to an A.C. mains supply voltage variation of $\pm 10\%$, or H.T. and L.T. battery voltage variations of $\pm$ 20%, according to the type of receiver.

(9) The frequency variation is that due to 1°C variation near the normal ambient temperature or, in the case of certain receivers, that due to a variation of temperature over the range indicated.

Column

(10) The indicated frequency variation resulting from light mechanical shock, e.g. due to striking the front of the receiver lightly with the hand. In certain cases, e.g. mobile service receivers, more comprehensive vibration and shock tests are desirable.

(11) This column contains information on the number of receivers used for the determination of the representative values for the frequency drift and variation including, when possible, some indication on the spread of the data; information on the vibration and shock tests referred to under Column (10) above is also to be included in this column.

Table I

Radiotelegraphy receivers

Entry	Class of emission	Service	Frequency range in Mc/s	Type of frequency changer used		Frequency drift at the following times (in minutes) after switching on: (×10⁻⁶)					Frequency variation (×10⁻⁶) due to supply voltage variation of:		Frequency variation (×10⁻⁶) due to temperature variation of:		Frequency variation (×10⁻⁶) due to mechanical shock	Remarks
						1	10	30	60	120	10%	20%	1°C	For range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1(L)	A1 A2	Fixed	1.6-30	No crystal control	Max. Mean Min.	— — —	33 17 3	20 9 0	0 0 0	8 4 1	— <10 —	— — —	17 7 0	— — —	— — —	Col. (7): 6 receivers tested Col. (8): 1 receiver tested Col. (9): 7 receivers tested
2(W)	A1 A2 F1	Fixed and mobile	1.5-28	No crystal control	Mean	125 109 190	105 42 42	50 26 26	0 0 0	35 4 5	10 1.3 0.8	— — —	11 6.4 1.3	— — —	— — —	f_{osc} = 2 Mc/s f_{osc} = 16 Mc/s f_{osc} = 27 Mc/s Variation over whole range. Only a few receivers tested
3(W)	A1 A2 F1	Fixed	3-30	With crystal control (synthesis method)	Mean	323 122 17	237 66 6	186 19 2	0 0 0	42 13 1	2.9 1.3 3.2	— — —	— — —	— — —	— — —	f_{osc} = 7 Mc/s f_{osc} = 16 Mc/s f_{osc} = 24 Mc/s Variation over whole range. Only a few receivers tested
4(W)	A1 A2 A3 F1	Fixed	2-30	With crystal control	Max. Mean Min.	— — —	— — —	110 50 20	0 0 0	— — —	— — —	— — —	2 1 0.4	— — —	— — —	Several receivers tested
5(L)	A2	Mobile	100-1000	No crystal control	Max. Mean Min.	— — —	— — —	— — —	— — —	— — —	4 3.3 2.6	— — —	1.7 1.1 0.4	— — —	— — —	1 receiver tested

Table II

Radiotelephony receivers

Entry	Class of emission	Service	Frequency range in Mc/s	Type of frequency changer used		Frequency drift at the following times (in minutes) after switching on: ($\times 10^{-6}$)					Frequency variation ($\times 10^{-6}$) due to a supply voltage variation of:		Frequency variation ($\times 10^{-6}$) due to a temperature variation of:		Frequency variation ($\times 10^{-6}$) due to mechanical shock	Remarks
						1	10	30	60	120	10%	20%	1°C	For range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1(L)	A3	Fixed	1.6-30	No crystal control	Max. Mean Min.	— — —	33 17 3	20 9 0	0 0 0	8 4 1	— <10 —	— — —	17 7 0	— — —	— — —	Col. (7): 6 receivers tested Col. (8): 1 receiver tested Col. (9): 7 receivers tested
2 (LW)	A3b	Fixed	1.6-30	No crystal control	Max. Mean Min.	— — —	468 184 10.2	176 84 2.1	0 0 0	95 43 12.9	36 — 1.5	— — —	— 5.5 —	— — —	10 — 0	Col. (7): 23 receivers tested Cols (8), (9) and (10): Only a few receivers tested
3(W)	A3b	Fixed	18.4	No crystal control	Mean	— — —	— 34 —	— 16 —	— 0 —	— — —	— 127 —	— — —	— — —	— — —	— 12 —	Adjustable temperature compensatory capacitor used
4(W)	A3 A3b	Fixed	4-28	With crystal control	Max. Mean Min.	— — —	— — —	— — —	— — —	— — —	1 0.5 0.2	— — —	7 5 3	— — —	— — —	Several receivers tested
5(W)	F3	Fixed	41-68	No crystal control	Mean	— 640 —	— 185 —	— 16 —	— 0 —	— — —	— 10* —	— — —	— 10 —	— — —	— — —	24 channel radio-relay link receivers. Only a few receivers tested. *For 5% supply volt. variation
6(W)	F3	Fixed	185	No crystal control	Mean	— — —	— 5 —	— 21 —	— 0 —	— 21 —	— 320 —	— — —	— — —	— — —	— 1 —	Multi-channel receiver, AFC on Osc. 1 with thermostatic control of discrim. Crystal Osc. 2 I.F. bandwidth 200 kc/s
7(W)	F3	Fixed	163.5	With crystal control	Mean	— — —	— 19 —	— 11 —	— 0 —	— — —	— 3.6 —	— — —	— — —	— — —	— 3.5 —	I.F. bandwidth 35 kc/s
8(W)	A3 F3	Mobile	70-200	With crystal control	Max. Mean Min.	— 8.5 —	— 5.5 —	— 2 —	— 0 —	— 0.9 —	150 17 1.8	— 4 —	0.8 — 0.5	50 - 10 } { + 0° C + 60° C	— <1 —	Only a few receivers tested
9(L)	A3	Mobile	100-1000	No crystal control	Max. Mean Min.	— — —	— — —	— — —	— — —	— — —	4 3.3 2.6	— — —	1.7 1.1 0.4	— — —	— — —	1 receiver tested

TABLE III

General purpose receivers

Entry	Class of emission	Service	Frequency range in Mc/s	Type of frequency changer used		Frequency drift at the following times (in minutes) after switching on: (×10⁻⁶) 1	10	30	60	120	Frequency variation (×10⁻⁶) due to a supply voltage variation of: 10%	20%	Frequency variation (×10⁻⁶) due to a temperature variation of: 1°C	For range shown	Frequency variation (×10⁻⁶) due to mechanical shock	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1 (LW)	A1 A2 A3	General purpose	1.6-30	No crystal control	Max.	—	390	223	0	—	176	—	—	—	140	13 receivers tested
					Mean	—	180	85	0	—	52	—	—	—	26	
					Min.	—	4	2	0	—	6.5	—	—	—	1	
2 (LW)	A1 A2 A3	General purpose	1.6-30	With crystal control	Max.	—	235	130	0	86	—	—	3	—	<1	11 receivers tested
					Mean	—	124	41	0	20	0.6	—	2	—	<1	
					Min.	—	5	1	0	1	—	—	1.5	—	<1	
3 (W)	A1 A2 A3 F3	General purpose	100	No crystal control	Max.	—	135	39	0	—	—	114	—	—	14	—
					Mean	—	—	—	—	—	10	—	—	—	—	
					Min.	—	47	35	0	—	—	3.6	—	—	3.5	

Table IV

Sound-broadcast receivers

Entry	Class of emission	Service	Frequency range in Mc/s	Type of frequency changer used		Frequency drift ($\times 10^{-6}$) in the following times (minutes) after switching on:					Frequency variation ($\times 10^{-6}$) due to a supply voltage variation of:		Frequency variation ($\times 10^{-6}$) due to a temperature variation of:		Frequency variation ($\times 10^{-6}$) due to mechanical shock	Remarks
						1	10	30	60	120	10%	20%	1°C	For range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1 (LW)	A3	Sound broad-cast	0.5-1.6	No crystal control	Max.	1000	830	470	0	234	1100	—	—	—	150	Col. (7): 52 receivers tested
					Mean	700	263	115	0	91	107	—	—	—	38	Col. (8): 48 receivers tested
					Min.	60	7	0	0	0	30	—	—	—	0	Col. (10): 6 receivers tested
2 (LW)	A3	Sound broad-cast	1.6-30	No crystal control	Max.	—	770	320	0	575	475	—	—	—	142	Col. (7): 17 receivers tested
					Mean	—	241	118	0	159	89	—	—	—	30	Col. (8): 13 receivers tested
					Min.	—	20	3	0	57	0.6	—	—	—	0	Col. (10): 15 receivers tested
3 (LW)	A3 F3	Sound broad-cast	30-100	No crystal control	Max.	—	494	79	0	21	—	—	—	—	—	Col. (7): 4 receivers tested
					Mean	—	236	33	0	11	107	—	—	—	—	Col. (8): 2 receivers tested
					Min.	—	49	0	0	0	—	—	—	—	—	

TABLE V

Television receivers

Entry	Class of emission	Service	Frequency range in Mc/s	Type of frequency changer used		Frequency drift ($\times 10^{-6}$) at the following times (minutes) after switching on:					Frequency variation ($\times 10^{-6}$) due to supply voltage variation of:		Frequency variation ($\times 10^{-6}$) due to temperature variation of:		Frequency variation ($\times 10^{-6}$) due to mechanical shock	Remarks
						1	10	30	60	120	10%	20%	1°C	For range shown		
(1)	(2)	(3)	(4)	(5)	(6)	(7)					(8)		(9)		(10)	(11)
1 (LW)	A5 F3	Television	100-300	No crystal control	Max.	2200	360	300	0	660	1000	—	—	—	—	Only a few receivers tested
					Mean	555	180	113	0	300	600	—	12*	—	350*	* approximate values
					Min.	200	80	0	0	0	200	—	—	—	—	

[redacted]

RECOMMENDATION No. 157

SENSITIVITY, SELECTIVITY AND STABILITY OF AMPLITUDE-MODULATION SOUND-BROADCAST RECEIVERS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that Recommendation No. 154 gives general recommendations on receiver sensitivity;

(b) that Recommendation No. 155 gives general recommendations on receiver selectivity;

(c) that Recommendation No. 156 gives general recommendations on receiver stability;

(d) that publication No. 69* of the I.E.C. gives definitions concerning the sensitivity, selectivity and stability of amplitude-modulation sound-broadcast receivers and the methods of measuring these properties;

(e) that the I.E.C. is contemplating periodical revision of these definitions and measurement methods;

UNANIMOUSLY RECOMMENDS

1. that, for measuring the sensitivity, selectivity and stability of amplitude-modulation sound-broadcast receivers, the C.C.I.R. shall provisionally adopt the definitions and measurement methods contained in I.E.C. publication No. 69*;

2. that, to the same end, the amendments that the I.E.C. might make to these definitions and measurement methods from time to time be used as a guide by the C.C.I.R.

RECOMMENDATION No. 158

SENSITIVITY, SELECTIVITY AND STABILITY OF FREQUENCY-MODULATION SOUND-BROADCAST RECEIVERS AND TELEVISION RECEIVERS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that Recommendation No. 154 gives general recommendations on receiver sensitivity;

(b) that Recommendation No. 155 gives general recommendations on receiver selectivity;

(c) that Recommendation No. 156 gives general recommendations on receiver stability;

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* Available at the Central Office of the I.E.C. in Geneva.

(d) that the I.E.C. has circulated, for final approval, two documents giving definitions of the sensitivity, selectivity and stability of frequency-modulation sound-broadcast receivers and television receivers and methods of measuring these properties;

e) that the I.E.C. is contemplating periodical revision of these definitions and measurement methods;

UNANIMOUSLY RECOMMENDS

1. that, for measuring the sensitivity, selectivity and stability of frequency-modulation sound broadcast receivers and television receivers, the definitions and measurement methods established by the I.E.C., to be published shortly *, be used as a guide by the C.C.I.R.;

2. that, to the same end, the amendments that the I.E.C. might make to these definitions and measurement methods from time to time be used as a guide by the C.C.I.R.

RECOMMENDATION No. 159

RESPONSE OF BROADCAST AND TELEVISION RECEIVERS TO QUASI-IMPULSIVE INTERFERENCE

(Question No. 79) **

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that many types of interference—e.g. from atmospheric phenomena, ignition systems and electrical equipment—cannot be considered as random noise or as simple isolated impulses, but may be regarded as " quasi-impulsive " ***;

(b) that the work of the C.I.S.P.R. has led to agreement on the performance specification of a measuring receiver designed to evaluate the importance of quasi-impulsive interference to broadcast sound reception in the frequency range 150 kc/s to 25 Mc/s;

(c) that the C.I.S.P.R. is studying the performance specification of a measuring receiver designed to evaluate the effect of quasi-impulsive interference on frequency modulation and television reception in the frequency range 25 Mc/s to 300 Mc/s;

(d) that the C.I.S.P.R. has reached partial agreement on and is further studying standard methods for measuring conducted and radiated interference;

UNANIMOUSLY RECOMMENDS

1. that the C.C.I.R. be guided provisionally by the methods and adopt the specifications of measuring receivers of the C.I.S.P.R.;

2. that the C.I.S.P.R. radio-interference measuring sets be used as a guide in evaluating the parameters of quasi-impulsive interference, affecting broadcast sound and television reception.

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* Will be available at the central office of the I.E.C. in Geneva.

** This Question has been replaced by Question No. 125 (II).

*** If a random sequence of a very large number of impulses occurs per second the effect is that of random noise. Impulse generators usually give a regular sequence of equal impulses. In interference problems the form and sequence of the impulses is irregular and their number is not high enough to give the effect of random noise. Therefore the name " quasi-impulsive " was introduced.

RECOMMENDATION No. 160

SPURIOUS EMISSIONS FROM BROADCAST AND TELEVISION RECEIVERS

(Question No. 80 *)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that many receivers produce undesired emissions, due e.g. to local oscillators and, in case of television receivers, to time-base circuits;

(b) that these radiations may emanate from the aerial circuits, the mains supply leads or the receiver chassis and may interfere with many services;

(c) that considerable data concerning these radiations have been obtained recently;

(d) that limiting values for such undesired emissions have been established, based on different methods, by several administrations;

(e) that international standardisation of measuring methods and limiting values is very desirable;

(f) that the I.E.C. is nearing completion of its work on the methods of measurement of spurious emissions from sound-broadcast and television receivers;

(g) that on completion of the above work the C.I.S.P.R. will study the magnitudes of emissions from such receivers in order to establish tolerable limits for undesired emissions;

(h) that considerable progress has been made on the methods of measurement and on the techniques of reducing undesired emissions which are particularly useful when designing receivers (see Docs. Nos. 181, 302 and 449 of Warsaw);

UNANIMOUSLY RECOMMENDS

1. that the C.C.I.R. be guided by the methods established by the I.E.C. for all types of broadcast and television receivers;

2. that the C.C.I.R. confirm to the C.I.S.P.R. its interest in knowing the magnitude of emissions from receivers and ask to be kept informed of the progress in establishing tolerable limits for such emissions;

3. that all possible means compatible with economy should be employed in the construction of receivers to reduce such undesired emissions.

ANNEX

A considerable amount of data has been produced by different administrations, as representative of the radiation figures of frequency-modulation and television receivers manufactured during recent years (see Docs. Nos. 8, 136, 181, 398 and 499 of Warsaw).

However, due to the fact that these data were taken by different methods and that a considerable improvement has recently been achieved in reducing receiver radiations, no data have been included here.

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* This Question has been replaced by Question No. 126 (II).

Nevertheless, useful information on " conversion factors " from one method to another and on limits that are now accepted for the various methods have been brought to the attention of the C.C.I.R.* Subjective measurements have confirmed the practical value of the methods mentioned above.**

RECOMMENDATION No. 161 ***

BANDWIDTHS AND SIGNAL-TO-NOISE RATIOS IN COMPLETE SYSTEMS

(Question No. 3 (III))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

that it is not yet possible to give a full and accurate answer to Question No. 3 (III) but that in order that such an answer may be given it is desirable to classify the important points with which future study will have to deal;

RECOMMENDS

1. that in the meanwhile the values given in the table in Ann. I should be adopted as provisional values for the signal-to-noise ratio required for the types of service concerned;
2. that in the further study relating to the minimum separation between frequencies of stations operating on adjacent channels, the factors detailed in Ann. II should be taken into consideration.

ANNEX I

Note 1. — Measured as the ratio of r.m.s. signal corresponding to peak output of the transmitter and r.m.s. noise in a 6 kc/s band, assuming stable conditions.

Note 2. — Carrier keyed. Beat-frequency oscillator used.

Note 3. — For A3 telephony the figures in this column represent the ratio of the audio signal as measured on a standard VU-meter to r.m.s. noise for a bandwidth of 3 kc/s. (The corresponding peak signal power, i.e., when the transmitter is 100% tone-modulated, is assumed to be 6 db higher.)

Note 4. — For 90% intelligibility of unrelated words.

Note 5. — When connected to the public service network.

Note 6. — These values are based on Washington Doc. No. 138, Geneva Doc. No. 112 and The Hague Doc. No. 11.

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* J. Meyer de Stadelhofen. Mesures du rayonnement parasite de récepteurs F.M. exécutées en Suisse par un groupe d'experts du sous-comité 12-1 (Radiocommunications — S.C. Mesure) de la C.E.I. — Bulletin Technique des P.T.T., 1956.

— id — Misure delle irradiazioni parassite dei ricevitori a modulazione di frequenza esequite in Svizzera da un gruppo di Esperti del SC 12-1 della CEI, — Elettronica, 1956.

** C. Egidi — Confronto di apparecchiature normalizzate per la misura delle irradiazioni parassite—Elettronica, 1956.

*** This Recommendation replaces Recommendation No. 99. The Bielorussian S.S.R., Czechoslovakia, the Hungarian P.R., the Roumanian P.R., the Ukranian S.S.R. and the U.S.S.R. reserved their opinions on this Recommendation.

SIGNAL-TO-NOISE RATIOS REQUIRED

(Stable conditions)

(Note 6)

Type of service	Receiver audio bandwidth kc/s	Audio signal-to-noise ratio db	Receiver bandwidth kc/s	Ratio of peak RF signal-noise in 6 kc/s band (Note 1) db
A1 telegraphy				
8 baud low grade	1.5	−4	3	−7
24 baud	1.5	11	3	8
120 baud recorder	0.6	10	0.6	0
50 baud printer	0.25	16	0.25	2
A2 telegraphy				
8 baud low grade	1.5	−4	3	−3 (Note 2)
24 baud	1.5	11	3	12 (Note 2)
F1 frequency-shift telegraphy				
120 baud recorder	0.25	4	1.5	2
50 baud printer	0.10	10	1.5	−2
Phototelegraphy F4				
Sub-carrier frequency-modulation single side-band emission	3	15	3	12
Hellschreiber				
Frequency-shift	1.5	6	3	3
A3 telephony		(Note 3)		
Double-sideband, just usable quality, operator to operator (Note 4)	3	6	6	18
Double-sideband, marginally commercial (Note 5)	3	15	6	27
Double-sideband, good commercial quality (Note 5)	3	33	6	35 *
Single-sideband, 1 channel	3	33	3	26 *
2 channels	3	33	3 **	28 *
3 channels	3	33	3 **	29 *
4 channels	3	33	3 **	30 *
Broadcasting	5	33	10	47

* Assuming 10 db improvement due to the use of noise reducers.

** Per channel.

ANNEX II

FACTORS TO BE TAKEN INTO ACCOUNT FOR VARIOUS SERVICES IN DETERMINING THE MINIMUM SEPARATION BETWEEN THE FREQUENCIES OF STATIONS OPERATING ON ADJACENT CHANNELS

1. Required signal-to-interference ratios.
2. Necessary bandwidth for required intelligence.
3. Transmitters:
   (a) out-of-band radiation.
   (b) frequency instability.
4. Propagation:
   allowances for fluctuations due to absorption and fading.
5. Receivers:
   (a) necessary bandwidth.
   (b) attenuation slope.
   (c) frequency instability.
6. Effect of:
   (a) inequalities of received field strength on desired and adjacent channels
   (b) antenna directivity at transmitter and receiver.

RECOMMENDATION No. 162 *

USE OF DIRECTIONAL ANTENNAE

(Question No. 3 (III) — Study Programme No. 45 (III))

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) the urgent need to determine the minimum separation between frequencies of stations operating on adjacent channels, below 30 Mc/s;

(b) that the improvement in the signal-to-noise ratio and signal-to-interference ratio to be obtained by the use of directional receiving antennae is an important means of reducing the necessary channel spacing to a minimum;

(c) that the use of directional transmitting antennae considerably reduces the level of interference by:

— providing at the receiver the necessary field strength with reduced transmitted power,
— reducing the field strength received at stations situated outside the principal lobe of the transmitting antennae;

(d) that, in addition, the use of a directional antenna can contribute an improvement by reducing echo and multipath effects;

(e) that, using known techniques, highly directional antennae can be constructed;

(f) that, despite the non-homogeneous nature of the transmission medium, it is possible to employ transmitting and receiving antennae with appreciably greater directivity than that of antennae in general use;

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* This Recommendation replaces Recommendation No. 103.

(g) That it is not yet possible to give full and precise answers to the questions posed in Study Programme No. 45 (III), § 1.1.9 and 1.2.9.

UNANIMOUSLY RECOMMENDS

1. that the characteristics which might reasonably be expected in practice for rhombic antennae at present in use for point-to-point circuits be considered in three main arcs as shown in Figure 1, i.e.:
   - (M) the main arc including only the main lobe
   - (A) consisting of two arcs A_1 and A_2 on either side of the main arc
   - (B) the remaining arc from the limits of the arcs A_1 and A_2 and including the whole of the backward arc.
2. that the gains in the correct azimuthal direction and the gains for the arcs A and B as shown in the Annex should be adopted for distances of 3000-10 000 km.

ANNEX

Frequency range in Mc/s	Median value of gain relative to optimum gain for half-wave dipole at the same height (in db)			Azimuthal range in degrees		
	In the correct azimuthal direction	In arc A	In arc B	Half of main arc	Arc $A_1 = A_2$	Half of arc "B"
4	6	0	−3	30	35	115
6	8	0	−3	25	30	125
8	10	0	−4	20	25	135
11	12	1	−5	15	22	143
15	14	2	−6	10	20	150
22	15	3	−6	8	18	154

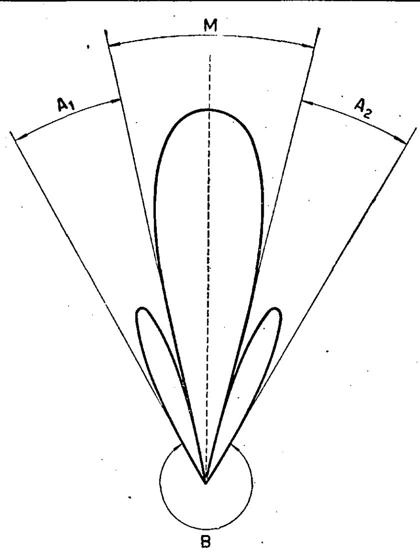

FIGURE 1

RECOMMENDATION No. 163 *

SIGNAL-TO-INTERFERENCE PROTECTION RATIOS

(Question No. 3 (III), Study Programme No. 45 (III))

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

that a knowledge of the signal-to-interference protection ratios for various types of service is needed;

RECOMMENDS

1. that the values of signal-to-interference ratios for stable conditions below which harmful interference occurs can be used in conjunction with the fading allowances in the annex to Recommendation No. 164;
2. that the values shown in the table below are appropriate to A1 and F1 emissions.

TABLE

Minimum protection ratios and frequency separations required under stable conditions

Wanted signal	Interfering signal							
Type of service	A1 50 baud Bandwidth limited to 500 c/s				F1 50 baud 2D=280 c/s Bandwidth limited to 500 c/s			
	1	2	3	4	1	2	3	4
	db	kc/s			db	kc/s		
A1 50 baud printer. Receiver pass-band 50 c/s	11	0.36	0.44	1.14	13	0.46	0.54	1.24
F1 50 baud printer. 2 D = 280 c/s Receiver passband 500 c/s	1	0.2	0.28	0.6	7	0.32	0.39	0.67

Note : Columns numbered 1 give in db the limiting values of signal-to-interference ratio in the cases when the occupied band of the interfering emission either falls entirely within the pass-band of the receiver, or covers it completely.

Columns numbered 2, 3 and 4 indicate the frequency separation necessary between a wanted and an interfering signal when the latter is 0, 6 or 30 db higher than the wanted signal.

* This Recommendation replaces Recommendation No. 104. The Bielorussian S.S.R., the P.R. of Bulgaria, Czechoslovakia, the Ukranian S.S.R. and the U.S.S.R. reserved their opinions on this Recommendation.

RECOMMENDATION No. 164 *

FADING ALLOWANCES FOR THE VARIOUS CLASSES OF SERVICE

(Question No. 3 (III) — Study Programme No. 45 (III))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that Annex I to Recommendation No. 99 is a provisional partial reply to Question No. 3 (III) for stable conditions;

(b) that there is a need for figures which take fading and field intensity fluctuation into account;

(c) that it is not yet possible to give a full answer to Study Programme No. 45 (III);

(d) that, however, the documents received relative to Question No. 52 and Study Programme No. 24 give some results from which can be derived provisional data on fading allowances;

RECOMMENDS

1. that the studies in connection with Recommendation No. 99 and Study Programme No. 45 (III) should be continued in conjunction with those of Study Programme No. 66 (VI), for the purpose of determining whether the provisional values given in the Annex may be accepted or should be modified;

2. that, meanwhile, the values given in the Annex may be regarded as provisional total fading allowances (combined fading safety factors and intensity fluctuation factors);

3. that, meanwhile, these values may be used as a guide in conjunction with the values for signal-to-noise ratios required for stable conditions given in Recommendation No. 99, Ann. I, to estimate monthly median values of hourly median field intensity necessary for the various types and grade of service; similarly, the fading allowances may be used as a guide in conjunction with the values for signal-to-interference ratios (for stable conditions) appropriate to the various services.

ANNEX

Note 1. — The allowance for day-to-day fluctuation (intensity fluctuation factor) for the signal, against steady noise, is 10 db, estimated to give protection for 90% of the days. The intensity fluctuation of atmospheric noise is also taken to be 10 db for 90% of the days. Assuming that there is no correlation between the intensity fluctuations of noise and of signal (the worst condition likely to exist), a good estimate of the combined signal and noise factor is:

$$\sqrt{10^2 + 10^2} = 14 \text{ db}.$$

* This Recommendation replaces Recommendation No. 105. The Bielorussian S.S.R., Czechoslovakia, the Hungarian P.R., the Roumanian P.R., the Ukranian S.S.R. and the U.S.S.R. reserved their opinions on this Recommendation.

PROVISIONAL TOTAL FADING ALLOWANCES *

Type of service **		For the protection of a fading signal against: atmospheric noise subject to day-to-day intensity fluctuation (subtract 4 db for protection against steady noise or steady interfering signal) (see Note 1)	interfering signal subject to fading and day-to-day intensity fluctuation (see Note 2)
		db relative to ratios of monthly median values of hourly median field strength	
A1 telegraphy			
8 baud, low grade	(Note 3)	21	17
24 baud	(Note 4)	25	20
120 baud recorder	(Note 6)	25	20
50 baud printer	(Notes 5, 6)	32	27
A2 telegraphy			
8 baud, low grade	(Notes 3, 7)	17	13
24 baud	(Notes 4, 7)	20	17
F1 telegraphy			
120 baud recorder	(Note 6)	25	20
50 baud printer	(Notes 5, 6)	32	27
automatic repetition printer (ARQ) . .	(Notes 6, 8)	17	12
Phototelegraphy F4			
sub-carrier frequency-modulation single-sideband emission		23	20
Hellschreiber			
frequency-shift	(Note 9)	23	20
A3 telephony			
DSB just usable quality, operator to operator	(Note 10)	17	11
DSB marginally commercial	(Note 11)	19	14
DSB good commercial quality	(Note 12)	21	17
SSB 1 channel / 2 channel / 3 channel / 4 channel	(Note 12)	21	17
Broadcasting		21	17

* Combined fading safety factor and intensity fluctuation allowances.
** From Annex I, Recommendation No. 99.

This figure has been added to the fading safety factor applied to each type of service to obtain the combined fading allowance in column 1. Subtraction of 4 db reduces the intensity fluctuation allowance to 10 db, which is the value for the signal alone; the net allowance would then be appropriate for the protection of a fading signal against a steady (non-fluctuating) noise or a steady (non-fading or fluctuating) interfering signal.

Note 2. — The probability distribution of the ratio of two signals fading independently has been used as given in London Doc. No. 443. The combined intensity fluctuation allowance for two signals has been taken as 7 db, which represents a compromise between the 0 db allowance appropriate in the case of perfectly correlated intensity fluctuations of the two signals, and the 14 db allowance appropriate (see Note 1) for uncorrelated intensity fluctuations of the two signals.

General Note. — In calculating the fading safety factor for rapid or short period fading, log-normal amplitude distribution of the received fading signal (using 7 db for the ratio of median level to level exceeded for 10% or 90% of the time) has been used, except in the case of high-speed automatic telegraphy services, where the protection has been calculated on the basis of Rayleigh distribution. The following notes refer to protection against rapid or short-period fading.

Note 3. — For protection 90% of the time.

Note 4. — For protection 98% of the time.

Note 5. — For protection 99.99% of the time.

Note 6. — Minimum of 2-element diversity assumed.

Note 7. — Total sideband power combined with keyed carrier is assumed to give partial (two-element) diversity effect. 4 db allowed for the case of 90% protection (8 baud) and 6 db allowed for the case of 98% protection.

Note 8. — Based on 90% traffic efficiency.

Note 9. — Based on 95% protection.

Note 10. — Based on 70% protection.

Note 11. — Based on 80% protection.

Note 12. — Based on 90% protection.

RECOMMENDATION No. 165 *

COMMUNICATION THEORY

(Question No. 44 **)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the study of both the practical and theoretical aspects of communication theory is of interest to the I.T.U.;

(b) that the bibliography on this subject and the documentation on the characteristics of various transmission systems in practical use, published by the Secretariat of the C.C.I.R. are useful for this study;

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* This Recommendation replaces Recommendation No. 107.

** This Question has been replaced by Question No. 133 (III).

(c) that the U.R.S.I. is willing to take part in the preparation of this bibliography, in particular through the help of its Netherlands Committee;

UNANIMOUSLY RECOMMENDS

1. that other administrations should co-operate in the preparation of the bibliography by sending to the Netherlands Administration a yearly list of papers on communication theory published in their country, where possible with an abstract;
2. that the Secretariat of the C.C.I.R. should continue the publication and dissemination of periodic supplements to the bibliography and to the documentation mentioned in paragraph *(b)*.

RECOMMENDATION No. 166

UNIT OF QUANTITY OF INFORMATION

The C.C.I.R., (Warsaw, 1956)

UNANIMOUSLY RECOMMENDS

the following definition of the unit of quantity of information:

" the unit of quantity of information corresponds to a ' message unit ' consisting of a random choice between two equally probable signals " (Xth General Assembly of U.R.S.I., Sydney, 1952).

This unit may be designated by the word " bit ".

Note. — The U.R.S.I. (The Hague, 1954) has drawn attention to the fact that the quantity of information in a message cannot be measured by a simple instrument. In most cases only a statistical estimate of an upper limit for the received quantity of information can be computed.

It is doubtful whether the construction of a computer for this purpose would serve a useful end, since such statistical estimates can also be made indirectly.

RECOMMENDATION No. 167

THE USE OF RADIO CIRCUITS IN ASSOCIATION WITH 5-UNIT START-STOP TELEGRAPH APPARATUS

(Question No. 83 *)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw 1956)

CONSIDERING

(a) that it is essential to be able to interconnect terminal start-stop apparatus employing the International Telegraph Alphabet No. 2 by means of radiotelegraph circuits;

(b) that radiotelegraph circuits are required to operate under varying conditions of radio propagation, atmospheric noise and interference which introduce varying degrees of distortion which may at times exceed the margin of the receiving apparatus;

* This Question has been replaced by Question No. 129 (III).

(c) that, in consequence, the transmission of 5-unit code signals over radio circuits is liable to errors and that such errors are not automatically detectable by the receiving apparatus;

(d) that an effective means of reducing the number of wrongly printed characters is the use of codes permitting the correction of errors, either by their intrinsic constitution or by detecting the errors and automatically causing repetition;

(e) that the methods using automatic repetition (ARQ) are well known at present;

RECOMMENDS

that when the direct use of a 5-unit code on a radio circuit gives an intolerable error rate and there is a return circuit, a 7-unit ARQ system be considered. In such a case the 7-unit system described in the Annex should be adopted as a preferred system.

ANNEX

I. *Table of code conversion* (See page 169)

II. *Channel arrangement*

1) *Two channels*

channels A and B consecutive
(A-direct keying, B-reversed keying)

2) *Four channels:*

channels A and B consecutive
channel C interlaced with channel A
channel D interlaced with channel B

(A and D—direct keying, B and C—reversed keying)

III. *Repetition cycle :* Four characters for normal circuits which are not subject to excessive delay.

IV. C.C.I.T. Study Group III in Draft Recommendation III/4 (Doc. No. 452 of the C.C.I.R., Warsaw, 1956) recommends that the interval between the beginning of successive start elements of the signals transmitted into the landline network is at least 144 ms with a tolerance of ± 1/10 000. Therefore the length of the transmission cycle on the radio circuit and also the keying speed must be chosen correspondingly if interconnection to the network is wanted.

Practical values for the keying speed in bauds and the length of the transmission cycle which enable synchronisation to be effected by means of one single oscillator for all three cases are:

Transmission cycle (in ms)	Keying speed (in bauds)
163 1/3	171 3/7
145 5/6	192
140	200

The transmission cycle of 163 1/3 ms is usable for connecting to 45 baud networks.

The transmission cycle of 145 5/6 ms may be used for interconnection of 50 baud networks. The transmission cycle of 140 ms is usable for radio links without direct connection to the network.

V. Study Group VII of the C.C.I.T. in Draft Recommendation VII/3 (Doc. No. 438 of the C.C.I.R., Warsaw, 1956) has given the signalling conditions to be used when telex communication is to be established by means of such radio circuits.

ANNEX

I—Table of code conversion

	International code No. 2	7-unit code
A	ZZAAA	AAZZAZA
B	ZAAZZ	AAZZAAZ
C	AZZZA	ZAAZZAA
D	ZAAZA	AAZZZAA
E	ZAAAA	AZZZAAA
F	ZAZZA	AAZAAZZ
G	AZAZZ	ZZAAAAZ
H	AAZAZ	ZAZAAZA
I	AZZAA	ZZZAAAA
J	ZZAZA	AZAAAZZ
K	ZZZZA	AAAZAZZ
L	AZAAZ	ZZAAAZA
M	AAZZZ	ZAZAAAZ
N	AAZZA	ZAZAZAA
O	AAAZZ	ZAAAZZA
P	AZZAZ	ZAAZAZA
Q	ZZZAZ	AAAZZAZ
R	AZAZA	ZZAAZAA
S	ZAZAA	AZAZAZA
T	AAAAZ	ZAAAZAZ
U	ZZZAA	AZZAAZA
V	AZZZZ	ZAAZAAZ
W	ZZAAZ	AZAAZAZ
X	ZAZZZ	AAZAZZA
Y	ZAZAZ	AAZAZAZ
Z	ZAAAZ	AZZAAAZ
carriage return	AAAZA	ZAAAAZZ
line feed	AZAAA	ZAZZAAA
figures	ZZAZZ	AZAAZZA
letters	ZZZZZ	AAAZZZA
space	AAZAA	ZZAZAAA
unperforated tape	AAAAA	AAAAZZZ
signal repetition	....	AZZAZAA
signal α	....	AZAZAAZ
signal β	....	AZAZZAA

RECOMMENDATION No. 168 *

PRESENTATION OF ANTENNA RADIATION DATA

(Question No. 49)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the aims pursued by the I.T.U. require a knowledge of the radiation in free space in all directions from the antennae used in international radiocommunication;

(b) that antenna radiation is well represented by diagrams showing the field strength or the power radiated in every direction of space;

(c) that, alternatively, the antenna radiation can be represented by the vectorial specific cymomotive force F in every direction in space (See *Note*);

UNANIMOUSLY RECOMMENDS

1. that, in diagrams of antenna radiation, contours representing the radiation in free space in all directions be labelled in terms of relative radiated power or field strength;
2. that an alternate method of presentation may also be employed consisting of diagrams of contours representing the radiation in all directions of space in terms of the vectorial specific cymomotive force F;
3. that the Director of the C.C.I.R. should take account of the above considerations, when antenna diagrams are being drawn;

Note. — Specific cymomotive force F is a vector expressed in volts and is defined as the product E. d, where E is the vectorial free-space field radiated by the antenna in a particular direction at a distance d from the centre of radiation of the antenna when the total radiated power is 1 kW.

In cases where the antenna dimensions are not negligible in relation to the wave-length, or to the distance at which the measurements are made, the limit of the product E.d as d approaches infinity, is regarded as the c.m.f. In order to measure the c.m.f. in these instances, the field measured at a finite distance must be modified by an appropriate correction factor **.

The radiated power W and the cymomotive force F are related by the equation $F^2 = 377$ W, where F is expressed in volts and W is expressed in watts per unit solid angle in the direction considered.

In cases where the polarisation of the electric field is elliptical, the c.m.f. may be shown as the magnitude and direction of the two main axes of the polarisation ellipse.

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* This Recommendation replaces Recommendation No. 108.

** See e.g. " Carlo Micheletta—Sulla determinazione della forza cimomotrice di emettitori con antenne a paraboloide "— Piccole Note-Recensioni e Notizie—I.S.P.T. No. 1, 1956 ,page 13.

RECOMMENDATION No. 169 *

GROUND-WAVE PROPAGATION OVER MIXED PATHS

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the calculation of ground-wave field strengths and phases for propagation over mixed paths, such as part land and part sea, is a matter of great importance in determining the service areas of radio transmitters and in the use of medium and low frequencies for navigational aids;

(b) that the mathematical analysis has now been reduced in some special cases of well-defined homogeneous sections to a graphical form convenient for use in the solution of practical problems (see point I of List of References);

(c) that, nevertheless, for the general case, calculations based on a rigid mathematical analysis are laborious;

(d) that, in many cases, the changes in the electrical constants of the ground with distances are gradual, ill-defined or imperfectly known;

(e) that computations made from the mathematical analysis confirm the results of well-defined experiments;

(f) that semi-empirical methods believed to be in current use (see point II of List of References) give good agreement with experimental results in many cases;

UNANIMOUSLY RECOMMENDS

1. That for cases for which the mathematical analysis has been reduced to a convenient form for practical application such methods should be used;

2. That, for other cases, the semi-empirical methods should be employed with due regard to the limitations of their use.

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4 E. L. Feinberg, Theory of mixed-path propagation of radio waves and engineering methods of calculation, Doc. No. 563, Warsaw 1956;

5) P. C. Clemmow:

(a) Ground-wave propagation across a land/sea boundary, *Nature* **165.** 107-108 (1950);

* This Recommendation replaces Recommendation No. 109.

(b) Radio propagation over a flat earth across a boundary separating two different media, *Phil. Trans. Roy. Soc.* A **246**, 1-55 (1953);

6) New method of calculating ground-wave field strength over mixed paths, Doc. No. 141, London, 1953;

7) J. R. WAIT, mixed-path ground-wave propagation, Part I, short distances, *N.B.S. Journ. of Res.*, July 1956;

8) H. BREMMER, The extension of Sommerfeld's Formula for the propagation of radio waves over a flat earth to different conductivities of the soil, *Physica* **20**, 441-460, (1954);

9) K. FURUTSU:

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(b) Propagation of electro-magnetic waves over a flat earth across two boundaries separating three different media, *Journ. Radio Res. Lab.* Tokyo, 2, No. 9, 239-279 (1955);

(c) Propagation of electro-magnetic waves over the spherical earth across boundaries separating different earth media, *Journ. Radio Res. Lab.* Tokyo 2, No. 10, 345-398 (1955);

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(e) Annex to Ref. 9 *(c)*.

10) Z. GODZINSKI, Expension of Feinberg's Theory on the case of electro-magnetic wave propagation over inhomogeneous spherical earth and introduction of an approximate method of computation based on equivalent secondary sources, Doc. No. 454, Warsaw 1956.

Ib. *Influence of a vertical inhomogeneity of the earth.*

11) J. GROSSKOPF

(a) Das Strahlungsfeld eines vertikalen Dipolsenders über geschichtetem Boden, *Hochfr. u. El.* Ak. **60**, 136-141 (1942);

(b) Ueber Bodenleitfähigkeitsmessungen in Schleswig-Holstein, FTZ *2*, 211-218 (1949);

12) (a) J. R. WAIT, Radiation from a vertical electric dipole over a stratified ground, *Trans. IRE*, Vol. AP-1, 9-11 (1953), No. 1;

(b) J. R. WAIT, W. A. Fraser, Radiation from a vertical dipole over a stratified ground (Part II), *Trans. IRE*, Vol. AP-3, 144-146 (1954) No. 4;

(c) J. R. WAIT, Radiation from a vertical antenna over a curved stratified ground, *N.B.S., Journ. of Res.* **56**, 237-244 (1956);

13) L. M. BREKHOVSKIKH, On the field of a point radiation source in a stratified inhomogeneous medium, *Bull. Ac. Sci. USSR*, Physical Series, **13**, 505-548 (1949) (in Russian).

II. **Semi-empirical methods.**

IIa. *Equivalent power method (Eckersley's Method).*

14) P. P. ECKERSLEY, The calculation of the service area of broadcast stations, *Proc. IRE* **18**, 1160-1194 (1930).

IIb. *Equivalent numerical distance methods (Equivalent conductivity methods).*

15) *(a)* J. GROSSKOPF, K. Vogt, Der Zusammenhang zwischen der effecktiven Bodenleitfahigkeit und der Ausbreitungsdämpfung, *Hochfr. u. El. Ak.* **62**, 14-15 (1943);

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(c) Variations de la constante de phase de l'onde de sol, *Onde Electr.* **35**, 687-691 (1955);

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IIc. *Millington's Method.*

19) G. MILLINGTON, Ground-wave propagation over an inhomogeneous smooth earth, *Proc. IEE*, Part III, **96**, 53-64 (1949);

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23) Ground-wave propagation over mixed paths (A brief review of the present situation), Doc. No. 501, Warsaw, 1956.

RECOMMENDATION No. 170 *

PRESENTATION OF DATA IN STUDIES OF TROPOSPHERIC-WAVE PROPAGATION

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that there is an urgent need for guidance to be given to engineers in the planning of broadcasting, television and fixed link services in the frequency band 30-4000 Mc/s;

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* This Recommendation replaces Recommendation No. 110.

(b) that it is important to determine how the field strength in this frequency band depends on meteorological conditions and upon the nature of the terrain at locations both within and beyond the horizon;

(c) that to facilitate the comparison of results, it is desirable that administrations and operating agencies should present field-strength data in a uniform manner;

(d) that it is not yet possible finally to establish a method of presenting results and a system of statistical analysis best suited to the requirements expressed in paragraph *(a)* and *(b)*;

UNANIMOUSLY RECOMMENDS

1. that the field strengths exceeded for 0.1%, 1%, 10%, 50%, 90%, 99% and 99.9% of the overall time should, whenever possible, be determined for all locations at which measurements are made;

2. that in the case of broadcasting and television the median values of field strength exceeded at 10%, 50% and 90% of the locations should be determined;

3. that it is desirable to amplify these overall statistics by a more detailed and precise analysis; for this purpose the methods proposed in Annex I of the present Recommendation or in Warsaw Document No. 172 (France) might be taken as a basis;

4. that the statistical results of field-strength measurements should be displayed on probability paper. The field strength should be plotted along the ordinate and expressed in decibels relative to 1 microvolt per metre, the values of field strength increasing, moving up the ordinate. The percentage of total valid recording time, or percentage of locations should be plotted along the abscissa, with a scale following the Gaussian probability law, percentages increasing from left to right. An example of a log-normal distribution plotted on probability paper is given in Ann. II;

5. that all measured values of field strength should be normalised to correspond to those that would be obtained with a vertical half-wave dipole, or with a similar horizontal dipole placed broadside to the direction of the receiving point, the dipole in each case being at least several wave-lengths above the ground and radiating 1 kW;

6. that in the case of broadcasting and television, and whenever possible, all measurements should be referred to a receiving aerial 10 metres above the ground and this aerial should not be highly directive in the vertical plane.

ANNEX I

It should be noted that the recommendations given above refer particularly to the propagation of waves over long distances (especially in connection with interference problems in sound and television broadcasting) and also to propagation characteristics within the service areas of sound and television broadcasting stations. While in these cases the first interest lies in ascertaining those values of field strength exceeded for various percentages of the overall time at varying distances, for a more detailed analysis it might, however, be useful to analyse measurements within unit periods of 1 hour. This latter procedure would permit studies to be made of diurnal variations, while seasonal variations could similarly conveniently be studied by grouping the values obtained at specified hours of the day for a whole month and examining the change of field strength distributions from month to month. Presentation of the results in this form would, moreover, permit later correlation of radio measurements with meteorological data.

For the study of propagation over fixed optical links, in the VHF (metric), UHF (decimetric) or SHF (centimetric) bands, a more precise correlation between received field strength and prevailing atmospheric conditions might be required. For this and other reasons it is considered that results should be capable of being presented separately for each hour of the day of each month during which tests are being conducted. At the same time, overall distribution curves for periods of one month will be required to permit a study of seasonal variations; overall distribution curves for even longer periods will also, no doubt, be required by the planning engineer. It is generally convenient to refer results to the free space value for the distance and other conditions concerned.

Although it will usually be necessary to preserve, for reference, the original charts upon which the field-strength variations are recorded, it is essential that some much simpler and more conveniently accessible means of displaying the essential data be employed. One method is to plot the maximum, median and minimum field strengths for each hour on linear graph paper, the spread of results within the hour being shown by a vertical line. In addition, by determining the hourly median value or value over some other percentage of the time, it is possible to obtain for any given hour of the day, the statistical distribution of these values for a month (or any other desired period of time).

ANNEX II

The Gaussian probability scale is defined by

$$P(x) = \frac{1}{\sqrt{2\pi}} \int_{x}^{\infty} e^{-\frac{1}{2}\xi^2} d\xi$$

For abscissae $x = 0$, $x \rightarrow \infty$ and $x \rightarrow -\infty$, the corresponding values of the probability P (x) are 50%, 0% and 100%.

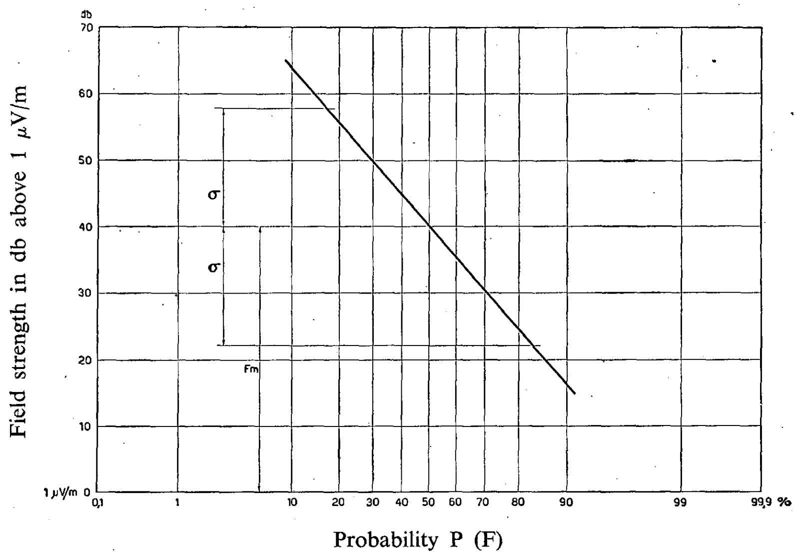
An amplitude Gaussian distribution for a field strength F measured in db (log-normal distribution) is given by:

$$P(F) = \frac{1}{\delta\sqrt{2\pi}} \int_{F}^{\infty} e^{-\frac{1}{2}\left(\frac{f-F_m}{\sigma}\right)^2} df$$

P (F) is the probability (percentage of time or locations) that the field strength E expressed in db above 1 μV/m ($F = 20 \log E$) will exceed the level F. F_m is the median value of F, i.e. that which is exceeded for 50% of the time or locations. σ is the standard deviation, so that $P(F_m - \sigma) \approx 84\%$ and $P(F_m + \sigma) \approx 16\%$.

It is often of interest to know the field strength exceeded for 1% or 10% of the time; when the distribution is log-normal, the distribution curve is a straight line, the corresponding deviations are given by 2.32 σ and 1.28 σ.

The accompanying graph illustrates the presentation of log-normal distribution.



GRAPH SHOWING LOG-NORMAL DISTRIBUTION OF FIELD-STRENGTH MEASUREMENTS

RECOMMENDATION No. 171 *

FIELD-STRENGTH MEASUREMENT

Influence of local conditions on interpretation and accuracy of measurements of field strength

(Question No. 8 § A. 5)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that field strengths are a function of time and local conditions;

(b) that is is desirable to distinguish between the effects of these two influences;

(c) that the most satisfactory site for observing the characteristics of the field strength as a function of time is one clear of buildings, flat and homogeneous over a wide area and to a sufficient distance without trees, wire lines, antennae or buried conductors;

(d) that the nature of the soil in the neighbourhood of the measuring site may affect the value of the field strength observed and that its influence depends on frequency, polarisation, type of antenna and the angle of arrival of the waves;

UNANIMOUSLY RECOMMENDS

1. that sites for measuring time variations of field strength should, whenever possible, have the characteristics indicated in paragraph *(c)* above;

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* This Recommendation replaces Recommendation No. 114.

2. that measurements of the space variability of field strength for determining the service area of transmitters should be made, in so far as is practicable, at a variety of locations typical of those where service might be required;

3. that measurements should be accompanied by:

3.1 a description of the equipment and the method used, with an assessment of the accuracy obtained;

3.2 a description of the measurement site, with details of any obstructions or inhomogeneities in the vicinity, regardless of direction, (buildings, overhead wires, cables, trees, cliffs, railways, roads, stretches of water, waterways etc.) and details of any buried conductors or non-uniformity of the ground;

3.3 values of the conductivity and dielectric constant of the soil, or failing this, information on the nature of the ground and its moisture content;

4. that, whenever possible, the variations of the field strength around the measurement site should be investigated by means of numerous measurements at different locations in the vicinity.

RECOMMENDATION No. 172 *

PREDICTION OF SOLAR INDEX

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that it is desirable to have an internationally agreed prediction of smoothed relative sunspot numbers for about six months in advance;

(b) that it is impracticable at present to obtain complete agreement on methods of prediction;

(c) that the methods studied by the Director of the C.C.I.R. based on autocorrelation techniques, have not led to a completely satisfactory method of prediction of solar index;

UNANIMOUSLY RECOMMENDS

1. that the Director of the C.C.I.R. should continue the studies on this subject;

2. that apart from objective autocorrelation methods, subjective methods, such as cycle matching, might also be used;

3. that as soon as practicable, predictions should be published by the Director of the C.C.I.R. with an indication of an estimated probable error;

4. that these predictions should be published in the " Telecommunication Journal " and should be made available monthly to all administrations and other interested parties by an inexpensive postcard subscription service utilising air mail;

5. that the Director of the C.C.I.R. and the various administrations should present to the next Plenary Assembly of the C.C.I.R. their comments on these predictions, stressing in particular:
   - the usefulness of 12-month smoothed averages,
   - the usefulness of predictions 6 months in advance,
   - the applicability of these predictions to their communication problems.

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* This Recommendation replaces Recommendation No. 117.

RECOMMENDATION No. 173 *

PROTECTION OF FREQUENCIES USED FOR RADIO ASTRONOMICAL MEASUREMENTS

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that protection from interference to radio astronomical measurements is required;

(b) that, for the observation of known spectral lines, certain bands at specific frequencies are of particular importance;

(c) that account should be taken of the Doppler shifts of the lines resulting from the motion of the sources which are in general receding from the observer;

(d) that for other types of radio astronomical observations a certain number of frequency bands are in use, the exact positions of which in the spectrum are not of critical importance;

(e) that a considerable degree of protection can be achieved by appropriate frequency assignments on a national rather than on an international basis;

(f) that, nevertheless, it may be impracticable to afford such protection in or near populous or industrial regions;

UNANIMOUSLY RECOMMENDS

1. that radio astronomers should be encouraged to choose sites as free as possible from interference;

2. that administrations should afford all practicable protection from interference to radio astronomical measurements in general, but give particular attention to the protection of observations of line emissions known or thought to occur in the following bands:

Line	Line frequency (Mc/s)	Band to be protected (Mc/s)
Deuterium	327.4	322 - 329
Hydrogen	1420.4	1400 - 1427
OH	1667	1645 - 1675

3. that administrations, in seeking to afford protection to particular radio astronomical observations, should attempt to limit harmonic radiations falling in the bands indicated above.

Note 1. — Administrations might consider the dual advantage to radio-astronomy of reserving or otherwise protecting the second and third sub-harmonics (1/2 and 1/3) of the line-frequency bands which could then be used for other radio astronomical purposes.

Note 2. — The Director of the C.C.I.R. should communicate this Recommendation to U.R.S.I.

* This Recommendation replaces Recommendation No. 118.

RECOMMENDATION No. 174 *

WORLD-WIDE ATMOSPHERIC RADIO NOISE MEASUREMENTS

(Study Programme No. 65 **)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that there is need for reliable quantitative information of an objective nature on world-wide radio noise levels;

(b) that one type of equipment suitable for obtaining such information, and which has been developed by the Central Radio Propagation Laboratory of the National Bureau of Standards, will automatically record detailed information on both the level and the character of the noise (See Annex, which is given for information only);

(c) that although other equipments developed by other countries may also be used to make such measurements, the C.R.P.L. equipment is being installed in a network of stations to be operated by a number of administrations (see list of stations in the Annex) during the Geophysical Year and possibly for several years thereafter;

(d) that uniform recording techniques will be in use at all these stations and, as a consequence, the data can be compared directly without the use of questionable conversion factors;

(e) that a revision of Report No. 65 is likely to be required as soon as a sufficient quantity of new reliable data are obtained;

UNANIMOUSLY RECOMMENDS

1. that interested administrations should co-operate in implementing and carrying out this measurement programme;

2. that the results of this world-wide measurement programme, as well as the results of other measurement programmes, should be considered in making a future revision of Report No. 65.

ANNEX

The Central Radio Propagation Laboratory of the National Bureau of Standards is establishing a programme for atmospheric radio noise measurements throughout the world. It is hoped that ultimately 50 recording stations will be involved. In order to cover the areas from which recorded data are needed, it is desirable to work with other agencies interested in similar work and other governments, institutions, or individuals who are interested in the noise studies.

In order to ensure uniform results from all stations it will be necessary to use, as nearly as possible, uniform equipment and procedures to obtain the data required. Therefore, it is the

* This Recommendation replaces Recommendation No. 119.

** This Study Programme has been replaced by Study Programme No. 96 (VI).

present plan of the Central Radio Propagation Laboratory to supply the equipment and procedures for the recording of data to each of the co-operating agencies.

The equipment to be furnished will consist of a radio noise recorder and antenna system. The National Bureau of Standards radio noise recorder measures the absolute power level of the noise received by a standard antenna, as averaged over a seven-minute interval. The range of average power levels that can be recorded is 100 db. The averaging process is accurate for fluctuations of noise power up to 40 db, regardless of the form of the fluctuations. The recorder operates at frequencies of 15 kc/s, 51 kc/s, 170 kc/s, 535 kc/s, 2.5 Mc/s, 5 Mc/s, 10 Mc/s and 20 Mc/s. The noise power level at each of these frequencies is sampled twice an hour, and the average power level is recorded on a paper tape chart.

The equipment will operate satisfactorily in the presence of strong off-band signals. The rejection for a signal that is 1 kc/s or farther from the recording frequency is 126 db. The equipment is fully automatic and carries on the measurements unattended. The stability of the equipment is such that, if necessary, it will operate for a week without attention and still maintain an accuracy of 2 db.

At some locations measurements will be made of two additional moments of the received noise, the average voltage and the average logarithm of the noise envelope. Statistical studies of the nature of the short-time variations of the noise have indicated that the amplitude-time distribution of the noise envelope can be closely approximated by a knowledge of the three moments recorded by this equipment and therefore a good measurement of the characteristics of the noise will be provided at these locations (see Annex II, Doc. No. 345, Warsaw, 1956).

The antenna system, consisting of a whip antenna and 100-ft. (about 30 m) radials for a ground plane, completes the basic equipment. Other measuring and calibrating equipment required for operation of the basic equipment will also be furnished. On installations where it is possible to do so, the power source for operation of the equipment should be the local power distribution system. Diesel powered generators will be furnished where commercial power is not available.

Operation of the equipment will normally be done by one man. The duties will be a daily calibration, and a tabulation on a record sheet of the measurements for each hour by frequencies. These report sheets, along with the recording tape, will be forwarded to Boulder, Colorado, U.S.A., for further processing. There will be routine adjustment and maintenance work to be done at varying times.

The installation of the equipment is to be made in a structure eight feet high (about 2.4 m) in the centre of the radial system. This structure will have special features such as an all-metal roof, attaching straps for the radials and an entrance panel for the whip-type antenna. Plans and specifications will be furnished to the co-operating agency for the erection of a housing structure.

PROPOSED RADIO NOISE RECORDING NETWORK TO BE IN OPERATION BY THE BEGINNING OF THE INTERNATIONAL GEOPHYSICAL YEAR

Location of station	Latitude	Longitude	Operated by	Type of measurements
Accra, Gold Coast	5 N	0	UK	3 moments
Bill, Wyoming, U.S.A. . .	42 N	105 W	NBS-CRPL	3 moments
Boulder, Colorado, U.S.A.	40 N	105 W	NBS-CRPL	Mean power
Darwin, Australia	12 S	131 E	Australia	3 moments, DF
Front Royal, Virginia, U.S.A.	39 N	77 W	NBS-CRPL	Mean voltage
Johannesburg, S. Africa .	26 S	28 E	TRL-CSIR	Mean power
Marie Byrd Base, Antarctica	80 S	120 W	NBS-CRPL	Mean power
Maui Hawaiian Islands . .	21 N	157 W	NBS-CRPL	3 moments, DF
Panama, Canal Zone . . .	9 N	80 W	SCRPA	Mean power
Rabat, Morocco	34 N	3 E	France	Mean power
Rio de Janeiro, Brazil . .	23 S	43 W	Brazil	3 moments, DF
Singapore, Malaya	2 N	104 E	UK	Mean power
Stockholm, Sweden . . .	59 N	18 E	Sweden	3 moments
Thule, Greenland	76 N	70 W	SCRPA	Mean power
Tokyo, Japan	36 N	140 E	Japan	3 moments, DF
India *			India	3 moments

* Equipment purchased by the Government of India.

RECOMMENDATION No. 175 *

ATMOSPHERIC RADIO NOISE DATA

The C.C.I.R., (Geneva, 1951 — Warsaw, 1956)

CONSIDERING

(a) that the problem of assembling useful data on world-wide atmospheric radio noise levels has been before the C.C.I.R. for a number of years;

(b) that Report No. 65 has been prepared in response to the need for up-to-date information of world-wide applicability;

RECOMMENDS

1. that in assessing the level of atmospheric radio noise throughout the world, the information

* This Recommendation replaces Recommendations Nos. 67 and 120. The Roumanian P. R. has since reserved its opinion on this Recommendation.

contained in Report No. 65 should be used, with some caution, until sufficient new data to justify a revision have been accumulated and made available;

2. that the Director of the C.C.I.R. should issue Report No. 65 in a separate printed form for public sale at as low a price as possible.

RECOMMENDATION No. 176

BASIC PREDICTION INFORMATION FOR IONOSPHERIC PROPAGATION

(Study Programme No. 60 (VI))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the objectives of Study Programme No. 60 (VI) have not yet been attained;

(b) that the I.F.R.B. has made known its urgent need for the most reliable median F2 MUF data which are available at the present time, for application on a world-wide scale, especially in connection with preparations for the next Administrative Radio Conference;

UNANIMOUSLY RECOMMENDS

1. that Study Group No. VI should study by correspondence the improvements that could be obtained by adopting the UT type of presentation and that the Chairman of this Study Group should send the results of this study, through the Director of the C.C.I.R., to the I.F.R.B. at the latest within one year of the close of the VIIIth Plenary Assembly and, if possible, within six months;

2. that administrations should make available to the I.F.R.B., for information, through the Chairman of Study Group No. VI and the Director of the C.C.I.R., operational data which may permit comparison with predictions for selected circuits. This should be in a suitable form and comprise statistics of fade-in and fade-out times and should indicate the effect of factors other than propagation conditions.

RECOMMENDATION No. 177

METHODS FOR ESTIMATING SKY-WAVE FIELD STRENGTH ON FREQUENCIES ABOVE 1500 kc/s FOR THE I.F.R.B.

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that, although question *(b)* of the Annex to Report No. 56 cannot yet be fully answered, a new method for calculation by the I.F.R.B. of field strengths above 1500 kc/s has been proposed to replace the method used at present and which was developed in 1947;

(b) that the I.F.R.B., in Doc. No. 507 (Warsaw), has indicated its need for an assessment of the precision of this new method submitted in response to this question and of the technical factors which affect the practicability of applying the new method;

(c) that it is estimated that the application of a new method, calling for a large scale revision of the I.F.R.B.'s existing propagation standards, would require at least two years for completion, even with some increase in the Board's present resources;

(d) the need of the I.F.R.B. for the best and most practical method available at present, especially in connection with its preparations for the administrative Radio Conference and in view of the possible use by that Conference of the standards of the I.F.R.B.;

(e) that, in accordance with Recommendation No. 14 of the E.A.R.C., the C.C.I.R. should, at the earliest possible date, make available to the administrations and to the I.F.R.B. interim reports on the matters upon which advice is urgently needed, even though the studies are not complete;

UNANIMOUSLY RECOMMENDS

1. that the assessment referred to in *(b)* above and the possibility of improving and/or simplifying any method proposed for use by the I.F.R.B. be the subject of urgent study by a small working party of the C.C.I.R. Study Group No. VI;

2. that the following administrations concerned with the computation of propagation data be invited to participate in the working party:

France (Chairman)
United States of America
Federal German Republic
Roumanian P.R.
Czechoslovakia
U.S.S.R.

3. that the work of the working party be organised by correspondence and be coordinated by its Chairman who will keep the Chairman of Study Group No. VI and the Director of the C.C.I.R. informed of the progress;

4. that a meeting of the working party be convened within one year of the close of the VIIIth Plenary Assembly or, if possible, within six months, for an exchange of views for the purpose of establishing, at the earliest date possible, an interim report to be presented, through the Chairman of Study Group VI, to the Director of the C.C.I.R. for further action.

RECOMMENDATION No. 178 *

ESTIMATION OF SKY-WAVE FIELD STRENGTH ON FREQUENCIES ABOVE 1500 kc/s

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the basic method used in estimating sky-wave field strengths for frequencies above 1500 kc/s by the I.F.R.B., the P.F.B., the Mexico City High Frequency Broadcasting Conference, and by a number of administrations was given in N.B.S. Circular 462;

* The Bielorussian S.S.R., the R.P. of Bulgaria, the Roumanian P.R., the Ukrainian S.S.R. and the U.S.S.R. reserved their opinion on this Recommendation.

(b) that in the above method certain procedures, using an absorption factor and justified by the state of knowledge at the time, were introduced in connection with multi-hop transmission to render it less laborious;

(c) that detailed observation of sky-wave field strengths made in various parts of the world have long indicated the desirability of using a more refined procedure taking account of individual modes;

(d) that in this connection R.P.U. Technical Report No. 9 represents a detailed revision of the method given in N.B.S. Circular 462 and contains a number of comparisons with observations;

(e) that the improvement in accuracy of field-strength estimates based on methods taking account of individual modes may not be sufficiently important in some cases to justify the complete abandonment of the earlier and simpler method;

RECOMMENDS

1. the continued use of the method contained in N.B.S. Circular 462 for the estimation of sky-wave field strengths on frequencies above 1500 kc/s in cases where the answer it gives is amply accurate for the purpose in hand;

2. that the method given in R.P.U. Technical Report No. 9 may be used with caution, at least in cases where the simpler method does not take adequate account of detailed propagation characteristics and allied operating conditions, until further experience substantiates its use or necessitates its revision;

3. that administrations and other users of the above method who have reason to believe that any of the basic information embodied in its procedures conflicts with their particular experience should assist the C.C.I.R. by supplying the data that will enable any necessary correction to be made;

4. that further comparisons should be made to define the conditions under which there is a difference of practical importance between the estimates made by the method given in R.P.U. Technical Report No. 9 and that in N.B.S. Circular 462, and to check the methods against observations;

5. that in making such comparisons special attention should be paid to tropical regions of low geomagnetic latitude where the E-layer critical frequencies may be high during the daytime and there may be considerable absorption at night.

Note. — R.P.U. Technical Report No. 9 is available, according to Doc. No. 285 of Warsaw, as Catalogue No. PB 103045 from:
The Office of Technical Services, Department of Commerce, Washington 25, D.C., U.S.A.

RECOMMENDATION No. 179 *

STANDARD FREQUENCY TRANSMISSIONS AND TIME SIGNALS

(Question No. 140 (VII)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the International Administrative Radio Conference, Atlantic City, 1947, allocated the frequency bands 2.5 Mc/s ± 5 kc/s (2.5 Mc/s ± 2 kc/s in Region 1), 5 Mc/s ± 5 kc/s, 10 Mc/s ± 5 kc/s, 15 Mc/s ± 10 kc/s, 20 Mc/s ± 10 kc/s, and 25 Mc/s ± 10 kc/s, requesting the C.C.I.R. to study the question of establishing and operating a world-wide standard-frequency and time service;

(b) that the operation of 10 standard-frequency and time-signal stations, 4 of which were put into operation since the VIIIth Plenary Assembly (London 1953), has allowed the collection of considerable data on their performance;

(c) that the usefulness of the standard-frequency transmissions would be improved appreciably if the exclusive bands allocated for the service were cleared from stations other than standard-frequency stations, since the present standard-frequency service is still experiencing interference from other services operating in the standard-frequency bands;

UNANIMOUSLY RECOMMENDS

1. that a standard-frequency transmission should comprise a standard carrier frequency, modulated by time signals and, if desired, by one or more standard audio frequencies;

2. that the standard audio frequencies should be chosen preferably from 440, 600, or 1000 c/s;

3. that the time signals should consist of impulses repeated at intervals of one second and maintained within 50 milliseconds of Universal Time, UT2.**

4. that the impulses should consist preferably of n cycles of 200 n c/s tone; where n is an integral number limited by the bands allotted for standard-frequency transmissions and time signals;

5. that the first impulse of each minute be prolonged so as to be easily identified;

6. that preferably the time signals should be transmitted without any other modulation for periods of 60 seconds or more and a total of at least 10 minutes per hour;

7. that each standard-frequency station have a silent period of at least 4 minutes per hour;

8. that the frequencies transmitted should be accurate within ± 2 parts in 10^8;

9. that the time intervals transmitted should be accurate within ± 2 parts in 10^8 ± 1 microsecond;

10. that the requirements of paragraphs 8 and 9 may be realised by direct or indirect reference to an atomic or molecular frequency standard, e.g., that based on the Cesium Fm (4.0) ⟷ (3.0) resonance at zero field (9,192,631,830 ± 10 c/s); ***

* This Recommendation replaces Recommendation No. 122.

** Provisional Uniform Universal Time No. 2 as adopted by the I.A.U., Dublin, 1955.

*** The observer of the B.I.H stated that his organisation could not guarantee the accuracy of this value.

11. that each administration should promptly publish:
— the provisional measured values of frequencies and time signals for each day at a specified time or for each group of 5 days at a specified time,
— the date, time and magnitude of adjustments to the time signals,
— the date, time and magnitude of adjustments to the frequency which exceed one part in 10^9 per day;

12. that each administration should send the following to the Director of the C.C.I.R. for collation and distribution;
— the final measured values of frequencies and time signals for each calendar year, the values being given for each group of 5 days at a specified time,
— the date, time and magnitude of adjustments to the time signals,
— the date, time and magnitude of adjustments to the frequency which exceed one part in 10^9 per day;

13. that each administration should coordinate with the Chairman and Vice-Chairman of Study Group No. VII, any new standard-frequency broadcasts or any changes in existing standard-frequency broadcasts;

14. that each administration should send all pertinent new information on standard-frequency broadcasting stations to the Chairman and Vice-Chairman of Study Group No. VII for forwarding to the Telecommunication Journal of the I.T.U. for publication in that Journal;

15. that no new standard-frequency station, operating in the standard frequency bands, shall be notified to the I.F.R.B. until experimental investigations and co-ordination have been completed in accordance with Recommendation No. 2 to the C.C.I.R. in the Radio Regulations;

16. that any standard-frequency station operating within the framework of this Recommendation and found to be causing harmful interference within the service areas of other established stations should eliminate such interference;

17. that administrations which have not already done so should clear the bands exclusively allocated for standard-frequency broadcasts and time signals according to the clearance programme proposed by the I.F.R.B. as soon as possible;

18. that co-operation with the B.I.H. and the U.R.S.I. should continue.

RECOMMENDATION No. 180 *

ACCURACY OF FREQUENCY MEASUREMENTS AT MONITORING STATIONS

The C.C.I.R., (Stockholm, 1948 - Warsaw, 1956)

CONSIDERING

(a) the requirements of the I.F.R.B. in respect of the necessary frequency measurements for the efficient performance of its duties;

(b) the general availability of suitable monitoring equipments for frequency measurements;

(c) the desirability that the error of frequency measurement shall be several times better than the tolerance used in practice and shall not exceed one-tenth of the tolerance specified in Col. 3 of the table of frequency tolerances (App. 3 to the Radio Regulations, Atlantic City, 1947);

* This Recommendation replaces Recommendation No. 20.

UNANIMOUSLY RECOMMENDS

that monitoring equipments and procedures used shall be such that frequency measurements shall be made with an accuracy equal to or better than that specified in the following table:

Type of measurement	Accuracy
a) Measurements, at fixed monitoring stations, of the frequencies of stations, excluding broadcasting stations, operating in the band 10 kc/s — 4000 kc/s.	± 5 parts in 10^6 (or, where this would be less than ± 2 c/s, to an accuracy within ± 2 c/s)
b) Measurements, at fixed monitoring stations, of the frequencies of broadcasting stations operating in the band 10 kc/s — 4000 kc/s.	± 2 c/s
c) Measurements, at fixed monitoring stations, of the frequencies of stations, excluding "standard" television stations †, operating in the band 4000 kc/s — 500 Mc/s	± 2 parts in 10^6
d) Measurements of the frequencies of "standard" television stations †, operating in the band 30 Mc/s — 300 Mc/s.	± 100 c/s
e) Measurements at mobile monitoring stations of the frequencies of stations, excluding standard television stations †, operating in the band 50 Mc/s — 500 Mc/s.	± 5 parts in 10^6

† By "standard" television stations are meant stations operating in the appropriate television broadcasting bands.

RECOMMENDATION No. 181 *

ACCURACY OF FIELD-STRENGTH MEASUREMENTS BY MONITORING STATIONS

(Question No. 55)

The C.C.I.R., (London, 1953—Warsaw, 1956)

CONSIDERING

(a) that field intensity measurements are being made by monitoring stations in the frequency range from 15 kc/s to 300 Mc/s;

(b) that the order of accuracy of such measurements would make them suitable for use in connection with the international registration and assignment of frequencies;

(c) that the publication of such data by monitoring stations is therefore desirable;

* This Recommendation replaces Recommendation No. 123.

UNANIMOUSLY RECOMMENDS

1. that, to obtain the accuracy specified in the table below, the field-strength measuring equipment at monitoring stations should be installed, calibrated and operated in accordance with the terms contained in the Annex to this Recommendation;

2. that, except where there are limitations due to receiver noise level, atmospheric noise or external interference, the accuracy to be expected in field-strength measurements at intensities above 1 μV/m is as shown in the following table.

Frequency band	Accuracy of measurement
Below 3000 kc/s	$\pm$1.5 db
3000 to 30 000 kc/s.	$\pm$2.0 db
30 to 300 Mc/s	$\pm$3.0 db

The accuracy specified in the table is obtainable with apparatus either manually operated or used with automatic recorders, provided that the time constant of the combined equipment is 0.1 second or less, when measuring unmodulated carriers, modulated emissions of all types except A1, A2, P and emissions with suppressed or reduced carriers;

3. that when, because of interference, signal instability or for other reasons, accuracy within these limits is not obtainable, the measurements should nevertheless receive due consideration if their accuracy is indicated;

4. that studies of methods and equipment for field-strength measurements at monitoring stations should be continued;

5. that further studies are not necessary at this time to improve the accuracy of the calibration of signal generators for field-strength measurements by the use of various secondary voltage standards or other means.

ANNEX

1. Antenna installation

(a) *Frequencies of 30 Mc/s and below.*

It is recommended that, for frequencies of 30 Mc/s and below, vertical antennae three-eighths wavelength or less in height should be used, with ground systems consisting of buried radial conductors at least half wavelength long or of an equivalent ground screen near the earth.

The radial conductors should be spaced 10 degrees or less apart. It is necessary to ensure that no significant distortion of the field being measured is caused by obstructions, buildings, buried pipes etc.

Vertical antennae as described above, are recommended as standard for field-strength measurement by monitoring stations, for ionospheric signals on frequencies of 30 Mc/s and below for the following reasons:

1. It is generally accepted that random variations in polarisation of ionospheric waves are such that the vertically polarised component is, in general, substantially equal to the horizontal component.

2. The effective height of a vertical stub-antenna is substantially independent of wavelength.
3. The disadvantage of using a horizontal antenna is that its gain depends on its elevation above the ground and on its orientation.

(b) *Frequencies above 30 Mc/s.*

Antennae for field-strength measurement on frequencies above 30 Mc/s are recommended to conform to the following conditions:

1. The receiving antenna must have the same polarisation as the transmitting antenna. For these frequencies stub-antennae, or half-wave dipoles can be used, as appropriate.
2. VHF (metric) antennae should be located at a standard height above ground, representative of average receiving conditions, and a height of 10 metres is recommended.
3. There should be a clearance of at least 100 feet (30 metres) from other structures.

(c) *Antenna factor.*

For frequencies below 30 Mc/s, the error in the determination of the antenna factor should be kept within ± 1 db and for frequencies from 30 Mc/s to 300 Mc/s it should be within ± 2 db. The antenna factor includes coupling or mismatch losses between antenna and receiver in the parts not common to the measuring and calibrating circuits.

2. Receiver

The receiver should have high inherent stability with respect to gain, frequency, bandwidth and attenuation calibrations. Particular attention is drawn to the desirability of using voltage regulators and crystal controlled oscillators to limit the effect of the receiver on the overall accuracy of field-strength measurements. Nevertheless, the frequent use of a signal generator for calibration of the field-strength measuring equipment is recommended. With current designs using recording equipment, calibration should be carried out at least daily.

3. Signal generator

The attainable accuracy of standard signal generators in the voltage range above $1 \mu V$ is ± 1 db.

This accuracy can be obtained using a bolometer secondary voltage standard or other recognised methods of comparable precision. However it should be noted that there is now available an improved device capable of greater accuracy, namely the micro-potentiometer.

The calibration of the signal generator should be checked frequently by means of such standards in order to maintain the desired accuracy of measurement.

Bibliography. — Selby, M. C., " Accurate R.F. voltages ". Communications and Electronics. *Trans. A.I.E.E.* No. 6, Page 158-164, May 1953.

RECOMMENDATION No. 182

AUTOMATIC MONITORING OF OCCUPANCY OF THE RADIO-FREQUENCY SPECTRUM

(Question No. 88 *)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the increasing demand for radio services requires the most efficient use of the radio-frequency spectrum;

(b) that the most efficient use of the spectrum can be arranged only when the distribution in time, magnitude and direction of the signals occupying it is known;

(c) that automatic monitoring equipment is now in use by administrations and that further development in automatic observation is foreseen, including methods for the analysis of records;

(d) that by the use of automatic monitoring equipment a number of parameters can be evaluated which are of considerable value in enabling more efficient utilisation of the spectrum;

UNANIMOUSLY RECOMMENDS

1. that, although automatic monitoring equipment will not completely replace manual observations, it is a valuable aid. Administrations should be encouraged to undertake the use and further development of such equipment;

2. that, although further study is needed to enable administrations and frequency planning authorities to derive the greatest benefit from the records produced, it is desirable that equipment should possess the following principal characteristics:

a) total frequency range	minimum 2 to 30 Mc/s; desirable 10 kc/s to 30 Mc/s or more;
b) swept frequency range	variable, typical range 100 to 1000 kc/s;
c) number of sweeps per hour	variable, 30 to 180;
d) maximum rates of sweeping	variable; dependent on the desired frequency resolution for the band being swept and the class or classes of emission being recorded;
e) sensitivity	1 μV/m or better;
f) resolving power	variable; approximately 100 c/s to 1000 c/s;
g) signal characteristics recorded	(i) carrier frequency, (ii) bandwidth, (iii) field strength, (iv) duration of occupancy;

* This Question has been replaced by Question No. 143 (VIII).

h) size of records — paper chart 20 cm × 32 cm for twenty-four hours; calibration at intervals of 1, 10 or 100 kc/s as appropriate.

3. that it is desirable that the records should also contain, if possible, the following information:

(a) name and location of monitoring station;

(b) date and period of recording;

(c) frequency band;

(d) signal identification, as appropriate;

(e) class of emission, as appropriate;

(f) direction of signal;

(g) noise level.

RECOMMENDATION No. 183

INTERNATIONAL WIDE-BAND RADIO RELAY SYSTEMS OPERATING ON FREQUENCIES ABOVE ABOUT 30 Mc/s

Interconnection of multiplex systems

(Question No. 90)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that frequency-division multiplex in accordance with C.C.I.F. recommendations is used widely for multi-channel telephony on line and for radio relay systems, while time-division multiplex is used only for radio relay systems of limited channel capacity;

(b) that interconnections between systems employing frequency-division multiplex in accordance with C.C.I.F. recommendations can readily be made for groups of 12 and supergroups of 60 channels, while interconnections between existing time-division multiplex systems on the one hand and frequency-division multiplex systems on the other must be made channel by channel at audio frequencies, requiring the use of additional equipment at the connection point and having disadvantages from the standpoints of economy, operation and circuit quality;

(c) that future time-division multiplex systems may combine small blocks of speech channels by frequency-division multiplex before multiplexing these blocks by time-division methods;

(d) that for level stabilisation, etc., some frequency-division multiplex systems transmit pilot signals which it is advantageous to transmit from one switching section to the next and that the extension of such pilot signals over a time-division multiplex system may give rise to appreciable complications;

(e) that the interconnection of basically different types of multiplex systems would generally add to the problems of maintenance, since circuit techniques, routine measurements and fault-finding procedures would tend to differ;

UNANIMOUSLY RECOMMENDS

1. that, where for operational reasons all international connections to a radio relay system must be made at audio frequencies, either a time-division multiplex or a frequency-division multiplex radio relay system may be employed and that, in such cases, interconnection should be made on a four-wire basis in accordance with the relevant C.C.I.F. rules;

2. that, where there are no operational reasons for an international connection between a new radio relay system and an existing radio relay or line system to be made at audio frequency, the new radio relay system should preferably use the same form of multiplexing as the system to which it is to be connected, in order to permit the connection to be made at baseband, intermediate or radio frequency as may be appropriate;

3. that, where the interconnection of time-division multiplex and frequency-division multiplex systems cannot be avoided, it should be made on a 4-wire basis in accordance with the relevant C.C.I.F. rules, either at audio frequencies or, if appropriate, at the baseband frequencies corresponding to the blocks of channels combined by frequency-division methods before time-division multiplexing;

4. that, in any case of international interconnection not covered by the above, frequency-division multiplex is in general to be preferred.

RECOMMENDATION No. 184

WIDE-BAND RADIO RELAY SYSTEMS

Frequency deviation for television

(Question No. 91) *

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the frequency deviation in a frequency-modulated radio relay system for the transmission of television is defined for the present purpose as the peak-to-peak excursion of the carrier frequency when fully modulated;

(b) that in existing radio relay systems which meet the draft report drawn up by the C.C.I.R. (meeting of Study Group No. IX, Geneva, 1954) for overall performance in long distance international television connections, various values of frequency deviation are used; e.g. 6, 8 and 10 Mc/s for 625 lines or less, and 8, 10 and 12 Mc/s for 819 lines;

(c) that the use of too large a frequency deviation results in an unnecessarily wide band of transmitted radio frequencies and should be avoided because of the need to economise in the use of the frequency spectrum;

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* This Question has been replaced by Question No. 146 (IX).

UNANIMOUSLY RECOMMENDS

that the value of the frequency deviation without pre-emphasis in international radio relay systems for the transmission of television should be 8 Mc/s for systems of 625 lines or less, and between 8 Mc/s and 12 Mc/s for systems with 819 lines. In particular international connections with 819-line television the value of deviation should be agreed between the administrations concerned.

RECOMMENDATION No. 185

PREFERRED CHARACTERISTICS OF MULTI-CHANNEL RADIOTELEPHONE SYSTEMS USING TIME-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

(Question No. 92 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that time-division multiplex radiotelephone systems may form parts of an international circuit;

(b) that general conformity with the relevant C.C.I.F. Recommendations in respect of overall performance measured between audio-frequency terminals, the method of making audio-frequency connections, and the method of signalling over international connections are already covered by Recommendations Nos. 40 and 186;

(c) that the art of time-division multiplex is still fluid and, while most systems in current use employ pulse-position modulation and provide not more than 24 speech channels, even the development of such systems has not yet reached the stage where general agreement is possible on all the baseband parameters necessary for interconnection at other than audio frequency (see Report No. 70);

(d) that certain systems now in service or under development provide for the transmission of several music channels or other types of service as an alternative to speech channels, or allow for more than 24 speech channels and that such systems could become of importance;

(e) that standardisation of baseband parameters at the present stage might therefore unduly restrict the future development of time-division multiplex systems;

UNANIMOUSLY RECOMMENDS

1. that where direct interconnection is required, at other than audio-frequencies, between two time-division multiplex systems across an international boundary, the connection between the two systems should be made in accordance with Recommendation No. 204;

2. that Part 2 of Question No. 92 (IX) should continue to be studied in the light of Report No. 70 and of the development of the art.

RECOMMENDATION No. 186

INTERCONNECTION AT AUDIO FREQUENCIES OF MULTI-CHANNEL RADIOTELEPHONE SYSTEMS USING TIME-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

(Question No. 92 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that time-division multiplex radio relay systems may form part of an international circuit;

(b) that international connections between such systems among themselves or with other radio relay or line systems may, at times, have to be made at audio frequencies;

(c) that general conformance with the relevant C.C.I.F. recommendations in respect of overall performance measured between audio-frequency terminals is already covered by Recommendation No. 40 relating to systems operating above about 30 Mc/s;

(d) that it will be necessary to signal over telephone circuits provided by means of such systems;

UNANIMOUSLY RECOMMENDS

that as far as is practicable, time-division multiplex radio relay systems forming part of an international circuit should conform to the relevant C.C.I.F. recommendations for modern types of telephone circuit in the following respects:

1. the method of making international connections at audio frequencies;
2. the method of signalling over international circuits.

RECOMMENDATION No. 187

INTERNATIONAL WIDE-BAND RADIO RELAY SYSTEMS OPERATING ON FREQUENCIES ABOVE ABOUT 30 Mc/s

Intermediate-frequency and radio-frequency characteristics for the transmission of television signals

(Questions Nos. 92 (IX) and 93 (IX))
(Study Programme No. 32 (XI))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that complete study of the preferred characteristics of radio relay systems for multi-channel telephony (Questions No. 92 and No. 93) and of the requirements for the transmission of television over long distances (Study Programme No. 32) may occupy a considerable time;

(b) that meanwhile, radio relay systems are being designed and installed for the transmission of multi-channel telephony and television;

(c) that the factors governing the choice of the characteristics of radio relay systems for television and for multi-channel telephony are largely similar;

(d) that if radio relay systems for television are considered independently from those for multi-channel telephony, an unnecessary diversity of characteristics may result;

(e) that at times it may be desirable to interconnect two systems, one of which is designed primarily for multi-channel telephony and the other for television;

(f) that even if radio relay systems are not used alternatively for television and telephony, economic and operational advantages may be obtained if, as far as possible, similar components are used in systems for telephony and television;

UNANIMOUSLY RECOMMENDS

that it is generally preferable for the major intermediate-frequency and radio-frequency characteristics of international radio relay systems for television to conform with those of large capacity systems for multi-channel telephony.

RECOMMENDATION No. 188

INTERCONNECTION AT AUDIO FREQUENCIES OF MULTI-CHANNEL RADIO RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

(Question No. 93 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that frequency-division multiplex radio relay systems may form part of an international circuit;

(b) that international connections between such systems among themselves or with other radio relay or line systems may, at times, have to be made at audio frequencies;

(c) that general conformance with the relevant C.C.I.F. recommendations in respect of overall performance measured between audio-frequency terminals is already covered by Recommmendation No. 40 relating to systems operating above about 30 Mc/s;

(d) that it will be necessary to signal over telephone circuits provided by means of such systems;

UNANIMOUSLY RECOMMENDS

that, as far as is practicable, frequency-division multiplex radio relay systems forming part of an international circuit should conform with the relevant C.C.I.F. recommendations for modern types of telephone circuit in the following respects:

1. the method of making international connections at audio frequencies;
2. the characteristics of the frequency-division multiplex terminal equipment;
3. the method of signalling over international circuits.

RECOMMENDATION No. 189

INTERCONNECTION AT BASEBAND FREQUENCIES OF MULTI-CHANNEL RADIO RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

(Question No. 93 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that frequency-division multiplex radio relay systems may form part of an international circuit;

(b) that international connections between such systems among themselves and with other radio relay or line systems may at times have to be made at baseband frequencies;

UNANIMOUSLY RECOMMENDS

that as far as is practicable, frequency-division multiplex radio relay systems forming part of an international circuit should conform to the preferred values shown in the Table for the following baseband characteristics:

1. maximum number of telephone channels;
2. highest and lowest frequencies of telephone traffic channels, that is, the frequency limits of the baseband;
3. nominal impedance of the baseband circuits at the point of interconnection;
4. relative input and output power levels, at the point of interconnection.*

Notes :

1) The particular preferred values for relative power level given in the table, excepting those for 120 channels, have been accepted by the C.C.I.F. They are not however considered to be essential (see Report No. 71) and other values may be used by agreement between the administrations concerned.

2) The level shown is referred to a point of zero relative level in the system, in accordance with the practice of the C.C.I.F.

3) For 12-channel systems either of the basic groups A (12-60 kc/s) or B (60-108 kc/s) recommended by the C.C.I.F. may be accommodated in the band 12-108 kc/s.

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* The choice and precise definition of a point of international interconnection is a subject for agreement between administrations concerned.

TABLE

Maximum number of telephone traffic channels	Frequency limits of baseband kc/s	Nominal impedance at baseband	Relative power level per channel (1) (2) db	
			Input	Output
24	12 - 108 (3)	150 ohms, bal.	—52	+ 4.5
60	12 - 252	150 ohms, bal.	—52	+ 1.75
	60 - 300	75 ohms, unbal.	—52	—15
120	12 - 552	150 ohms, bal.	—52	+ 1.75
	60 - 552	75 ohms, unbal.	—52	—15
240	60 - 1052	75 ohms, unbal.	—52	—15
600	60 - 2540	75 ohms, unbal.	—52	—15

Larger capacity systems are not excluded by the above table.

RECOMMENDATION No. 190

INTERCONNECTION AT INTERMEDIATE FREQUENCIES OF MULTI-CHANNEL RADIO RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

(Question No. 93 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that frequency-division multiplex radio relay systems may form part of an international circuit;

(b) that it may at times be desirable to make international connections between such systems at intermediate frequency;

(c) that it is desirable to adopt a preferred intermediate frequency to facilitate the optimum choice of a radio-frequency channelling plan;

UNANIMOUSLY RECOMMENDS

that as far as is practicable frequency-division multiplex radio relay systems forming part of an international circuit should have intermediate-frequency circuits which at a point of international connection conform to the preferred values listed below:

Centre value of the intermediate frequency

35 Mc/s for radio frequencies from 50 to 1000 Mc/s.
70 Mc/s for radio frequencies above 1000 Mc/s *.

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* Where it is desirable to interconnect systems transmitting 60 or 120 channels at frequencies above 1000 Mc/s with similar systems operating below 1000 Mc/s the intermediate frequency used shall be the subject of agreement between the administrations concerned.

Input and output levels of the intermediate-frequency signal

Output level : 0.5 volt r.m.s.
Input level: 0.3 volt r.m.s.

Impedance of the intermediate-frequency circuit

Nominal 75 ohms unbalanced.
Where relatively long intermediate-frequency connections are used an adequate return loss is required, but the determination of a recommended value for the minimum return loss and of the frequency range to which it applies, require further study.

RECOMMENDATION No. 191

INTERCONNECTION AT INTERMEDIATE AND RADIO FREQUENCIES OF FREQUENCY-MODULATED MULTI-CHANNEL RADIO RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

(Question No. 93 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that frequency-division multiplex systems using frequency modulation may form part of an international circuit;

(b) that it may at times be desirable to make international connections between such systems at intermediate or radio frequencies;

(c) that to economise in the use of the frequency spectrum it is desirable to use the smallest satisfactory frequency deviation;

(d) that the use of pre-emphasis allows a more uniform distribution of signal-to-noise ratio in the various channels of a multi-channel telephony system;

UNANIMOUSLY RECOMMENDS

that as far as is practicable frequency-division multiplex radio relay systems forming part of an international circuit should conform to the following characteristics:

1. *Frequency deviation without pre-emphasis*

Maximum number of channels	r.m.s. deviation per channel * (see Note)
24	35 kc/s
60	50, 100, 200 kc/s
120	50, 100, 200 kc/s
240	200 kc/s
600	200 kc/s

Larger capacity systems are not excluded.

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* For 1 mW 800 c/s tone at a point of zero reference level.

Note: It is recognised that in certain cases it may be desirable to use other deviations by agreement between the administrations concerned.

2. *Pre-emphasis characteristic*

2.1 Where pre-emphasis is to be used, the pre-emphasis characteristic should preferably be such that the effective (r.m.s.) deviation due to the multi-channel signal is the same with and without pre-emphasis and the total range of the pre-emphasis characteristic should not exceed 10 db.

2.2 Within the limits set by 2.1 above, the choice of pre-emphasis characteristic should be a matter for agreement between the administrations concerned.

RECOMMENDATION No. 192

INTERCONNECTION OF WIDE-BAND RADIO RELAY SYSTEMS AT RADIO FREQUENCIES

(Question No. 93 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that interconnection of radio relay systems at radio frequencies is the most common practice in international interconnection, and that it is desirable to define the preferred values of the characteristics for such interconnection and in particular the frequency plan to be used;

(b) that, in the case of certain existing circuits, use is made of special frequency plans since each administration is free to use any system of its own choice within its national territory;

(c) that Study Group No. IX of the C.C.I.R. has already indicated preferred values in a draft report (Docs. Nos. 62 - Rev. and 69 - Rev. Geneva, 1954) and that certain administrations utilise, in a 400 Mc/s band between 3800 and 4200 Mc/s, equipments operating in accordance with frequency plans as in these documents;

(d) that for technical reasons it has been found necessary to propose revision of the Geneva plan;

UNANIMOUSLY RECOMMENDS

that international connection of wide-band radio relay systems should preferably be carried out in conformity with Recommendations Nos. 193, 194 and 195. Nevertheless, in cases where such a course is justified, in order to utilise an existing design of equipment, international interconnection involving the equipment and systems referred to in paragraphs *(b)* and *(c)* above, or their possible extension, may be carried out, after agreement between the administrations concerned, in accordance with the particular characteristics of such installations.

RECOMMENDATION No. 193

STANDARDISATION OF MULTI-CHANNEL RADIO RELAY SYSTEMS
Radio-frequency interconnection of 240-channel telephony systems

(Question No. 93 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that in certain cases it is desirable to be able to interconnect wide-band radio relay systems on international circuits at radio frequencies;

(b) that it is desirable to use a radio-frequency arrangement for systems transmitting 240-channel telephony signals which is compatible with that for 600-channel telephony systems;

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to six go and six return radio-frequency channels, each accommodating 240 telephony channels, is the same as that given in paragraph 1 of Recommendation No. 194;

2. that where additional RF channel frequencies, each accommodating 240 telephony channels, are required on the same route, up to six additional pairs of channels may be interleaved between the initial channels at channel frequencies which are 14.5 Mc/s below those of the corresponding channel frequencies;

3. that in a section over which the international interconnection is arranged, all the go channels shall be in one half of the band and all the return channels shall be in the other half of the band;

4. that the initial six channels in any one half of the band should have a common polarisation;

5. that the second six channels in any one half of the band should have a common polarisation which differs from that of the initial six channels in the same half of the band, except by agreement between the administrations concerned;

6. that the value of the centre frequency f_o should be agreed between the administrations concerned. However, the attention of administrations is drawn to the fact that, in systems using an intermediate frequency and in which the frequency of each wide-band channel is shifted in passing from one section of the route to the next, interference due to harmonics of the shift frequency can be reduced by choosing a suitable value for f_o.

For example, if a 400 Mc/s band is chosen, located between 3800 and 4200 Mc/s, interference effects due to a shift frequency of 213 Mc/s can be reduced by choosing f_o = 4003.5 Mc/s. Alternatively, if it is desired to use a second frequency pattern, a centre frequency f_o = 3989 Mc/s might be used.

Similarly, in the 1800-2200 Mc/s band a first choice might be f_o = 2004.5 Mc/s and a second choice 1990 Mc/s. In the 1700-2100 Mc/s band, a first choice might be 1903 Mc/s, and a second choice 1888.5 Mc/s.

Other suitable frequencies can be chosen for other frequency bands.

RECOMMENDATION No. 194 *

STANDARDISATION OF MULTI-CHANNEL RADIO RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX

Radio-frequency interconnection of 600-channel telephony systems

(Question No. 93 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that in certain cases it is desirable to be able to interconnect wide-band radio relay systems on international circuits at radio frequencies;

(b) that in a frequency band 400 Mc/s wide it may be desirable to interconnect up to six go and six return wide-band channels;

(c) the economies may be achieved if at least three go and three return channels can be interconnected between systems each of which uses common transmit-receive aerials;

(d) that many interfering effects can be substantially reduced by a carefully planned arrangement of the radio frequencies in radio relay systems employing several radio-frequency channels;

(e) that in certain cases it may be desirable to interleave additional radio-frequency channels between those of the main pattern;

RECOMMENDS

1. that the preferred radio-frequency channel arrangement for up to six go and six return channels, each accommodating 600-telephone channels and operating at frequencies above about 1000 Mc/s, should be as shown in the attached figure and should be derived as follows:

Let f_o be the frequency of the centre of the band of frequencies occupied;

f_n be the centre frequency of one radio-frequency channel in the lower half of the band;

f_n^1 be the centre frequency of one radio-frequency channel in the upper half of the band;

then the frequencies in megacycles per second of individual channels are expressed by the following relationships:

lower half of band, $f_n = f_o - 208 + 29\ n$

upper half of band, $f_n^1 = f_o + 5 + 29\ n$

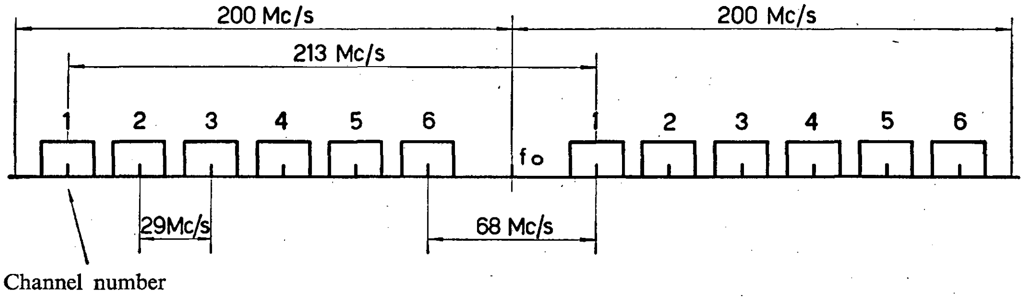
where n = 1, 2, 3, 4, 5 or 6;

2. that in a section over which the international interconnection is arranged, all the go channels shall be in one half of the band, and all the return channels shall be in the other half of the band;

3. that for adjacent radio-frequency channels in the same half of the band, different polarisations should be used alternately;

4. that when common transmit-receive aerials are used and not more than three wide-band channels are accommodated on a single aerial it is preferred that the channel frequencies be selected by either making n=1, 3 and 5 in both halves of the band or making n=2, 4 and 6 in both halves of the band;

* Italy reserved its opinion on this Recommendation.



Radio-frequency channel arrangement for six radio-frequency channels, each with 600-telephone channels, for use in international connections.

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5. that when additional radio-frequency channels, interleaved between those of the main pattern, are required, the values of the centre frequencies of these radio-frequency channels should be 14.5 Mc/s below those of the corresponding main channel frequencies;

6. that the choice of the value of the centre frequency f_0 should be agreed between the administrations concerned. However, the attention of administrations is drawn to the fact that, in systems using an intermediate frequency and in which the frequency of each wide-band channel is shifted in passing from one section of the route to the next, interference due to harmonics of the shift frequency can be reduced by choosing a suitable value for f_0. For example, if the 400 Mc/s band which is chosen lies between 3800 and 4200 Mc/s, interference effects due to a shift frequency of 213 Mc/s can be reduced by choosing $f_0 = 4003.5$ Mc/s. Alternatively, if it is desired to use a second frequency pattern, a centre frequency, $f_0 = 3989$ Mc/s might be used.

   Similarly, in the 1800-2200 Mc/s band, a first choice might be $f_0 = 2004.5$ Mc/s and a second choice 1990 Mc/s, while in the 1700-2100 Mc/s band, a first choice might be 1903 Mc/s and a second choice 1888.5 Mc/s.

   Other suitable frequencies can be chosen for other frequency bands.

Note. — It is recognised that, in the future, larger capacity systems may be developed for use at frequencies above about 6000 Mc/s and that such systems may not conform to the frequency arrangement of this Recommendation.

RECOMMENDATION No. 195

STANDARDISATION OF MULTI-CHANNEL RADIO RELAY SYSTEMS

Radio-frequency interconnection of radio relay systems transmitting television alone or television and multi-channel telephony at frequencies above about 1000 Mc/s

(Question No. 93 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that in certain cases it is desirable to interconnect wide-band radio relay systems at radio frequencies on international circuits;

(b) that it is desirable to use, as far as possible, the same radio-frequency arrangements for television relay systems as for large capacity multichannel telephony systems;

UNANIMOUSLY RECOMMENDS

1. that the preferred radio-frequency arrangements for the international interconnection of relay systems transmitting television signals with any combination of the following signals: *(a)* television of 819 lines, *(b)* television of 625 lines or less, *(c)* multichannel telephony, is the same as that given in Recommendation No. 194. The choice of the particular channels for the television signals should be agreed between the administrations concerned;

2. that, for the international interconnection of systems transmitting television signals only and where the television signals are of 625 lines or less, the preferred radio-frequency arrangement is the same as that given in Recommendation No. 194;

3. that, for the international interconnection of systems transmitting television signals only and where the television signals are of 819 lines, the preferred radio-frequency channels are 1 and 4 of the frequency arrangements defined in paragraphs 1, 2 and 3 of Recommendation No. 194. Alternatively, if further channels are required radio-frequency channels 3 and 6 of the interleaved radio-frequency channels, defined in paragraph 5 of Recommendation No. 194 may be used by agreement between the administrations concerned.

RECOMMENDATION No. 196

STANDBY ARRANGEMENTS FOR WIDE-BAND RADIO RELAY SYSTEMS

(Question No. 96 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that in radio-relay systems it is indispensable to have standby arrangements to decrease the time when the circuit is out of action as a result of a fault in equipment, or to facilitate periodical maintenance operations;

(b) that it is generally advisible to utilise for this purpose a standby channel replacing the channel normally in service along the entire length of a switching section;

(c) that for technical or operational reasons it may be desirable to use, in certain cases, standby installations of a different type such as standby equipment with switching at each station on the same carrier frequency;

(d) that a distinction should be made according to whether the system is intended for the transmission of telephone channels, of telephone and television channels possessing very similar radio characteristics, or of telephone and television channels with differing characteristics;

UNANIMOUSLY RECOMMENDS

1. that when several radio channels possessing the same characteristics are used for multiplex telephony, it is preferable to use a standby channel common to the channels in service (or several such standby channels, if necessary);

2. that when some of the radio channels are utilised for multiplex telephony and others for television and all the radio channels possess very similar characteristics, it is preferable to use a standby channel common to the channels in service (or several such standby channels, if necessary);

3. that in certain specific cases such as when some of the radio channels are utilised for multiplex telephony and others for television and when the characteristics of such channels are substantially dissimilar, the administrations concerned may, by mutual agreement and if they so desire, use standby arrangements differing from those specified in paragraphs 1 and 2 of the present Recommendation, such as, for example, standby equipment operating on the same carrier frequency as the equipment in service and which can be substituted for that equipment station by station.

RECOMMENDATION No. 197

MEASUREMENT OF THE PERFORMANCE OF MULTI-CHANNEL TELEPHONE CIRCUITS ON RADIO RELAY SYSTEMS WITH THE HELP OF A SIGNAL WITH CONTINUOUS UNIFORM SPECTRUM

(Question No. 96 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that it is desirable to measure the performance of radio relay systems for frequency-division multiplex (FDM) telephony under conditions closely approaching those of actual operation;

(b) that a signal with continuous uniform spectrum (white noise) has statistical properties similar to those of a multi-channel multiplex signal;

(c) that the use of a signal with a continuous uniform spectrum to measure the performance of such radio relay systems is already widespread;

(d) that the C.C.I.F. has indicated, for the planning of telephone circuits, a mean value of speech current power in a telephone channel to be taken into consideration during the busy hour (Doc. No. 339 C.C.I.F., Geneva, March, 1956, pp. 7 and 8);

UNANIMOUSLY RECOMMENDS

1. that the performance of frequency-division multiplex radio relay systems should be measured by means of a signal of continuous uniform spectrum in the frequency band used for the telephone channels;

2. that the power level of this signal with uniform continuous spectrum should for wide-band radio-channels with at least 240 telephone channels, be equal to $(-15 + 10 \log_{10} N)$ db relative to one milliwatt, at a point of zero relative level, N being the total number of channels in the circuit;

3. that, for wide-band radio channels of less than 240 telephone channels, allowance may have to be made for the dispersion of speech current power during the busy hour. The determination of the power level, which may be slightly different from that indicated in paragraph 2 above, should be effected in consultation with the C.C.I.T.T.;

4. that the choice of frequencies to be recommended for the measurements should continue to be studied in consultation with the C.C.I.T.T. An indication can, however, be given even now to the effect that it is desirable to carry out measurements at different points in the base-band, in particular, at the ends of this band and generally near the middle also;

5. that for the moment it is not possible to fix specifications for transmission performance to be attained on a given circuit. Further study should be made of this point.

RECOMMENDATION No. 198

MAINTENANCE PROCEDURE FOR WIDE-BAND RADIO RELAY SYSTEMS

Use of special pilot frequencies on wide-band radio relay links for 600 telephone channels

(Question No. 96 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that for the operation and maintenance of wide-band radio relay links a special pilot frequency may be required in addition to any pilot frequencies needed by the circuits to which they may be connected;

(b) that it is desirable, in order to facilitate international interconnection, to agree upon a preferred frequency for this pilot and upon the level of the pilot signal;

(c) that for telephony and television different pilot frequencies may in some cases be required;

UNANIMOUSLY RECOMMENDS

1. that for wide-band radio relay links transmitting 600 telephone channels on each radio channel, a pilot frequency of 3.2 Mc/s is preferred;

2. that the level of the pilot signal should be restricted to an upper limit of -10 db, relative to a tone of 1 mW applied at a point of zero relative level.

RECOMMENDATION No. 199

MAINTENANCE PROCEDURE FOR WIDE-BAND RADIO RELAY SYSTEMS

Use of special pilot frequencies on wide-band radio relay links for monochrome television of 625 lines or less

(Question No. 96 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that for the operation and maintenance of wide-band radio relay links, a special pilot frequency may be required in addition to any pilot frequencies needed by the circuits to which they may be connected;

(b) that it is desirable, in order to facilitate international interconnection, to agree upon a preferred frequency for this pilot and upon the level of the pilot signal;

(c) that the characteristics of monochrome television with 625 lines or less are sufficiently known to allow the frequency of such a pilot to be specified;

UNANIMOUSLY RECOMMENDS

1. that for wide-band radio relay links transmitting monochrome television with 625 lines or less the pilot frequency should be 7.0 Mc/s or 8.5 Mc/s;

2. that the choice as to which of the above two frequencies should be used, should be a matter of agreement between the administrations concerned;

3. that, as no recommendation can be given at present on the level of this pilot tone, this level should be a matter for agreement between the administrations concerned.

RECOMMENDATION No. 200

ALLOWABLE NOISE POWER IN THE HYPOTHETICAL REFERENCE CIRCUIT FOR FREQUENCY-DIVISION MULTIPLEX RADIO RELAY SYSTEMS

(Question No. 97 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the hypothetical reference circuit is intended as a guide to designers and constructors of actual systems;

(b) that the total noise power in a radio relay system is dependent on the one hand upon a number of factors concerned with equipment design, and on the other hand upon the path attenuation and the variation of path attenuation with time, which is in turn dependent upon factors such as the spacing of stations and the nature of the intervening terrain;

(c) that it is desirable to fix nominal values for propagation conditions in the hypothetical reference circuit, but at present there is insufficient information to enable this to be done precisely (See Question No. 136 (V));

(d) that typical values of the factors concerned with equipment design and path attenuation are given in Annex I ;

(e) that the total noise may be calculated by methods such as those given in Annex II, which gives also the numerical results of typical calculations;

(f) that the total noise power in the hypothetical reference circuit should not be so great as to cause serious hindrance to conversation in a substantial proportion of telephone calls or to the transmission of telegraph signals;

(g) that, in the opinion of the C.C.I.R. based on evidence so far available from the C.C.I.F. and other sources, a distribution of noise power with time in a month, such as that given in Annex III, is considered provisionally to be unlikely to cause serious hindrance to telephone conversations;

(h) that it is convenient to specify the total noise power in the hypothetical reference circuit in a manner suitable for sub-division of the noise power into each of the 6 or 9 equal homogeneous sections;

(i) that the noise power in actual radio relay systems may differ from that in the hypothetical reference circuit due, for example, to the use of equipment designed for association with a given station spacing in the hypothetical reference circuit but used in an actual system with much greater spacings;

(j) that it is advisable that in view of the application of the data of the hypothetical reference circuit to physical circuits, the method of specification and permissible values of psophometric noise for short percentages of time should be stated;

UNANIMOUSLY RECOMMENDS

1. that the local psophometric noise power at a point of zero relative level in any telephone channel in the 2500 km hypothetical reference circuit for frequency-division multiplex radio relay systems with 12 to 60 channels and in the 2500 km hypothetical reference circuit for radio relay systems with more than 60 channels, should not exceed the provisional values: (*) (**)

(a) 5000 pW mean value in the busy hours, in the absence of fading,

(b) 7500 pW mean value in any hour;

2. that the method of specification and permissible values of the psophometric noise for short percentages of the time should be defined, but that a precise answer cannot be given at the present time. Proposals under consideration are given in Annex II and in Annex III.

ANNEX I

Factors affecting noise in a long radio relay system for multi-channel telephony

1. **Introduction**

The value of the total noise power is affected by two groups of factors:

(a) features of the equipment design such as the transmitter power output, the aerial gains, the use of diversity reception and the amplitude and phase characteristics, etc.

(b) the path attenuation and the variation of path attenuation with time, which are dependent upon factors such as the radio frequency, the distance between stations and the nature of the terrain.

These factors will vary from system to system. In order to give guidance on methods of computing the total noise, some examples are given below. *These are examples only*, and different examples could be chosen which are equally representative of good practice.

2. **Examples of features of equipment design**

(a) Transmitter output power.

The transmitter output power might be between about 0.2 watt and about 20 watts or more, with a tendency for the higher powers to be available at the lower frequencies. Typical values of output power at 4000 Mc/s might be 1 to 3 watts.

(b) Transmitting and receiving aerial gains.

It is often the practice to use aerials with a gain at 4000 Mc/s of between 30 and 40 db.

(c) Frequency deviation and maximum modulating frequency.

In accordance with Recommendation No. 191, the frequency deviation without pre-emphasis in a 600-channel system, for example, would be 200 kc/s for the test tone at zero relative level in each telephone channel. The use of pre-emphasis may be allowed for, if desired, by assuming

(*) Noise in the frequency-division multiplex equipment is excluded. The C.C.I.F. allows 2500 pW for this noise.

(**) It is emphasised that these values are provisional and may be revised later to take account of additional information on path attenuation (Question No. 136 (V)) and of the later opinions of the C.C.I.F.

an improvement of several decibels (e.g., 4 db) in the signal-to-noise ratio in the " top " telephone channel—i.e., the telephone channel at the maximum modulating frequency which would be 2.54 Mc/s for a 600-channel system.

3. Examples of features affecting the path attenuation

(a) Radio frequency.

Radio frequency bands centred on approximately 2000 Mc/s, 4000 Mc/s and 6500 Mc/s are available for wide-band radio relay systems and in the present examples a frequency of about 4000 Mc/s will be assumed; the path attenuation, aerial gains, and fading characteristics would of course be different for another frequency band.

(b) Number and length of repeater sections.

A radio relay system is made up of repeater sections which might vary in length between a few kilometres and perhaps 100 kilometres or more, depending on the terrain, the meteorological conditions and other factors which affect fading, and on the design of the equipment. In the present example it will be assumed that a 2500 km radio relay system is composed of 9 equal homogeneous sections, each with 5 repeater sections of average length 55.6 km.

(c) Path attenuation of a single repeater section.

The attenuation between isotropic aerials in free space at 4000 Mc/s for a distance of 55.6 km is approximately 139 db.

The path attenuation varies with time due to fading, and the thermal noise power in a telephone channel varies in an approximately similar manner. The distribution of noise power with time depends on a number of geographical and other factors and so varies from one radio link to another. It has been found as a result of experience that the distribution often approximates to either a Rayleigh or a log-normal * distribution and it is possible as a result of experience to suggest the likely form of distribution for particular cases. More specific information can be obtained by making tests over the particular path in question but this requires a long period of testing.

For an overland path without a strong ground reflection, the path attenuation does not vary by more than a few decibels from the free space value during much of the time (e.g., 90% of the time). For these periods, typical curves showing approximately the distribution of thermal noise power in a telephone channel in one repeater section are given in Fig. 1, curve A (log-normal, standard deviation 1 db) and curve B (log-normal, standard deviation 3 db).

At other periods, e.g., in the remaining 10% of the time, severe multi-path propagation may occur, and a Rayleigh distribution (Fig. 1, curve C) or a log-normal distribution with a large value of standard deviation, e.g., up to 14 db (curve D) might apply.

In day-time (and of course during the busy hours) the fading is often slight and curves A and B may be typical, but occasionally more severe fading approaching that of curves C and D may take place.

At night-time and in the early morning, severe fading for which curves C and D may be appropriate, is more common than in day-time. The traffic is, however, considerably smaller at night, and the intermodulation noise power is therefore smaller, thus allowing a greater thermal noise power.

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* See page 176.

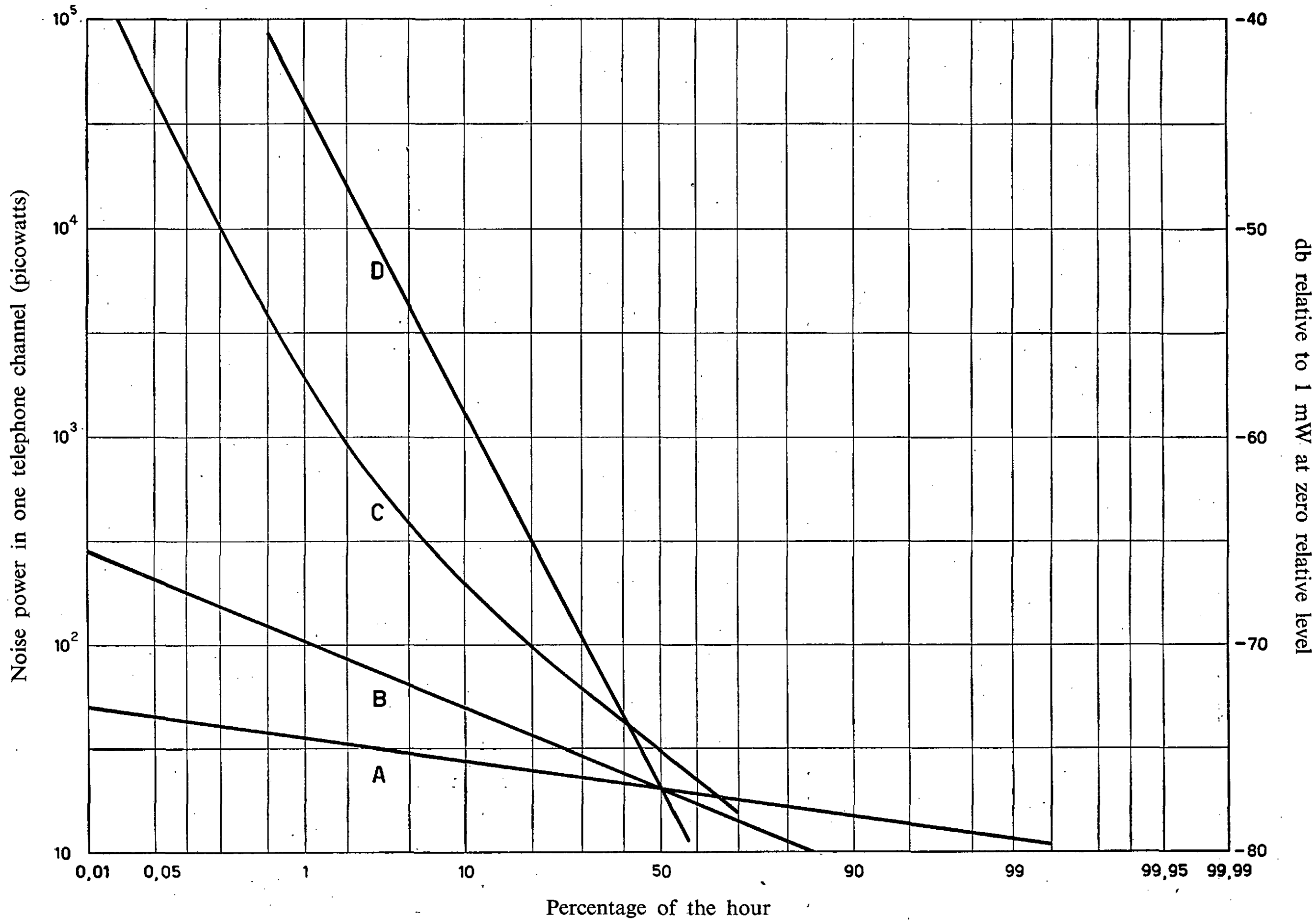
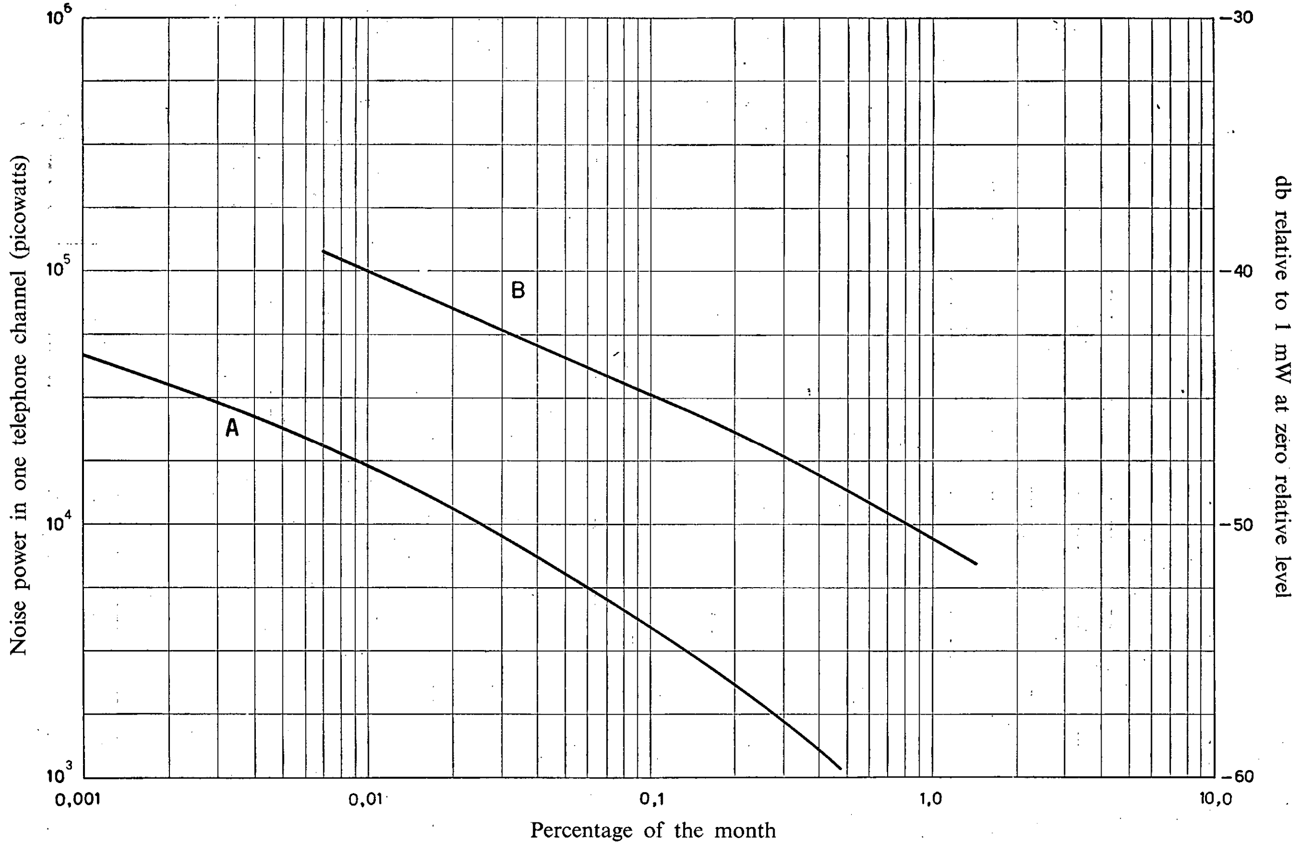


FIGURE 1

Examples of distributions of noise with time in one hour

(Psophometric noise in one repeater section of a radio relay system)

[redacted]



A (one repeater section) B (45 repeater sections)

FIGURE 2

Examples of distributions of psophometric noise with time in one month

In considering high values of noise existing for only short periods of time, a curve of distribution with time over a month is useful. A typical curve obtained from measurements on several overland paths in which conditions are not too severe is given as curve A of Fig. 2; this is a log-normal curve with a standard deviation of 8 db.

For oversea paths and for very long overland paths, the distributions of noise with time may be worse than those given here as examples. Moreover, for oversea paths severe fading may occur in every hour of every day and not just in certain hours at night. In such cases, however, the use of diversity reception may result in curves of distribution of noise power with time representing conditions which are not too severe. Diversity reception in the form of frequency diversity may be used if a protection channel is provided.

ANNEX II

AN EXAMPLE OF THE COMPUTATION OF TOTAL NOISE POWER IN A LONG CIRCUIT

The methods of computation given here are for example only. The values assumed are based on Annex I, and are typical of normal overland routes with first Fresnel zone clearance operating at frequencies of several thousand Mc/s.

1. Mean thermal noise power of one repeater section for a period with severe fading.

If a Rayleigh distribution applies (see Annex I, 3, c)), and under practical conditions the thermal noise power varies inversely with the received signal power,

$$W(N) = e^{-\frac{N_0}{N}} \qquad (1)$$

W (N) is the probability of N not being reached in a repeater section, where N is the fluctuating noise power and N_0 the noise power without fading.

The mean value of the noise power $\overline{N}$ can be obtained by an integration which has to be broken off at a high value N′. It could be assumed for example that a standby or diversity device is provided for protection when the noise power exceeds N′; the choice of the value N′ is not very critical. The result is, according to Jahnke-Emde:

$$\frac{\overline{N}}{N_0} = 0.23 . 10 \log_{10} \frac{N'}{N_0} - 0.577 \qquad (2)$$

As an example, if

$$10 \log_{10} \frac{N'}{N_0} = 45 \text{ db}$$

then

$$\overline{N} = 10 \; N_0 \qquad (3)$$

The mean value of the noise power of one section during a period with Rayleigh distribution fading exceeds by approximately 10 db the value without fading.

If, alternatively, a log-normal distribution with standard deviation σ decibels applies, it can be shown that

$$\text{mean value (in db)} = \text{median value (in db)} + 0.115\, \sigma^2.$$

2. **Mean value of the thermal noise power at the end of the hypothetical reference circuit.**

It may be assumed that the hypothetical reference circuit consists of z repeater sections of equal lengths. Only on k sections may Rayleigh distribution occur at the same time. The mean value of the noise power coming from these k sections is then

$$\overline{N}_k = 10\ N_o . k \qquad (4)$$

The average noise power for the remaining z − k sections does not differ much from the value without fading and according to experimental data

$$\overline{N}_{z\text{-}k} = 1.44\ N_o\ (z-k) \qquad (5)$$

The mean noise power $\overline{N}_z$ at the end of the hypothetical reference circuit is given by the sum of eq. (4) and eq. (5). Divided by the value without fading this gives

$$\frac{\overline{N}_z}{z . N_o} = 10\ \frac{k}{z} + 1.44\ \frac{z-k}{z} \qquad (6)$$

For z = 50 repeater sections each 50 km long (total length 2500 km), we arrive at the following if propagation conditions in k sections correspond to Rayleigh distribution

Table I

k	$\frac{k}{z}$ (in %)	$\frac{\overline{N}_z}{z.N_o}$	$10 \log_{10} \frac{\overline{N}_z}{z.N_o}$ (in db)
5	10	2.3	3.6
10	20	3.15	5
20	40	4.9	6.9
50	100	10	10

Assuming, in that example, that during a very unfavourable hour, 10 out of a total of 50 sections will simultaneously suffer from strong fading, the mean noise power in an hour without fading must be 5 db smaller than the required mean value with fading. Taking typical figures for the noise power in the hypothetical reference circuit:

Thermal noise power without fading		1250 pW
Mean value of the thermal noise power	3750 pW	
Intermodulation noise	3750 pW	3750 pW
Mean value of total noise power in any hour	7500 pW	
Total noise power without fading		5000 pW

3. Noise power in a very small percentage of the time.

The high values of noise power in a very small percentage of the time are largely due to the increase of thermal noise at times of severe fading. The value of noise power may be estimated from previous experience. Taking as an example curve A of Fig. 2 (see Annex I, 3) (based on measurements over a month on single repeater sections in which the conditions are not too severe) then curve B of Fig. 2 can be deduced as appropriate (with a small error of the order $\pm$ 1 db) for a 2500 km circuit with 45 repeater sections. Thus in this example, the noise power in the 2500 km circuit would be approximately 100 000 pW for 0.01% of a month. This example, however, relates to a radio link in which the fading is not very severe, due perhaps to the particular meteorological conditions or to close spacing of the repeater stations. An example will now be given of computation of noise power for short periods of time in a radio link with more severe fading.

The probability that a noise power value N which is very high with respect to N_0 is exceeded on a single section, according to equation (1) (Annex II) is, to a good approximation:

$$1 - W(N) = \frac{N_0}{N} \qquad (7)$$

for the time a Rayleigh distribution prevails.

Let us denote by p the probability that this distribution prevails. The probability that the noise power is exceeded for long periods is thus found to be

$$p \cdot \frac{N_0}{N}$$

For z sections there is, with sufficient accuracy

$$1 - W_z(N) = z \cdot p \cdot \frac{N_0}{N} \qquad (8)$$

In this second example a value p = 0.08 was found from propagation measurements for a year in a particular radio link. It might be assumed that for an unfavourable month a value three times as great, p = 0.24, is appropriate. Furthermore, for $z \cdot N_0$ a value of 1250 pW is assumed. Then a noise power of 300 000 pW is exceeded in the 2500 km circuit in an unfavourable month, with a probability of 0.1%.

The second example shows that it is possible for the noise power in short periods of time to reach high values. For this reason, radio links are often designed with small repeater spacings or with protection channels which automatically take over service when the noise power exceeds a predetermined value. By these methods, smaller values of noise power, such as a maximum value of 300 000 pW for 0.01% of a month, may be achieved. It may be noted that a protection channel is usually necessary also because of equipment failure which in the absence of a protection channel is likely to result in a probability of interruption at least as great as (and perhaps much greater than) that due to fading in a single channel.

ANNEX III

DISTRIBUTION OF NOISE ON RADIO CIRCUITS

(C.C.I.F. doc. 339 — page 18 curve A)

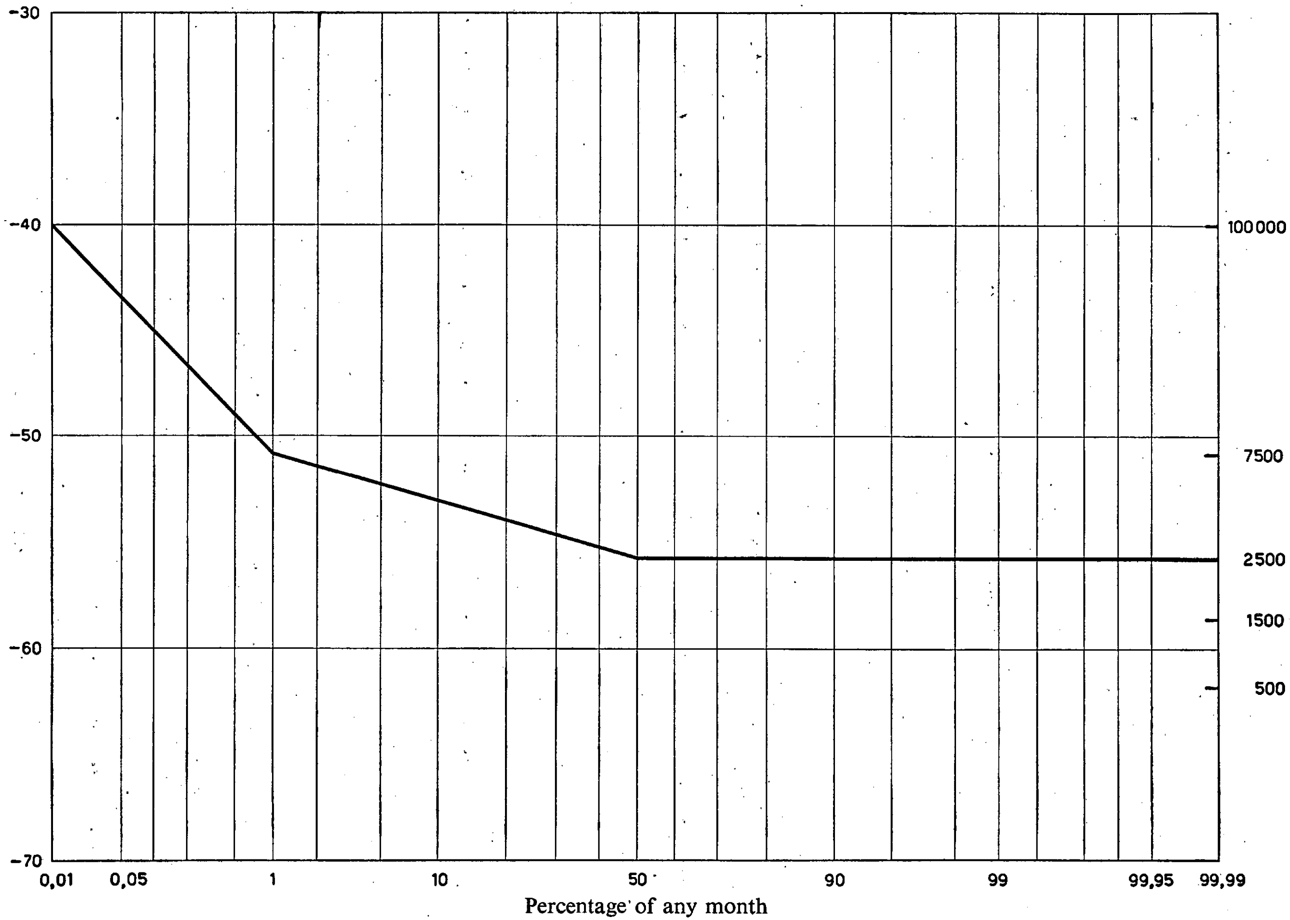


FIGURE 3

Allowable weighted noise power at zero level, excluding noise due to FDM terminal equipments

(Suggested for 2 500 km hypothetical reference circuit)

ANNEX IV

An example of a method for calculating the principal parameters of radio equipment on the basis of the mean noise power in a telephone channel at the end of a hypothetical reference circuit

The principal parameters of radio equipment can be calculated if the allowable mean noise power P_{Na} during any hour (including the busy hour) at the end of a hypothetical reference circuit is specified.

The allowable mean noise power P_{Na1} produced on one homogeneous section of the hypothetical reference circuit is

$$P_{Na1} = \frac{P_{Na}}{\nu} \qquad (1)$$

ν— is the number of homogeneous sections in the hypothetical reference circuit.

It is well known, that the mean noise power at the end of a modulation section is

$$P_{Na1} = P_{Nt} + P_{N2} + P_{N3} \qquad (2)$$

where

P_{Nt} is the average thermal noise power,

P_{N2} is the average intermodulation noise power due to non-linearity of the second order,

P_{N3} is the average intermodulation noise power due to non-linearity of the third order.

It is assumed that the intermodulation noise due to non-linearity of the orders higher than 3 is negligible.

It can be shown that equation (2) is expressed by:

$$P_{Na1} = P_{Nt} + P_{N2} + P_{N3} = A\frac{1}{x} + Bx + Cx^2 \qquad (3)$$

at the point of zero relative level,
where the values of x, A, B and C in the case of hypothetical reference circuit are the following:

$$x = \left(\frac{\Delta f_o}{\Delta f_1}\right)^2 \qquad (4)$$

Δf_o is the r.m.s. frequency deviation per channel (for 1 mW 800 c/s tone at a point of zero relative level);

Δf_1 is the unit value of a frequency deviation (for example: $\Delta f_1 = 1$ Mc/s);

$$A = A_o \gamma = \frac{4n \Delta F_c K_p^2}{P_e} \left(\frac{F_c}{\Delta f_1}\right)^2 \frac{16 \pi^2 R_o^2 b_f^2}{\lambda^2 G_A^2} m \gamma \text{ (in pW)} \qquad (5)$$

n is the noise factor of receiver;

P_e the transmitter power expressed in pW;

ΔF_c = 3100 c/s, the bandwidth of a telephone channel;

K_p = 0.75, the psophometric factor according to the psophometrical curve recommended by the C.C.I.F. in 1946;

F_c is the mean frequency of a telephone channel at the baseband;

R_o is the length of one repeater section;

m is the number of repeater sections in one modulation section of the hypothetical reference circuit;

λ is the wave-length;

G_A is the aerial gain with reference to an isotropic antenna;

b_f is the attenuation of the feeder;

γ is the average ratio (during one hour):
— of the received signal power in the absence of fading
— to the received signal power in typical fading conditions (the fading margin required for each repeater section).

$$B = \frac{\triangle F_c K_p^2 \quad 10^9}{\triangle F} e^{4b_N} \; y_2(\sigma_c) \left[4 \, e^{-2b_{21}} + (2 \pi F_c)^2 \triangle f_1^2 \cdot \frac{1}{2} \alpha_1^2 \right] (pW) \qquad (6)$$

$$C = \frac{\triangle F_c K_p^2 \quad 10^9}{\triangle F} e^{6b_N} \; y_3(\sigma_c) \left[24 \, e^{-2b_{31}} + (2 \pi F_c)^2 \triangle f_1^4 \frac{2}{3} \alpha_2^2 \right] (pW) \qquad (7)$$

where

$\triangle F = F_2 - F_1$; (F_2 and F_1 are the frequency limits of the baseband);

$e^{2b_N} = S_N$ (mW) is the mean power of the multiplex signal with N channels during the busy hour in mW;

$b_N = \left(-1.72 + \frac{1}{2} \log_e N\right)$ nepers according to the Document No. 339 of the C.C.I.F.;

$y_2(\sigma_c)$ and $y_3(\sigma_c)$ * are coefficients depending on the mid-frequency F_c, or on the value

$\sigma_c = \frac{F_c - F_1}{F_2 - F_1}$ of the channel considered;

b_{21} and b_{31} are the attenuations of non-linearities of second and third orders of the quadripole consisting of a modulator, demodulator and telephone amplifiers, measured with a unit value of frequency deviation $\triangle f_1$;

α_1 and α_2 are the non-linearity coefficients for the group-delay characteristic of the whole modulation section of the hypothetical reference circuit (the coefficients of linear and parabolic terms).

When long feeders are used it may be necessary to add to the value of B, defined above (6), the following value

$$B_f = \frac{\triangle F_c K_p^2 \, 10^9}{\triangle F} e^{4b_N} \; (2 \pi F_c)^2 \, (2 \pi \triangle f_1)^4 \; \frac{4 \, m \, r_2^1 \, r_2^2 \, \tau_f^4}{b_f^2} \; (pw) \qquad (8)$$

if the feeders are identical,

where

r_1 and r_2 are the reflection coefficients at the ends of a feeder;

τ_f is the group delay of a feeder.

---

* Brockbank and Wass—" Non-linear distortion in transmission systems ", Proc. I.E.E. Vol. 94, part 3, March 1945.

The equation (8) is correct if

$$4\,\pi \,\triangle\, f_o \;\tau_f e^{\,b_N} \leqslant 0.5$$

The quantities A_0, B and C are the principal parameters of radio equipment. If the values of γ and x are known, the optimum values of A_0, B and C can be determined in the following way.

Values of A, B and C are the optimum values, when the noise power at the end of a modulation section is equal to a minimum value and is equal also to the allowable value P_{Nal}. As it can be seen from (3) these conditions correspond to:

$$\frac{d}{dx} P_{Na1} = 0$$

or

$$0 = -A \frac{1}{x^2} + B + 2\,Cx \qquad (9)$$

From (3) and (9) can be obtained:

$$B\,x = 2\,P_{Na1} - 3\,A\,\frac{1}{x} \quad \text{or} \quad P_{N2} = 2\,P_{Na1} - 3\,P_{Nt} \qquad (10)$$

$$C\,x^2 = 2\,A\,\frac{1}{x} - P_{Na1} \quad \text{or} \quad P_{N3} = 2\,P_{Nt} - P_{Na1} \qquad (11)$$

It is completely clear, that in any case $P_{N2} > 0$ and $P_{N3} > 0$

therefore from equations (10) and (11) it follows

$$\frac{1}{2} P_{Na1} < P_{Nt} < \frac{2}{3} P_{Na1} \qquad (12)$$

Let us write:

$$P_{Nt} = A\,\frac{1}{x} = A_{\,0}\,\gamma\,\frac{1}{x} = \xi\,P_{Na1} \qquad (13)$$

where the values of ξ in accordance with (12) are within the limits:

$$\frac{1}{2} < \xi < \frac{2}{3} \qquad (14)$$

Then, from (10) and (11) we can obtain:

$$P_{N2} = Bx = 3\,P_{Na1}\left(\frac{2}{3} - \xi\right) \qquad (15)$$

$$P_{N3} = Cx^2 = 2\,P_{Na1}\left(\xi - \frac{1}{2}\right) \qquad (16)$$

To illustrate these relations the graph in figure 4, showing

$$\frac{P_{Nt}}{P_{Na1}}, \quad \frac{P_{N2}}{P_{Na1}} \quad \text{and} \quad \frac{P_{N3}}{P_{Na1}}$$ as functions of ξ may be used.

Lastly, we can find the principal parameters of radio equipment from equations (13), (15) and (16).

$$A_o = P_{Na1} \frac{\xi x}{\gamma} \tag{17}$$

$$B = P_{Na1} \frac{2 - 3\xi}{x} \tag{18}$$

$$C = P_{Na1} \frac{2\xi - 1}{x^2} \tag{19}$$

The value of ξ defining a relationship between three components of the total noise power must be chosen by a designer of equipment within certain limits according to the inequality (14).

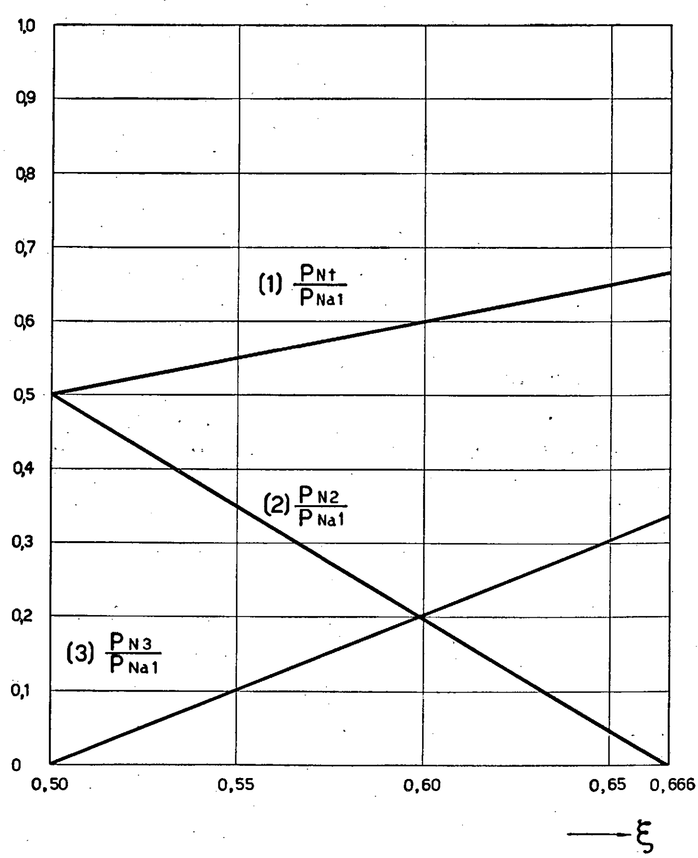


FIGURE 4

RECOMMENDATION No. 201

HYPOTHETICAL REFERENCE CIRCUIT FOR TIME-DIVISION MULTIPLEX RADIO RELAY SYSTEMS WITH 60 OR LESS TELEPHONE CHANNELS

(Question No. 97 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that it is desired to define hypothetical reference circuits for radio relay systems in order to offer guidance to the designers of equipment and systems for use in international telecommunication networks;

(b) that time-division radio relay systems may form a part of an international circuit;

(c) that the C.C.I.F. has established a hypothetical reference circuit for the similar case of 60 and 120 telephone channels on symmetrical pairs (Volume III of the Green Book of the C.C.I.F., Geneva 1954, page 68);

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference circuit for time-division multiplex radio relay systems with a capacity of 60 or less telephone channels per radio channel should be 2500 km long;
2. that this reference circuit should be constituted by 9 sections approximately 280 km long with voice-channel modulation and demodulation at each terminal of a section;
3. that in any hour the mean psophometric noise in a telephone channel at the ends of the overall circuit should not exceed 10 000 pW at a point of zero relative level;
4. that the allocation of this noise power to the single sections and the time distribution of the noise power should be further studied;
5. that the method of specification and permissible values of the psophometric noise for small percentages of time should be defined, but that a precise answer cannot be given at the present time.

RECOMMENDATION No. 202

HYPOTHETICAL REFERENCE CIRCUIT FOR WIDE-BAND FREQUENCY-DIVISION MULTIPLEX RADIO RELAY SYSTEMS WITH CAPACITY OF 12 TO 60 TELEPHONE CHANNELS

(Question No. 97 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that it is desired to establish hypothetical reference circuits for radio relay systems in order to afford guidance to the designers of equipment and systems for use in international telecommunication networks;

(b) that hypothetical reference circuits for radio relay systems should be in agreement as far as possible with the circuits specified by the C.C.I.F. for cable systems;

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference circuit for frequency-division multiplex radio relay systems with a capacity of 12 to 60 telephone channels per radio channel should be 2 500 km long;

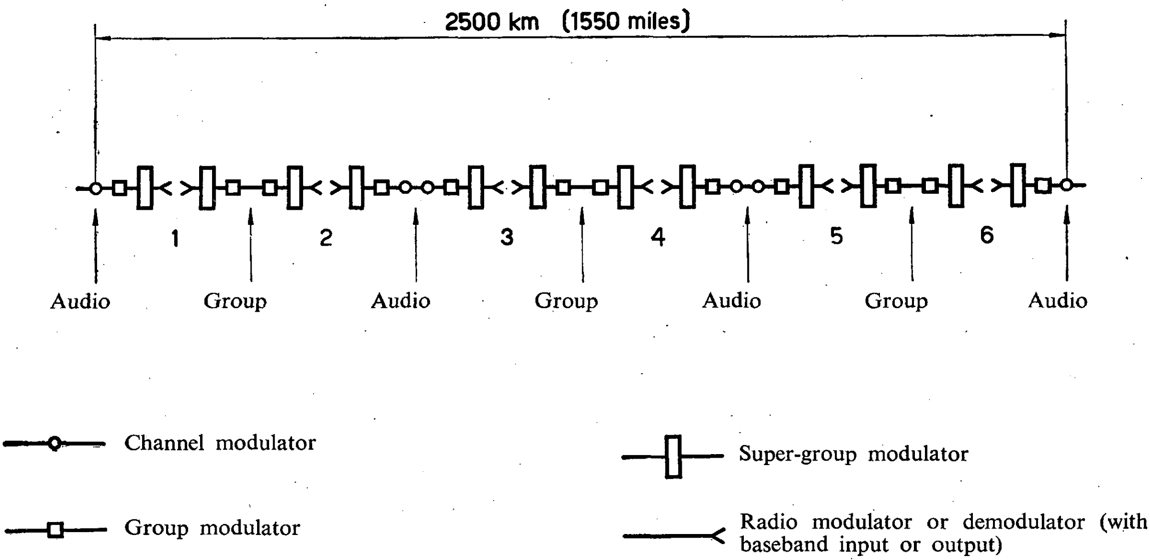
2. that the circuit should include, for each direction of transmission:

3 sets of channel modulators,
6 sets of group modulators,
6 sets of supergroup modulators,

it being understood that a " set of modulators " comprises a modulator and a demodulator.

3. that this circuit should include respectively 6 sets of radio modulators and demodulators, for each direction of transmission and that these should divide the circuit into 6 homogeneous sections of equal length.

Note. — In estimating noise, the position of a telephone channel in the baseband frequency range should be considered for each of the 6 homogeneous sections of the hypothetical reference circuit.



Hypothetical reference circuit for FDM radio relay systems with capacity of 12 to 60 telephone channels per radio-frequency channel

RECOMMENDATION No. 203

HYPOTHETICAL REFERENCE CIRCUIT FOR WIDE-BAND FREQUENCY-DIVISION MULTIPLEX RADIO RELAY SYSTEMS WITH CAPACITY OF MORE THAN 60 TELEPHONE CHANNELS

(Question No. 97 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that it is desired to establish hypothetical reference circuits for radio relay systems in order to afford guidance to the designers of equipment and systems for use in international telecommunication networks;

(b) that hypothetical reference circuits for radio relay systems should be in agreement as far as possible with the circuits specified by the C.C.I.F., for cable systems;

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference circuit for frequency-division multiplex radio relay systems with a capacity of more than 60 telephone channels per radio channel should be 2 500 km long;

2. that the circuit should include, for each direction of transmission:

3 sets of channel modulators,
6 sets of group modulators,
6 sets of supergroup modulators,

it being understood that a " set of modulators " comprises a modulator and a demodulator;

3. that this circuit should include 9 sets of radio modulators and demodulators respectively, for each direction of transmission, and that these should divide the circuit into 9 homogeneous sections of equal length.

Note. — In estimating noise, the position of a telephone channel in the baseband frequency range should be considered for each of the 9 homogeneous sections of the hypothetical reference circuit.

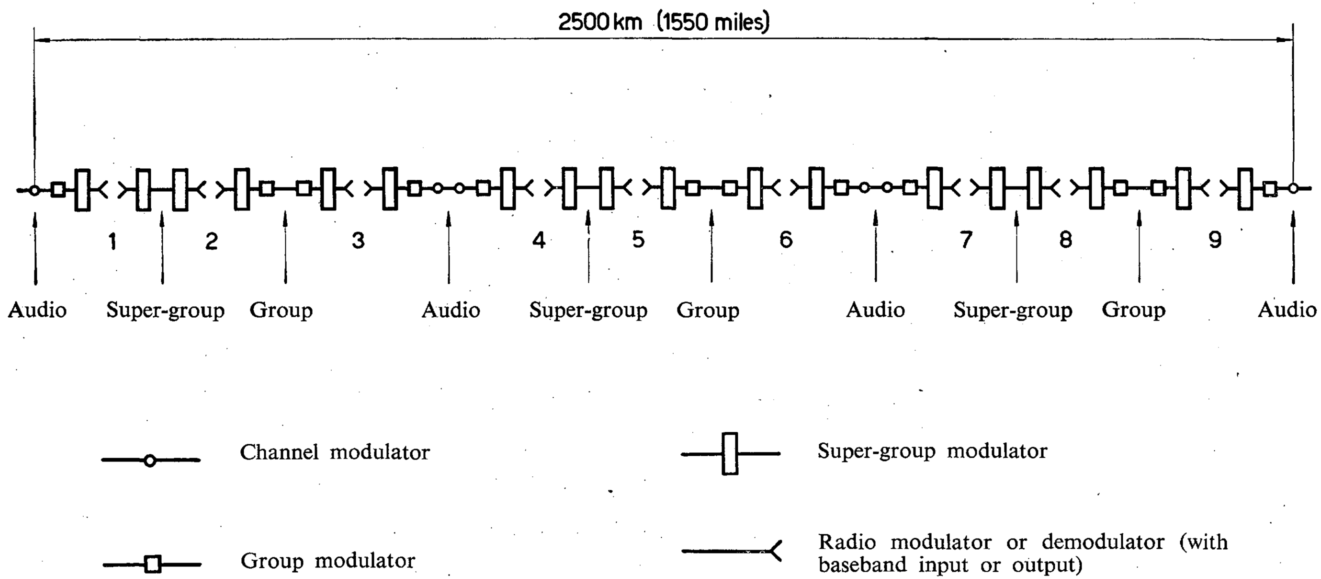


FIGURE 1

Hypothetical reference circuit for FDM radio relay systems with capacity of more than 60 telephone channels per radio-frequency channel

RECOMMENDATION No. 204

PROCEDURE FOR INTERNATIONAL CONNECTIONS BETWEEN RADIO RELAY SYSTEMS WITH DIFFERENT CHARACTERISTICS

(Question No. 113)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that, in order to simplify interconnection across frontiers and to ensure the best transmission quality on international circuits, interconnection between systems with different characteristics should be avoided as far as possible;

(b) that, however, when such interconnection cannot be avoided, special arrangements will have to be made at the junction;

(c) that the C.C.I.F. recommends * that, where different types of coaxial systems are directly connected across a frontier, each administration concerned should accept, on the receiving side, the transmission conditions normal to the incoming system;

UNANIMOUSLY RECOMMENDS

that, if different types of radio-relay systems are directly connected across a frontier, each administration concerned should accept on the receiving side the transmission characteristics normal to the incoming system, unless a better or more practical arrangement can be arrived at between the administrations concerned.

RECOMMENDATION No. 205 **

USE OF SYNCHRONISED TRANSMITTERS IN HF (DECAMETRIC) BROADCASTING

The C.C.I.R., (London, 1953 — Warsaw, 1956)

UNANIMOUSLY RECOMMENDS

that two synchronised transmitters at the same site, driven by a common oscillator and modulated by the same programme in the correct phase, may be considered not to introduce any appreciable deterioriation in reception

(a) for non-overlapping service areas;

(b) for overlapping service areas provided that due consideration is given to:
- the shape and size of the reception area;
- the availability of suitable aerials with similar transmission characteristics;
- the propagation conditions over the two transmission paths, corresponding to the two aerials.

These considerations become more critical as the transmission distance increases.

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* Green Book of the XVIIth Plenary Assembly of the C.C.I.F.—Geneva 1954, Volume III—paragraph 346 (page 102): "Interconnection of coaxial carrier systems using different techniques".

** This Recommendation replaces Recommendation No. 137.

RECOMMENDATION No. 206 *

STANDARDS FOR FREQUENCY-MODULATION SOUND BROADCASTING IN THE VHF (METRIC) BAND

(Question No. 99 **)

The C.C.I.R., (Warsaw, 1956)

RECOMMENDS

that for frequency-modulation sound broadcasting:

1. the maximum frequency deviation should be either ± 75 kc/s or ± 50 kc/s;
2. the pre-emphasis characteristic should be defined as a curve rising with frequency in conformity with the admittance of a parallel combination of a capacitance and a resistance having a time constant of 50 microseconds;
3. in the absence of interference from industrial and domestic equipment a minimum field strength *** of 50 microvolts per meter can be considered to give an acceptable service;
4. in the presence of such interference a satisfactory service requires a minimum median field strength *** of

— 250 microvolts per meter in rural areas,
— 1 mV/m in urban areas,
— 3 mV/m in large cities.

RECOMMENDATION No. 207 ****

STANDARDS OF SOUND RECORDING FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES

(Questions Nos. 42 and 63)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

RECOMMENDS

that the international exchange of recorded sound programmes between broadcasting organisations should be by means of lateral-cut recording on disc and single-track magnetic recording on tape, conforming to the technical standards given in

Recommendation No. 208 for disc,
Recommendation No. 209 for tape.

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* Canada and the United States of America reserved their opinion on this Recommendation.

** This Question has been replaced by Question No. 150 (X).

*** The field strengths are measured 10 metres above ground level.

**** This Recommendation replaces Recommendation No. 133.

RECOMMENDATION No. 208 *

STANDARDS OF SOUND RECORDING FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES

Lateral-cut recording on discs

(Questions Nos. 42 and 63 — Recommendation No. 207)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

RECOMMENDS

that lateral-cut recording on disc should be in accordance with the following technical standards:

1. *type of groove:*
   (a) coarse groove
   - minimum top width: 0.004″ (0.1 mm),
   - maximum bottom radius: 0.0015″ (0.038 mm),
   - included angle: 80° to 90°;

   (b) fine groove
   - minimum top width: 0.002″ (0.05 mm),
   - maximum bottom radius: 0.0003″ (0.0076 mm),
   - included angle: 80° to 90°.
2. *speed of rotation:*
   $33^1/_3$ r.p.m. ± 0.5%,
   78 r.p.m. ± 0.7%.
3. *direction of rotation:*
   clockwise.
4. *direction of cut:*
   outside to inside.
5. *type of disc:*
   lacquer coated or processed.
6. *maximum diameter of disc:*
   - for $33^1/_3$ r.p.m. $16^1/_{16}$″ (408 mm),
   - for 78 r.p.m. $12^1/_{32}$″ (306 mm).
7. *centre hole diameter:*
   $$0.285'' \begin{cases} +0.002'' \\ -0'' \end{cases} \left(7.24 \text{ mm} \begin{cases} +0.05 \text{ mm} \\ -0 \text{ mm} \end{cases} \right)$$
8. *minimum diameter of recorded surface:*
   - for $33^1/_3$ r.p.m. coarse groove: 7½″ (190 mm),
     fine groove: 4¾″ (120 mm),
   - for 78 r.p.m. 3¾″ (95 mm).
9. *number of plain grooves:*
   at start: minimum 2, maximum 4,
   at finish: minimum 2, maximum 4.

* This Recommendation replaces Recommendation No. 134.

10. *minimum information to be stated on label:*

— broadcasting organisation,
— programme title,
— side number,
— total number of sides,
— reference number,
— total playing time of programme,
— speed of rotation in r.p.m.,
— type of groove.

(The last two items should be marked as prominently as possible.)

11. *recording characteristic:* (fine and coarse groove discs)

(a) nominal characteristic

With constant voltage applied to that point in the recording chain where the normal signal has the frequency characteristic that it is desired subsequently to reproduce, the curve of recorded velocity * versus frequency shall be that which results from the combination of three curves as follows:

— one rising with frequency in conformity with the admittance of a parallel combination of a capacitance and a resistance having a time constant of t_1;
— one rising with frequency in conformity with the admittance of a series combination of a capacitance and a resistance having a time constant of t_2;
— one falling with rise of frequency in conformity with the impedance of a series combination of a capacitance and a resistance having a time constant of t_3.

The combined curve is defined by:

$$N\ (\text{db}) = 10 \log. (1 + 4\pi^2 f^2 t_1^2) - 10 \log. \left(1 + \frac{1}{4\pi^2 f^2 t_2^2}\right) + 10 \log. \left(1 + \frac{1}{4\pi^2 f^2 t_3^2}\right)$$

where

f = frequency in c/s
t_1 = 50×10^{-6} seconds
t_2 = 318×10^{-6} seconds
t_3 = 3180×10^{-6} seconds

This curve is shown in the figure.

Note. — This paragraph defines the relative velocities to be recorded on a disc; but to ensure that the proper response is obtained on reproduction it is necessary to use a pickup with a suitable stylus and with working pressures low enough to avoid any appreciable deformation of the disc material.

(b) Tolerance

Discs for international interchange of programmes should be recorded within ± 2 db of the nominal characteristic, taking as reference point the value at 1000 c/s.
Any variation, for example that which results from the application of radius compensation, should be within the stated tolerance.

Note on use of recording characteristic. — Within the U.S.A. a different characteristic will be used for the interchange of programmes between broadcasting organisations but the C.C.I.R. characteristic will be used by the broadcasting companies of the U.S.A. for international exchange.

* "Recorded velocity" is here defined as that determined by the Buchmann-Meyer light-band method.

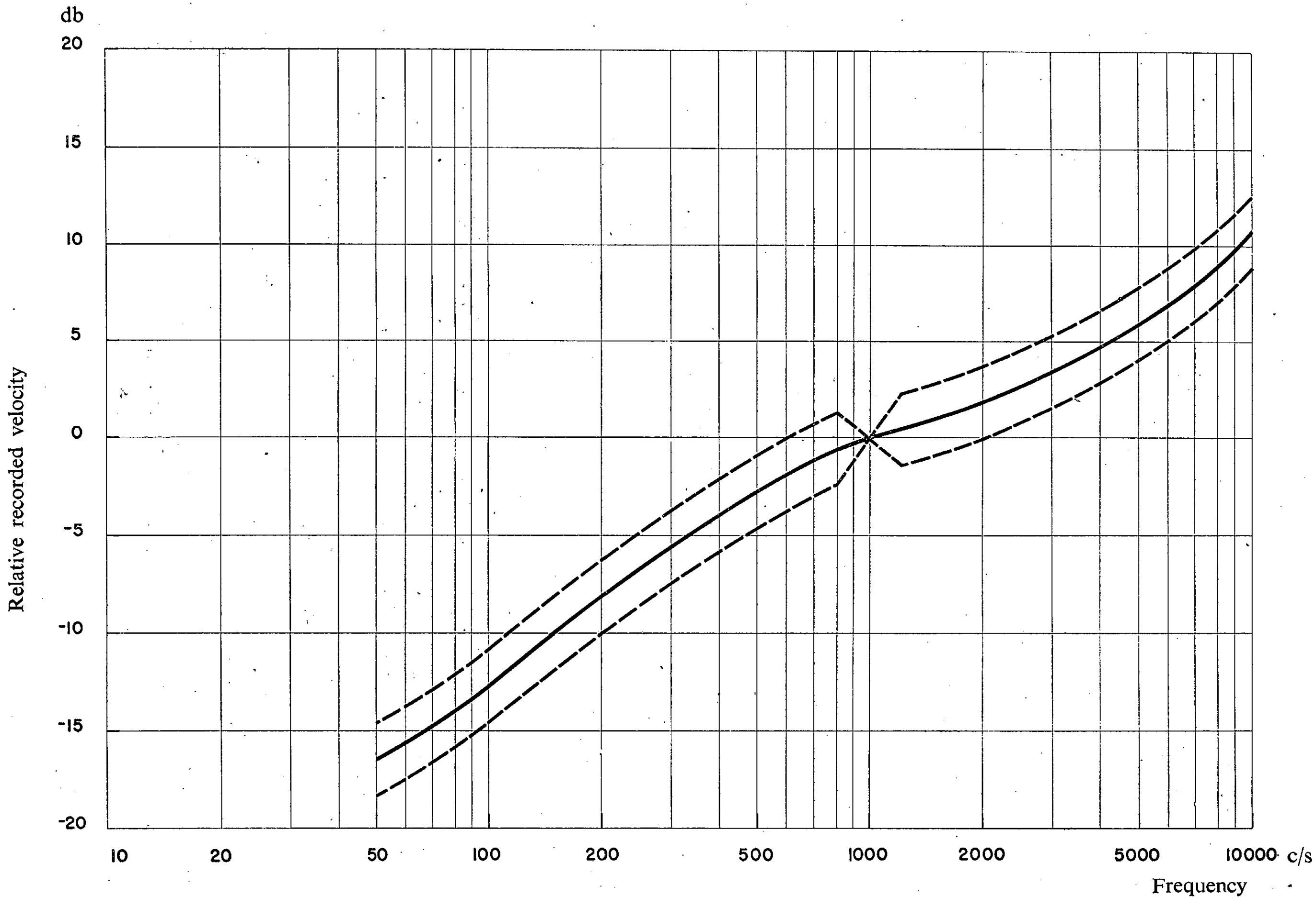

FIGURE 1

I.E.C. nominal recording characteristic for lateral-cut discs of fine groove and the tolerance within which discs should be recorded

RECOMMENDATION No. 209 *

STANDARDS OF SOUND RECORDING FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES

Single track recording on magnetic tape

(Questions Nos. 42 and 63 — Recommendation No. 133)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

UNANIMOUSLY RECOMMENDS

that single track recording on magnetic tape should be in accordance with the following technical standards:

1. *Speed of tape*

   Primary speed: 15 inches/s ± 0.5% (38.1 cm/s ± 0.5%),
   Secondary speeds **: 30 inches/s ± 0.5% (76.2 cm/s ± 0.5%),
   7½ inches/s ± 0.5% (19.05 cm/s ± 0.5%).

2. *Width of tape*

   $0.250 \text{ inches} \begin{cases} +0 \\ -0.006 \text{ inches} \end{cases} \left(6.35 \text{ mm} \begin{cases} +0 \\ -0.15 \text{ mm} \end{cases}\right)$

3. *Strength of tape*

   The tape should be suitable for use on a machine exerting a maximum (transient) stress of 2.2. pounds (1 kg).

4. *Direction of winding*

   The tape should be wound in such a way that it may be unwound in an anti-clockwise direction during playing.

5. *Tape spools*

   Two types of hub are accepted for international programme exchange:

   Figure 1 gives the principal dimensions of the type more generally used in Europe;
   Figure 2 gives the dimensions of the hub more generally used in the United States and of the accompanying flange;

   Figure 3 gives the main dimensions of a typical machine fitting to receive the hub of Figure 1.

   Figure 4 gives the main dimensions of an adapter to enable the machine fitting of Figure 3 to receive the hub of Figure 2.

   Whenever the exchange of recorded programmes has to be effected with cine-type flanged spools, the spools must conform to the standards established by the International Electrotechnical Commission.

6. *Maximum outside diameter of the reel of tape*

   For hub of Fig. 1: 11.4 inches (290 mm),
   For hub of Fig. 2: 10.5 inches (267 mm).

7. *Tape leader*

   A non-magnetic identification strip at least one meter long should be placed at the beginning of the tape giving at least the number of the spool and the reference number

* This Recommendation replaces Recommendation No. 135.

** The secondary speeds should only be used by prior agreement.

(see § 8 below). This information should be given on the side of the leader continuous with the unrecorded side of the tape.

Note. — It is recommended that whenever possible the unrecorded side of the tape should be identified by some form of marking continuous throughout the length of the tape.

8. *Programme identification*

A label giving the following information should accompany each reel:

— broadcasting organisation,
— programme title,
— reel number,
— total number of reels,
— reference number,
— total playing time of programme,
— speed of tape (marked as prominently as possible).

9. *Reproducing characteristics*

A Standard Replay Chain is specified and recordings for programme interchange should give a response within the tolerances stated below when reproduced on this Standard Replay Chain:

(a) Nominal characteristic

The Standard Replay Chain is defined as one having the same response as that of an " ideal " reproducing head, the open-circuit voltage of which is amplified in an amplifier with a response curve as specified below:

For tape speeds of 15 in/s (38.1 cm/s) and 30 in/s (76.2 cm/s), the specified frequency response curve falls with increasing frequency in conformity with the impedance of a series combination of a capacitance and a resistance having a time constant of 35 μs. This curve is shown in Figure 5;

For a tape speed of 7½ in/s (19.05 cm/s) the specified frequency response curve falls with increasing frequency in conformity with the impedance of a series combination of a capacitance and a resistance having a time constant of 100 μs. This curve is shown in Figure 6.

(b) Tolerances

Tapes for international programme interchange should be recorded so that, when reproduced on a Standard Replay Chain the response falls between upper and lower limits defined as follows for tape speeds of 15 in/s (38.1 cm/s) and 30 in/s (76.2 cm/s):

upper limit

— from 50 c/s to 100 c/s falling regularly by 1 db,
— from 100 c/s to 5 000 c/s flat,
— from 5 000 c/s to 10 000 c/s rising regularly by 1 db,
— from 10 000 c/s to 15 000 c/s flat;

lower limit

— from 50 c/s to 100 c/s rising regularly by 3 db,
— from 100 c/s to 7 500 c/s flat,
— from 7 500 c/s to 15 000 c/s falling regularly by 3 db.

From 100 to 5 000 c/s the flat portions of the upper and lower limits are 2 db apart. These limits are shown in Figure 7;

For a tape speed of 7½ in/s (19.05 cm/s), the response should fall within limits defined as follows:

upper limit

— from 50 c/s to 10 000 c/s flat;

lower limit

— from 50 c/s to 100 c/s rising regularly by 3 db,
— from 100 c/s to 5 000 c/s flat,
— from 5 000 c/s to 10 000 c/s falling regularly by 3 db;

From 100 to 5 000 c/s the flat portions of the upper and lower limits are 2 db apart. These limits are shown in Figure 8.

Notes

1. An " ideal " reproducing head is defined as a ferromagnetic reproducing head, the losses of which are negligible. Normally this means that the gap is short, that the arc of contact with the tape is long compared with the relevant wavelengths on the tape and that the losses in the material of the head are small.
With the reproducing heads used in practice, compensation for the head losses must be added to the replay amplifier.
With good replay heads a mean value of this equalisation may be used for the two higher speeds and even for the three speeds.

2. The open circuit voltage developed in a ferromagnetic reproducing head depends on the surface induction * on the tape while it is in contact with the head. It has been found that, provided a coated high-coercivity tape is used, the surface induction in free space will be altered, when the tape is placed in contact with the head, by an approximately constant factor over the whole range of wavelengths. Under these circumstances the relative surface inductions at different frequencies can be measured by at least three methods that are described in the Annex. From such measurements the departure of the response of a reproducing head from the " ideal " can be defined, and consequently a Standard Replay Chain can be established as a primary standard. Test tapes can then be made which can serve as secondary standards for use in normal operation.

Note on use of reproducing characteristics

A different Standard Replay Chain has been adopted in the U.S.A. for 15 in/s (38.1 cm/s). The difference between the nominal characteristics of the Standard Replay Chain of the U.S.A. and that of the C.C.I.R. is less than the tolerance in § 9.
Furthermore a different characteristic is used in France for 30 in/s (76.2 cm/s).

ANNEX

Methods of measuring the magnetisation of a tape

There are two general ways in which the surface induction/frequency characteristic of a tape may be determined:

1. by means which do not affect the surface induction. This implies the use of a non-magnetic reproducing device. For example, reproduction by means of a simple non-magnetic conductor placed in the field at the surface of the moving tape is practicable as a laboratory method and may therefore be used to establish a primary standard. This can be used to determine the relative change of surface induction with wavelength created by the presence of a magnetic head;

2. by means of a magnetic reproducing device, which necessarily affects the surface induction of the tape in a manner dependent on recorded wavelength. In this category there are two ways in which conventional magnetic heads have been used, one method involving heads with a short gap, the other involving heads with a long gap. In both cases the gap in the reproducing head must be sufficiently accurate, magnetically, to give well-defined minima of reproduced level, one in the short gap method or several in the long gap method. In order to ensure that the same results will be obtained with both magnetic and non-magnetic reproducing devices, a coated high-coercivity tape must be used.

* In this Recommendation and in the Annex the term surface induction means the normal surface induction, that is to say, the flux density at right angles to the surface of the tape.

Steps must be taken to ensure that the arc of the tape in contact with the head is long enough in relation to the longest wavelengths recorded. If this is not so, it may be found that output level at the lower frequencies is slightly higher than that given by an ideal head and that the deviation increases as the frequency decreases while remaining as a general rule within the tolerances defined above. The error may be reduced by using bigger reproducing heads for the very low frequencies.*

(a) The " short gap " method

The longest wavelength at which a minimum of reproduced level occurs is called the effective gap length: d. The necessary correction for the gap length is calculated on the assumption that output is proportional to

$$\frac{\sin \frac{\pi d}{\lambda}}{\frac{\pi d}{\lambda}}$$

This correction must not exceed 5 db at the shortest wavelength considered. Any necessary correction for eddy current losses must also be determined, for example, by comparing outputs at various tape speeds or by the use of an inducing loop. Once these corrections are known and applied, the head may be used as an " ideal " head to measure relative surface inductions on the tape over the wavelength range considered.

(b) The " long gap " method

In this method a head is used with a gap some 50 times longer than that of the normal reproducing head. In practice an erase head can usually be adapted for the purpose. The response of such a head should show a series of well defined maxima and minima as shown in Figure 9.

A curve through the successive maxima is a measure of the relative surface induction on the tape, when the necessary correction for the eddy current losses of the head has been made. This curve falls approximately 4 db/octave compared with the curve of surface induction/frequency in air as determined by a non-magnetic reproducing device, or by a " short gap " head. This correction must therefore be applied.

The precise steps by which the procedures of 2 *(a)* and *(b)* may be applied in practice are outlined in the following.

Standardisation by the short gap magnetic head

Using the short gap method a recording equipment is set to the standard condition in the following way:

1. A " gliding tone " is recorded on a tape and reproduced by means of the head to be used for the measurements. The longest wavelength at which the output disappears is noted. This wavelength will be equal to the effective gap length, from which the gap correction may be deduced. If this correction exceeds 5 db the head is unsuitable for this measurement.

   Since the measurement must take place at a very short recorded wavelength, a high-coercivity tape should be used, and a certain amount of pre-emphasis will be found useful. In order to avoid making the measurements at an unnecessarily high frequency the lowest tape speed available should be used.

2. The tape with the gliding tone is reproduced at two different speeds and the output curves are compared. If the curves can be brought to coincidence by displacing one frequency scale so that equal wavelengths coincide, it may be assumed that frequency-dependent losses are negligible. If not, these losses may be deduced from the two curves mentioned or, alternatively, from a measurement with an inducing loop.

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* See Report No. 79.

3. The frequency response of the reproducing chain is now adjusted to be that specified in § 9 *(a)* of this Recommendation together with the gap correction noted in 1. above and the compensation for frequency dependent losses noted in 2. above.

4. The recording equalisation is then adjusted so that a flat overall response is obtained.

Standardisation by the long gap magnetic head.

Using the long gap method a recording equipment is set to the standard condition in the following way:

1. The reproducing head used has a well-defined gap long enough to give successive maxima of response at intervals of 1 kc/s, or less, in the audio-frequency range (with a tape speed of 30 in/sec (76.2 cms/sec) the gap length required would be about 800 microns). If the successive minima in the response curve are not equally well defined the head is not suitable for this measurement. A short preliminary experiment is carried out to determine the exact frequencies at which successive maxima occur at the relevant tape speed.

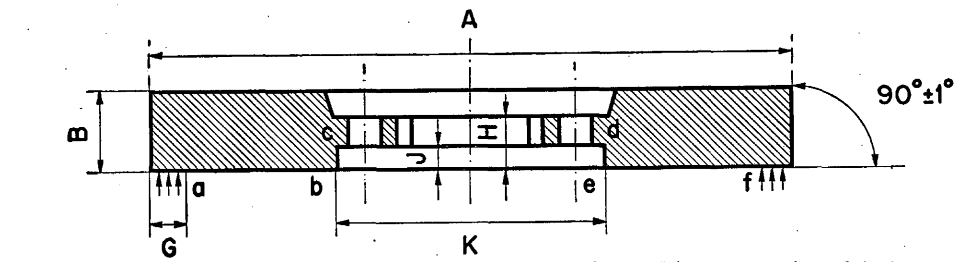
2. A " gliding tone " test tape of the audio frequencies of maximum level is then recorded with constant voltage input to the recording chain and the tape is reproduced using the long gap head. The open circuit voltage of the head around these frequencies is then plotted against frequency, and a smooth curve is drawn through the successive maxima.

3. The tape with the gliding tone is reproduced at two different speeds using the long gap head and the output curves are compared. If the curves can be brought to coincidence by displacing one frequency scale so that equal wavelengths coincide it may be assumed that frequency-dependent losses are negligible. If not, these losses may be deduced from the two curves mentioned or, alternatively, from a measurement with an inducing loop.

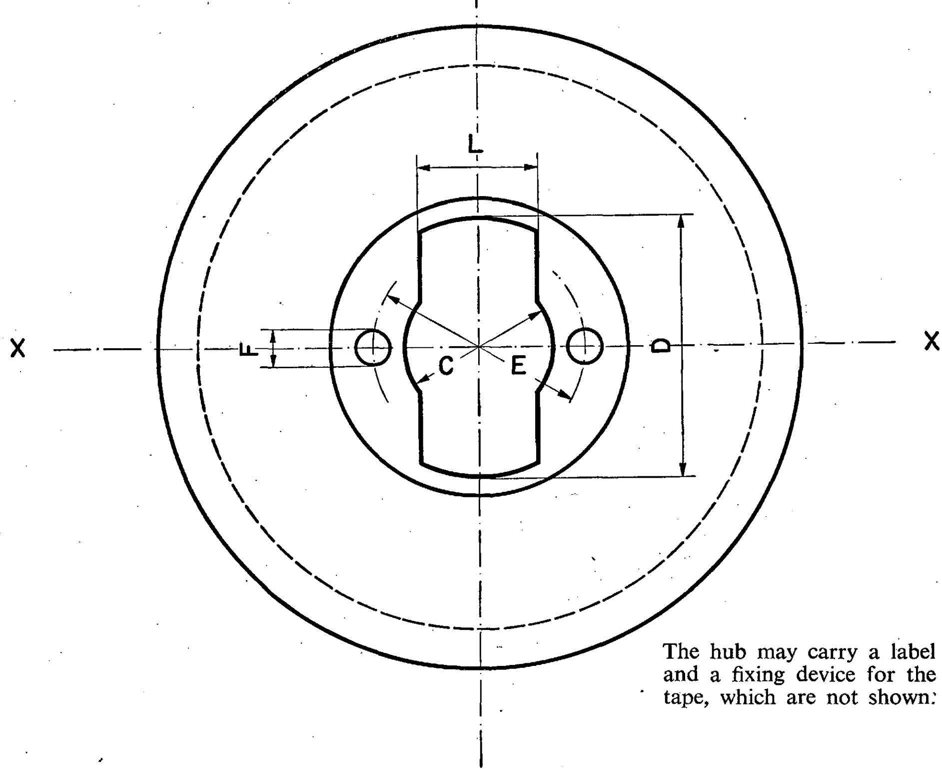
4. When the curve drawn in § 2 has been corrected by a 6 db/octave rise with increasing frequency together with the correction for frequency-dependent losses and a correction of 2 db/octave falling with increase of frequency, the result defines the relative surface inductions on the tape.

5. The equalisation of the recording amplifier is now altered to obtain a characteristic of surface induction/frequency that is the inverse of the equalisation specified for the reproducing chain (without allowance for the replay head losses).

6. The reproducing amplifier equalisation is then adjusted so that a flat overall response is obtained when using a normal reproducing head.



NOTE: The cross-section of the inner surface abcdef must fall within the shaded area.



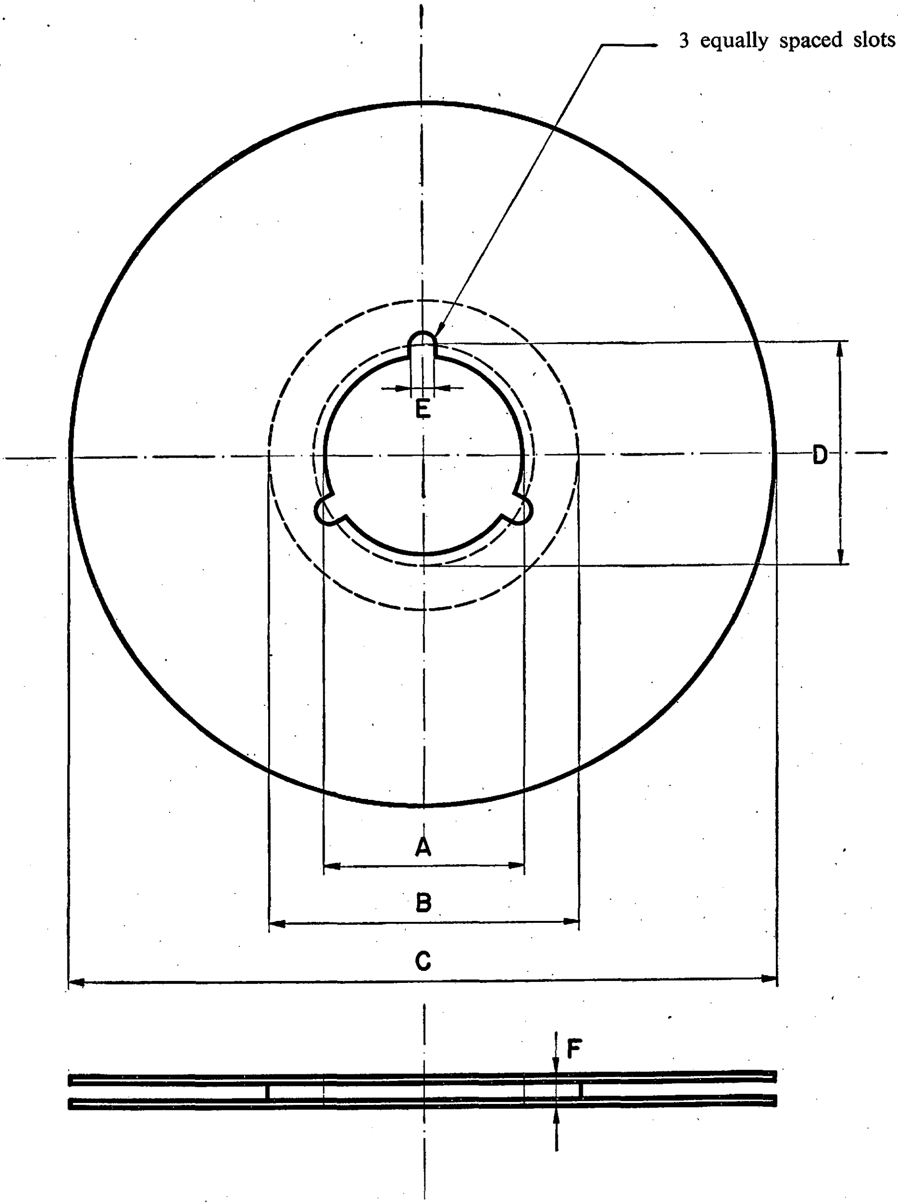
The hub may carry a label and a fixing device for the tape, which are not shown.

Dimensions	Millimètres	Inches	Dimensions	Millimètres	Inches
A	58 à 100	2.28 to 3.95	G	4	0.157
B	11 $^{+0}_{-0.2}$	0.433 $^{+0}_{-0.008}$	H	7 $^{+0}_{-1}$	0.275 $^{+0}_{-0.04}$
C	20.1 $^{+0.1}_{-0}$	0.791 $^{+0.004}_{-0}$	J	3.5 min.	0.138 min.
D	35 $^{+0.2}_{-0}$	1.378 $^{+.008}_{-0}$	K	36 min.	1.417 min.
E	28 $^{+0.2}_{-0}$	1.102 $^{+0.008}_{-0}$	L	16 $^{+0.2}_{-0}$	0.63 $^{+0.008}_{-0}$
F	5 $^{+0.2}_{-0}$	0.197 $^{+0.008}_{-0}$			

FIGURE 1

EUROPEAN STANDARDS

Spool hub for magnetic tape recording



Dimension	Inches		Millimetres	
	Minimum	Maximum	Minimum	Maximum
A	3.000	3.004	76.20	76.30
B	4.490	4.510	114.05	114.55
C	10.50	10.52	267.0	267.5
D	3.248	3.252	82.45	82.55
E	.219	.225	5.60	5.75
F	.447	.457	11.35	11.60

FIGURE 2

U.S.A. TYPE OF SPOOL FOR MAGNETIC TAPE RECORDING

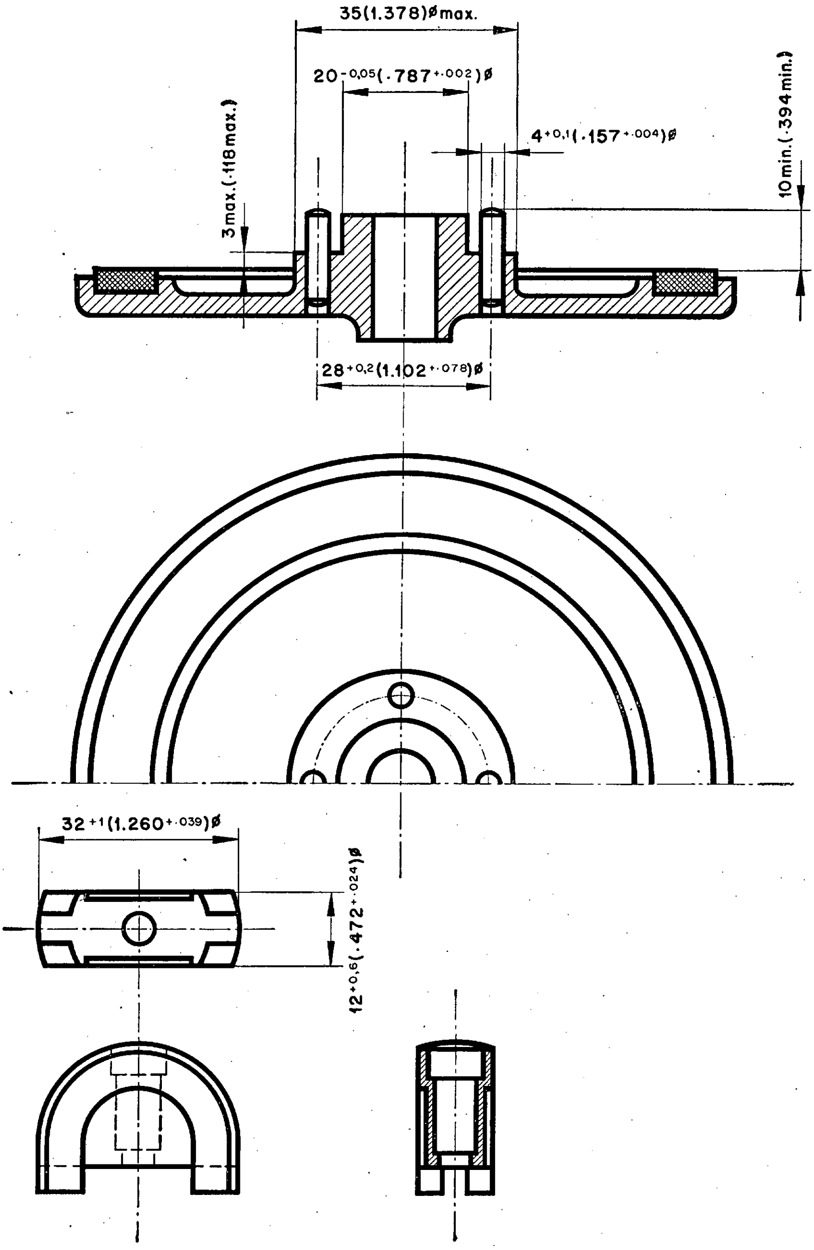


FIGURE 3

EUROPEAN STANDARDS

Machine fitting to receive spool hub

Note.—Unless otherwise indicated, all dimensions are in millimetres, with corresponding figures in inches in parenthesis.

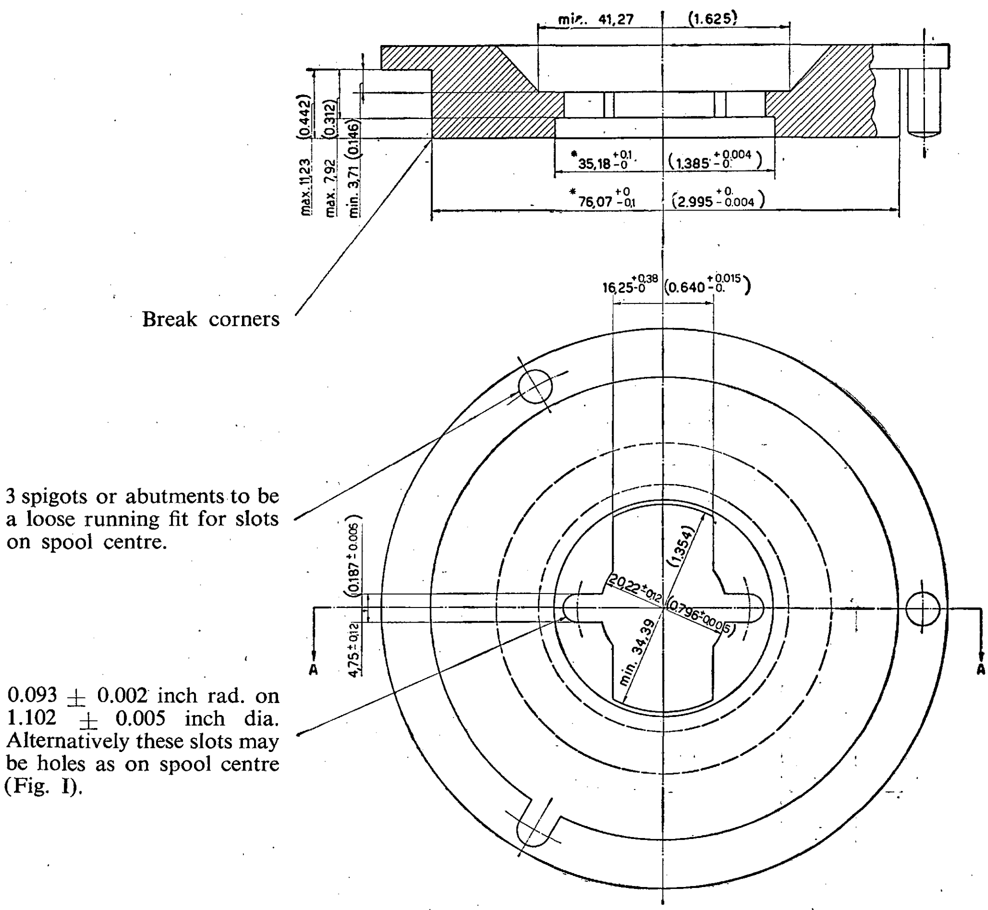


FIGURE 4

Typical adaptor to enable the European type of machine fitting to receive hub of Figure 2

Note. — Diameters marked thus * to be concentric within 0.003″.
— Unless otherwise indicated, all dimensions are in millimetres, with corresponding figures in inches in parenthesis.

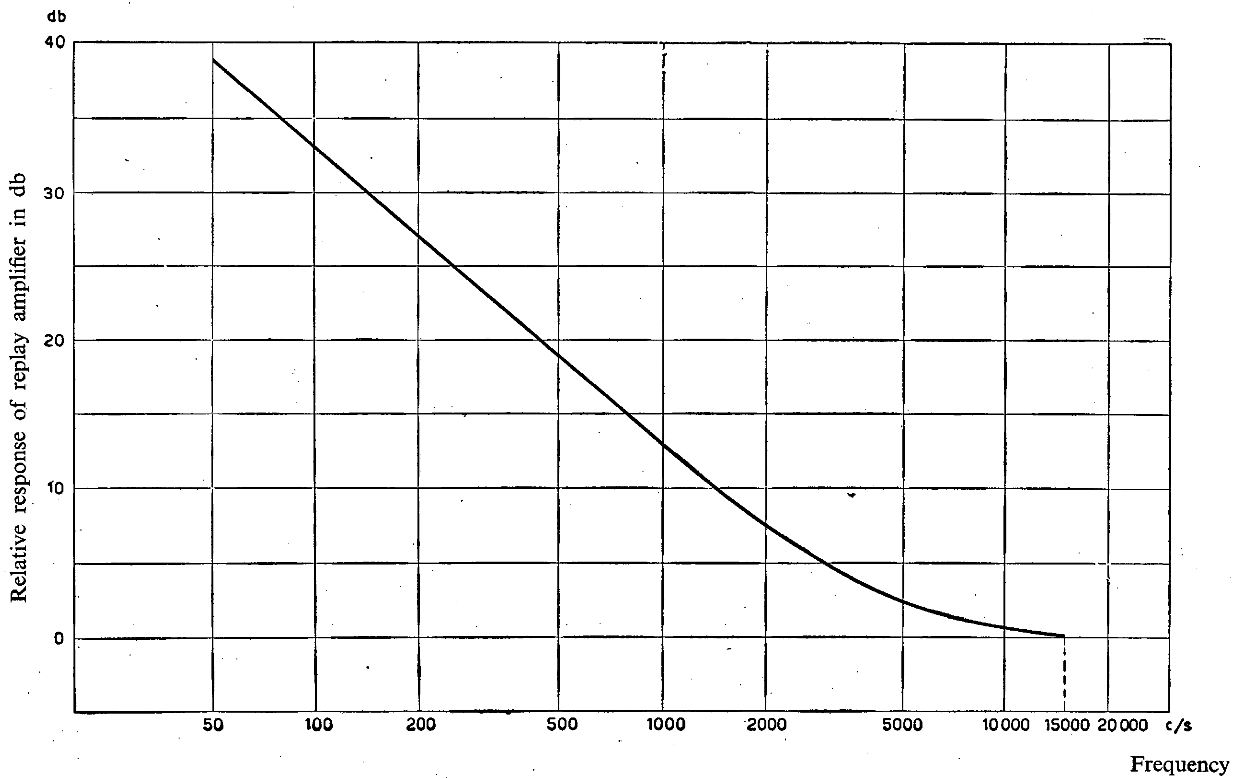


FIGURE 5

Nominal reproducing characteristic for magnetic tape at 15 in/s and 30 in/s

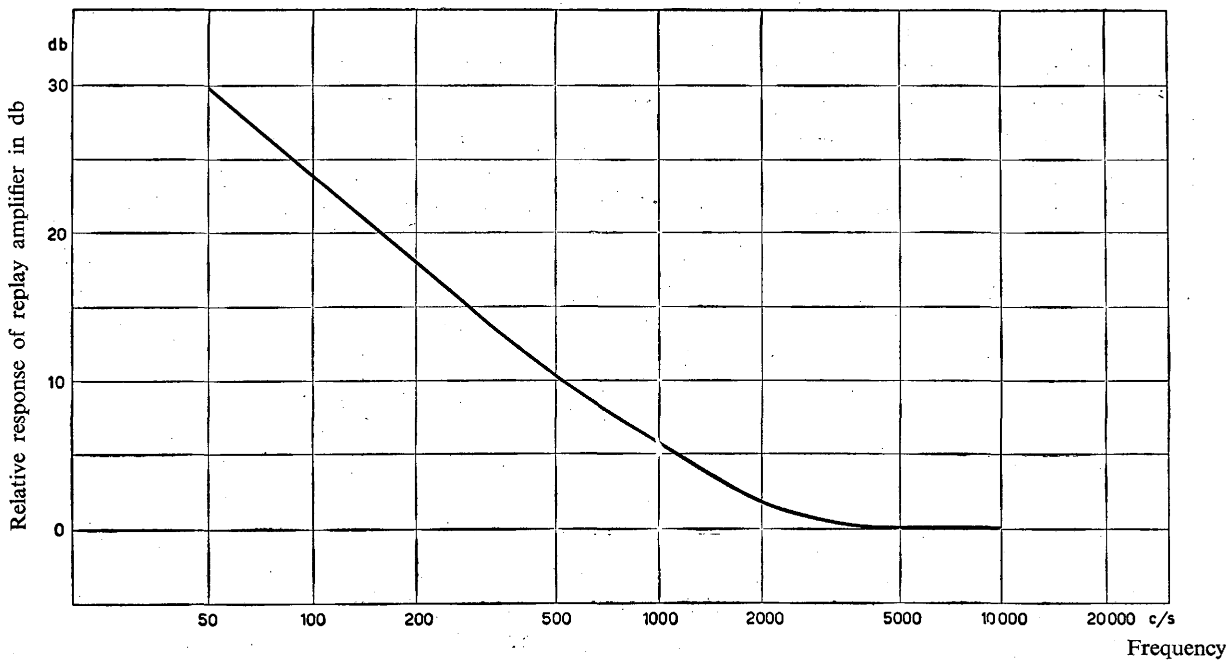


FIGURE 6

Nominal reproducing characteristic for magnetic tape at 7½ in/s

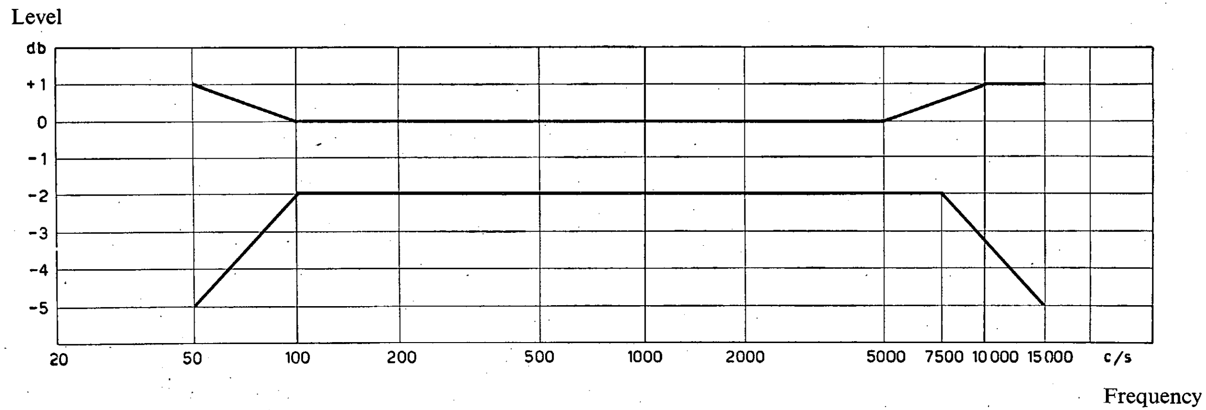


FIGURE 7

Recording tolerance for the speed of 15 and 30 in/s. Limits within which the response should lie when reproduction is carried out on the Standard Replay Chain.

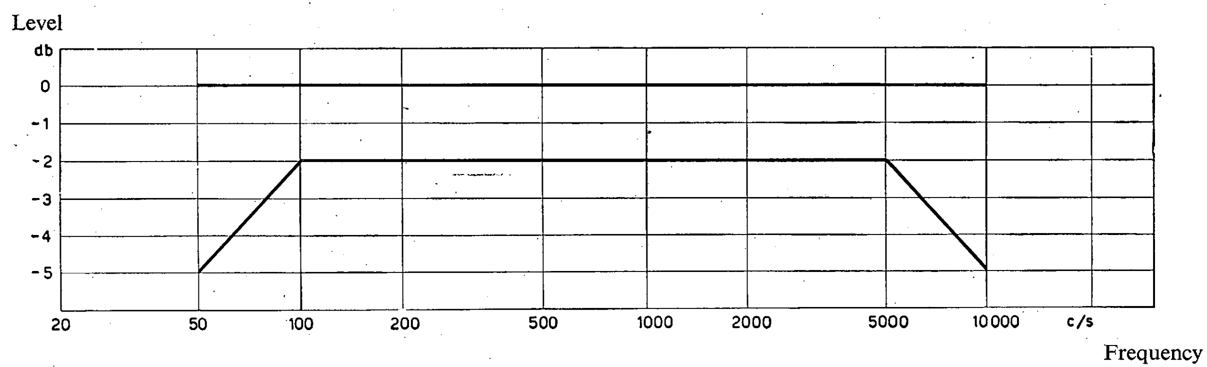


FIGURE 8

Recording tolerance for the speed of 7½ in/s. Limits within which the response should lie when reproduction is carried out on the Standard Replay Chain.

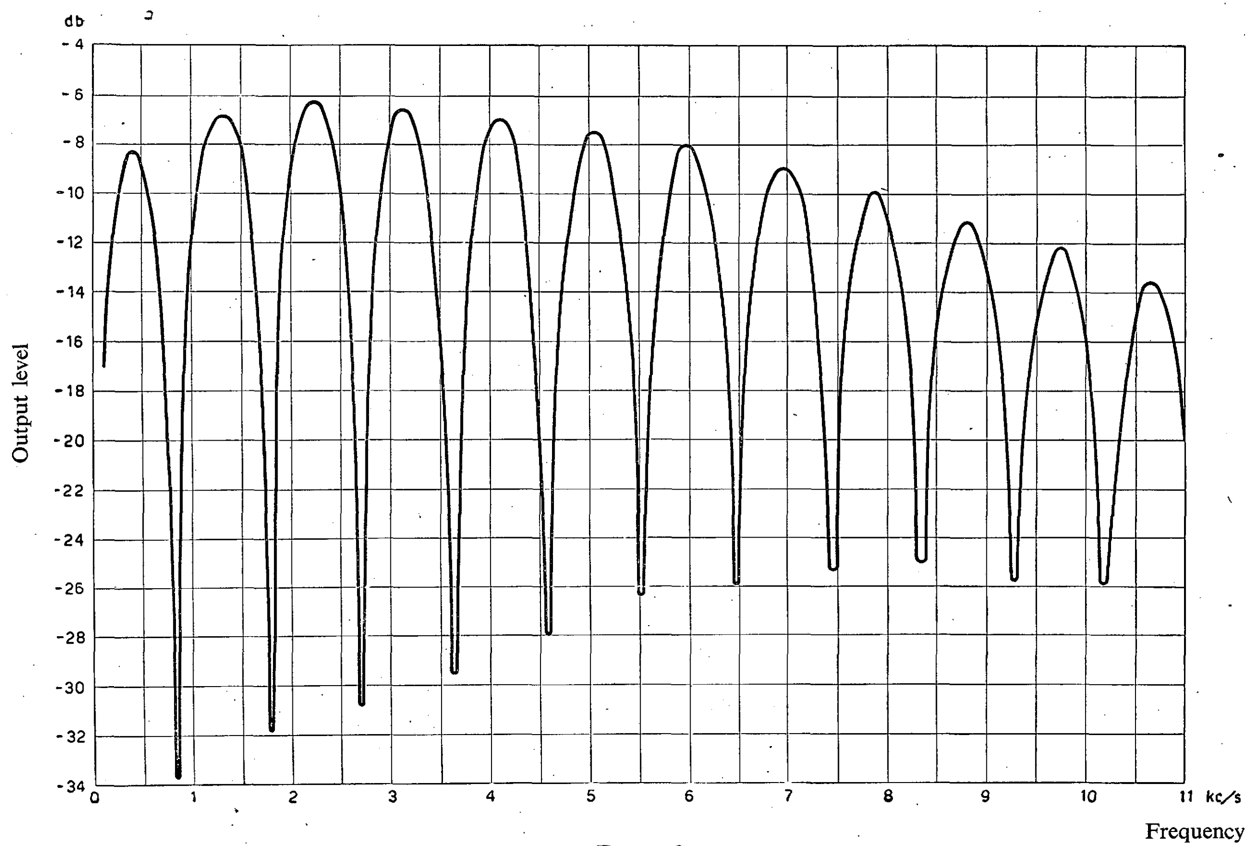


FIGURE 9

Typical response curve of a " long gap " reproducing head

RECOMMENDATION No. 210

MEASUREMENT OF WOW AND FLUTTER IN EQUIPMENT FOR SOUND RECORDING AND REPRODUCTION

(Study Programme No. 74 (X))

The C.C.I.R., (Warsaw, 1956)

UNANIMOUSLY RECOMMENDS

1. that the tone to be recorded for the measurement of wow and flutter measurement should preferably be 3000 c/s;

2. that the equipment used should measure wow and flutter within a minimum frequency range of 0-200 c/s.

RECOMMENDATION No. 211

SOUND RECORDING ON FILM FOR THE INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES

(Question No. 100)

The C.C.I.R., (Warsaw, 1956)

UNANIMOUSLY RECOMMENDS

that in the exchange of television programmes on film, the recording of the sound should be carried out:

1. by conventional optical means on 35 mm perforated film with dimensions according to the ASA specifications:

PH 22.36	PH 22.58
PH 22.59	PH 22.40

2. by conventional optical means on 16 mm perforated film with dimensions according to the ASA specifications:

PH 22.12	Z 22.8
Z 22.7	Z 22.41

3. by conventional magnetic means on 16 mm perforated film with a single perforation and with the magnetic sound stripe towards the edge of the film remote from the perforations, and conforming to the following standards:

3.1 the dimension and position of the magnetic stripe should be as given in Figure 1;

3.2 safety film should be used;

3.3 the film should normally be photographic positive;

3.4 the film should be on reels as specified in ASA standard PH 22.11;*

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* A different hub is used in France.

3.5 splicing of the film should be carried out according to the ASA standard PH 22.24;

3.6 the picture frequency should be either 25 frames or 24 frames (perforations) per second and should always be indicated;

3.7 the sound record should be in advance of the picture by 28 ±0.5 frames;

Note. — The figure of 26 ±0.5 frames has been previously proposed by certain organisations. This figure is the same as that used in optical sound recording. At a meeting in Stockholm of an I.S.O. commission, the delegates agreed on a spacing of 28 ±0.5 frames between picture and magnetic sound record. To facilitate the construction of machines with reproducing heads for both types of sound, the spacing between the picture and the magnetic and the optical sound recording should be different for the two systems. A difference of the order of 2 frames is considered desirable.

3.8 the magnetic stripe should be on the side of the film that faces the light source of a projector arranged for direct projection on a reflecting type screen;

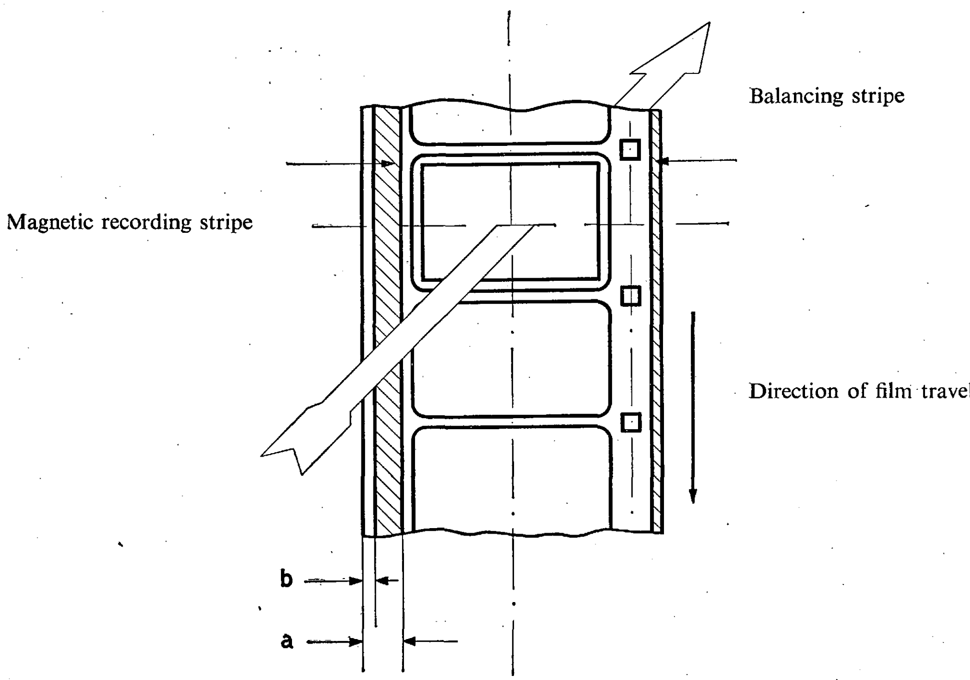
3.9 the maximum additional thickness due to the magnetic stripe should be 0.0008 inch (20 microns);

3.10 if a balancing magnetic stripe is used outside the sprocket holes it should have the same composition and thickness as the main magnetic stripe;

3.11 the recording characteristic should be that defined in Recommendation No. 209, § 9 for a tape speed of 7½ inches (19.05 cm) per second;

4. in certain cases by conventional magnetic means on 16 mm perforated film separate from the picture film, carrying magnetic sound stripes only and running at the same mean speed as the picture film.

Until standards for the second film can be agreed, reference should be made to Report No. 81.



Size of the magnetic recording stripe :

a) $2.5\,^{+0.1}_{-0}$ mm $\left(0.1\,^{+0.004}_{-0}\text{ in.}\right)$

b) $0.125\,^{+0}_{-0.125}$ mm $\left(0.005\,^{+0}_{-0.005}\text{ in.}\right)$

RECOMMENDATION No. 212 *

TELEVISION STANDARDS

(Recommendation No. 29)

The C.C.I.R., (Geneva, 1951 — Warsaw, 1956)

CONSIDERING

that a study of television standards was recommended by the C.C.I.R. at its Vth Plenary Assembly, to facilitate the interchange of programmes and to coordinate the design of receivers;

UNANIMOUSLY RECOMMENDS

1. that television systems should be capable of operating independently of the frequency of the power supply;

2. that the aspect ratio of the picture should be 4/3;

3. that line interlacing should be used in the ratio 2/1;

4. that the scanning of the picture viewed during active periods should be from left to right and top to bottom;

5. that the vision carrier should be modulated in amplitude;

6. that receivers should be designed for the reception of vestigial-sideband transmissions and that the vision carrier should be attenauted in the receiver;

7. that transmitters should be designed to attenaute the lower or the upper sideband without attenuating the carrier;

8. that the vision and sound carriers should be located within the channel, the vision carrier being 1.25 Mc/s from one edge and the sound carrier being 0.25 Mc/s from the other edge;

9. that the unwanted sideband should be attenuated so that the radiated field is reduced by at least 20 db at that edge of the channel which is 1.25 Mc/s away from the vision carrier;

10. that the black level should be a definite carrier level independent of the picture content;

11. that the gamma characteristic of the radiated signal should be lower than unity in order to take account of the signal/brightness characteristic of the average receiving picture tube;

12. that there is no necessity to standardise the polarisation of the transmitted wave.

Note. — In those countries where transmitters are already operating on a regular basis administrations are free to use their discretion as to the extent to which the provisions of § 6, 7, 8 and 9 of this recommendation may be implemented in the case of these transmitters, taking into account the modifications to existing receivers that might be necessary.

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* This Recommendation replaces Recommendation No. 82.

RECOMMENDATION No. 213

GAIN OF A TELEVISION TRANSMISSION CIRCUIT

(Question No. 122)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that, due to non-linear distortion, the apparent gain of a television transmission circuit may vary according to the form of signal transmitted;

(b) that in many cases the presence of synchronising pulses in the signal transmitted is necessary to ensure proper functioning of the transmission equipment;

(c) that the gain of the transmission circuit in respect of the picture portion of the composite waveform (that is, excluding the synchronising pulses) is of the greatest interest to the user;

(d) that an average amount of picture brightness content should be included in the test signal;

(e) that the nominal value for the input and output impedances of a television transmission circuit is 75 ohms;

UNANIMOUSLY RECOMMENDS

1. that the gain of a television transmission circuit be measured with a test signal comprising synchronising pulses together with a full white bar of approximately half-line duration, such as that described in Annex I to Report No. 84;

2. that in measuring the input and output amplitudes, only the picture part of the waveform between black level and white level be included, the synchronising pulses being ignored;

3. that the gain be expressed as the insertion gain when the television transmission circuit is interposed between a 75-ohm generator and a 75-ohm load.

Notes :

1. In practice the measurement may be carried out in the following way:
At the sending end of the circuit an accurate 75-ohm load is first connected across the output terminals of a suitable waveform generator and the voltage of the picture part of the signal across this load is adjusted to the nominal input value V_{pi} for the circuit under test. Without changing the output amplitude control of the generator, its output is transferred from the 75-ohm load to the input terminals of the circuit to be tested. At the receiving end of the circuit an accurate 75-ohm load is connected across the output terminals and the picture signal voltage across it, V_{po}, is measured. Then the insertion gain expressed in decibels is:

$$20 \log_{10} \frac{V_{po}}{V_{pi}}$$

2. To avoid errors due to irregularities in the waveform response of the circuit under test, all amplitudes should be measured at the centre points in time of the appropriate parts of the waveform.

RECOMMENDATION No. 214 *

LIMITATION OF THE POWER OF TRANSMITTERS IN THE TROPICAL ZONE TO AVOID INTERFERENCE IN THE BANDS SHARED WITH TROPICAL BROADCASTING

(Question No. 4 **)

The C.C.I.R., (Geneva, 1951 — Warsaw, 1956)

CONSIDERING

(a) that the power of transmitters for radio services in the tropical zone operating within the bands shared with tropical broadcasting (Art. 9, § 244, Radio Regulations, 1947) should be determined so as to ensure full protection to broadcasting in the tropical zone;

(b) that it is preferable to exploit the possibilities of " time sharing " between broadcasting services in the tropical zone and radiotelegraph services operating within the shared bands;

(c) that, at sunspot minimum, when certain frequencies become useless for tropical broadcasting, such frequencies could be used by other services;

(d) that Recommendation No. 215 recommends provisional power limitations for broadcasting stations in the tropical zone;

(e) that the maximum power of radiotelegraph stations can best be determined in the light of the permissible " repetition distance " (geographical sharing***);

(f) that the protection ratio to be considered in the determination of the " repetition distance " will be that set forth in Recommendation No. 216 read with Report No. 89;

(g) that the factors governing the limitation of power for A3 emissions by services other than broadcasting within the shared bands are similar to those for radio telegraphy;

RECOMMENDS

1. that, for the particular cases not involving simultaneous operation of broadcasting and other services, no limitations be imposed on the power of radiotelegraph stations operating within the shared bands other than those necessary to comply with the provisions of Section I, Art. 13, Radio Regulations, 1947;

2. that, for the general case involving simultaneous operation of broadcasting and radiotelegraph services within the shared bands, the limitation to be imposed on the power of radiotelegraph stations in the tropical zone should be only that required to provide adequate protection for the broadcasting services;

3. that the limitations for fixed service stations in the tropical zone employing A3 emissions and operating within the shared bands should be similar to those for radiotelegraph stations operating under like conditions.

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* This Recommendation replaces Recommendation No. 47.

** This Question has been replaced by Question No. 112 (XII).

*** See P.F.B. Doc. No. 712, dated 14th February, 1950.

RECOMMENDATION No. 215 *

MAXIMUM POWER FOR SHORT-DISTANCE HIGH-FREQUENCY BROADCASTING IN THE TROPICAL ZONE **

(Questions Nos. 27 and 102 (XII), Study Programme No. 112 (XII) Recommendations Nos. 47 and 84)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the prolonged observations and studies which have been carried out confirm the existence of high noise levels in tropical zones;

(b) that good quality service pre-supposes the maintenance of a satisfactory value of signal-to-noise ratio in the entire service zone which the provisional power limits mentioned in Recommendation No. 84 cannot ensure with appropriate coverage up to 800 km;

(c) that the high value of noise level observed in tropical regions during certain hours of the day and certain periods of the year, together with the need for signal-to-noise ratios such as to ensure a satisfactory service for practically all listeners within the specified service area tends to suggest the use of a high transmitter power for tropical broadcasting services. It is therefore advisable when evaluating the powers to be used to assume reasonable values for the average noise level and signal/noise ratio in order to reach practical values of transmitter powers, ensuring at the limit of the service area acceptable conditions of reception for a suitable percentage of transmission time;

(d) that, when the service zone is limited to 400 km, vertical incidence antennae may effectively be used in order to concentrate the energy in the service zone and to reduce radiation beyond this zone;

(e) that for greater distances it appears necessary to use types of antenna with low gain, such as a simple dipole, in order to obtain the desired field strength at a distance of 800 km. Nevertheless this type of antenna radiates at low angles of elevation and may give rise to interference at great distances;

(f) that it is advisable to make a judicious choice of transmitting frequencies which, for a tropical broadcasting programme, may be located in the shared bands whose upper limit is 5060 kc/s and in the HF (decametric) broadcast bands above 5060 kc/s;

RECOMMENDS

1. that the upper power limit for the unmodulated carrier wave of short-distance high-frequency broadcast transmitters employing double-sideband emission, operating in the tropical zones should be determined as follows:

(a) for a service area limited to 400 km the nominal power of the transmitter should not exceed 10 kW,

* This Recommendation replaces Recommendation No. 84. France, the Overseas Territories of the French Republic, Turkey (for § 1 *(c)*), the Union of South Africa, and the United Kingdom (for § 1 *(c)*) reserved their opinion on this Recommendation.

** As defined in the " considerations " of Question No. 27, given in the Annex to Study Programme No. 112 (XII), for this service.

(*b*) for a service area limited to 800 km the nominal power of the transmitter should not exceed 30 kW,

the powers mentioned above being for frequencies below 5060 kc/s used in tropical broadcasting for such ranges;

(*c*) for frequencies above 5060 kc/s, where tropical broadcasting services use the same frequency bands as the high-frequency broadcasting services, the same power limit as recommended by the Mexico City Conference (1949) shall apply;

2. that, within the above limits, administrations should use, as far as possible, lower powers, if these will assure satisfactory service throughout the reception area;

3. that the frequency used should always be as near as possible to the optimum working frequency (provided that the frequency employed is within one of the permissible broadcasting bands), in order to provide as good a received signal-to-noise ratio as possible;

4. that, in conformity with the provisions of Recommendation No. 139, and in order to make the best possible use of the frequency bands which have been allocated, administrations should use appropriate antennae, so that radiations at low angles be reduced to a minimum to avoid all harmful interference outside the service zone.

RECOMMENDATION No. 216 *

MINIMUM PERMISSIBLE PROTECTION RATIO TO AVOID INTERFERENCE IN THE BANDS SHARED WITH TROPICAL BROADCASTING **

(Question No. 4 ***)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(*a*) that it is necessary to establish, as soon as possible, a value for the minimum permissible protection ratio for broadcasting within the shared bands in the tropical zone;

(*b*) that the operation of broadcasting transmitters with 10 kc/s separation makes it difficult to measure the protection ratio with a receiver having an audio-frequency cut-off in excess of 5 kc/s;

(*c*) that, in the absence of sufficient information concerning noise values in various parts of the tropical zone, it is difficult to state a value of minimum field strength to which the minimum permissible protection ratio should be maintained; however, this minimum field strength should provide satisfactory reception at the limit of the broadcast station service area as provided by Art. 9, No. 243, Radio Regulations, 1947;

RECOMMENDS

1. that, for the present and wherever practicable in the tropical zone, the ratio of median wanted broadcasting carrier to median unwanted carrier shall be 40 db, to provide a signal-to-inter-

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* This Recommendation replaces Recommendation No. 138.

** See Report No. 89.

*** This Question has been replaced by Question No. 102 (XII).

ference ratio of not less than 23 db for 90% of the hours and 90% of the days (ref: Mexico City 1948/49, Doc. No. 635, § 13) *;

2. that the protection ratio thus defined should be measured at the output of a receiver provided with a filter having an audio-frequency cut-off of 5.0 kc/s **;

3. that, for the present, the protection ratio, as defined in § 1 above, should be maintained throughout the broadcast service area in the tropical zone to a minimum field strength of 200 microvolts/metre or any lower value consistent with satisfactory reception;

4. that the conditions of operation required for broadcasting in the tropical zone should be compatible with the protection ratio required for other services outside the tropical zone, in accordance with Art. 3, No. 90, § 5, of the Radio Regulations, 1947.

RECOMMENDATION No. 217 ***

USE OF 8364 kc/s FOR RADIO DIRECTION FINDING

(Question No. 21)

The C.C.I.R., (Geneva, 1951 — Warsaw, 1956)

CONSIDERING

(a) that the International Radio Conference of Atlantic City (1947) in No. 780 of the Radio Regulations states that

> " The frequency 8364 kc/s must be used by lifeboats, liferafts and other survival craft, if they are equipped to transmit on frequencies between 4000 and 23 000 kc/s, and if they desire to establish with stations of the maritime mobile service communications relating to search and rescue operations (see No. 600) " **** ;

(b) that land stations will, when the appropriate portions of Art. 33 of the Atlantic City Radio Regulations become effective, keep watch during their service hours on the band 8356 kc/s to 8372 kc/s; of which 8364 kc/s is the centre;

(c) that Regulations 13 and 14 of Chapter IV of the Safety of Life at Sea Convention (1948) indicate minimum specifications for automatic distress transmitters;

(d) that tests and operational experience have shown that radio direction finding on 8364 kc/s may be a valuable aid (in conjunction with direction finding on 500 kc/s), in finding the position of both aircraft and ships in distress and survival craft;

(e) that complete coverage cannot be obtained with direction finding on only one frequency in the HF (decametric) band because of the limitations caused by radio propagation conditions;

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* Doc. No. 43 of Washington refers, in particular, to the effect of long and short term fading.

** Practical consideration of the frequency separation of adjacent channels requires the use of an audio-frequency cut-off of 5 kc/s in the measurement in preference to 6.4 kc/s, appropriate corrections being applied, if considered necessary, to correspond do an audio-frequency cut-off of 6.4 kc/s.

*** This Recommendation replaces Recommendation No. 72. The P. R. of Poland reserved its opinion on this Recommendation.

**** The use of 8364 kc/s for these purposes depends upon the implementation of the appropriate portion of the Atlantic City Table of Frequency Allocations.

(f) that HF (decametric) radio direction finding requires apparatus as free as possible from local site error and polarisation error;

(g) that the accuracy of the bearing will depend upon the field strength of the signal and the signal/noise ratio;

(h) that in view of the rapid variation of the apparent azimuth of the bearing which is frequently observed in HF (decametric) radio direction finding, measurements should be made over several minutes to obtain a more accurate mean bearing; and that the bearing and fix may be improved subsequently by a further series of measurements;

(i) that standardised distress transmissions are desirable;

(j) that it is essential to have a means of rapid communication between the watch-keeping station and the direction-finding stations;

RECOMMENDS

1. that the site of the HF (decametric) radio direction-finding station should be, as far as possible :

1.1 flat and horizontal for a radius preferably of at least 200 metres, with the surrounding neighbourhood flat and free from obstruction;

1.2 of high and uniform ground conductivity;

1.3 free from large metallic masses and objects likely to resonate at frequencies near to 8364 kc/s;

2. that the aerial system should be as free as possible from wave polarisation error (e.g. Adcock systems and spaced-loop systems);

3. that the bandwidth of the direction-finding receiver used when bearings are taken should be as narrow as possible, compatible with the modulation and frequency stability of the signal on 8364 kc/s, and that a broader bandwidth position should also be incorporated in the receiver for watch-keeping purposes;

4. that the sensitivity of the direction-finding equipment should be such that it operates satisfactorily with a field strength as low as 5 μV/m;

5. that the bearing should be determined by an aural-null method or by any other method of comparable or better accuracy;

6. that the direction-finding equipment should be adjusted, balanced and calibrated at frequent intervals on the frequency of 8364 kc/s;

7. that the signal radiated by survival craft should be as strong as possible and stable in frequency to ensure the greatest accuracy in determining the bearings;

8. that the signals transmitted by survival craft should preferably include long dashes sent over a period of not less than five minutes for direction-finding purposes. The attention of administrations should be drawn to the precise form and content of such signals proposed by France, U.S.A. and U.K., given in Doc. Nos. 39 (France), 43 and 99 (U.S.A.) and 44 (U.K.) of Geneva, and to the question of whether it would be desirable to use a common form of signal for both 500 kc/s and 8364 kc/s;

9. that, in order to give as great an accuracy of fix as possible, several widely-spaced and interconnected direction-finding stations should be employed (see Annex);

10. that the classification of accuracy of bearings or of fix, as the case may be, as given in App. 15, § 5 and 6 of the Atlantic City Radio Regulations should be used when exchanging direction finding information;

11. that the attention of administrations concerned should be drawn to the advantage of their studying further;

11.1 the most suitable type of network for providing rapid communication between direction-finding stations and plotting centres;

11.2 the most suitable way in which information should be exchanged between different stations or networks (e.g. use of " Q " code);

11.3 the best way to evaluate the most probable fix (position) from bearings supplied by the direction-finding stations;

12. that the attention of administrations should also be drawn to the fact that world-wide direction-finding coverage cannot be obtained with only one frequency in the HF (decametric) band.

ANNEX

Accuracy of bearings on 8364 kc/s

At distances greater than about 1200 km the root-mean-square (r.m.s.) bearing error to be expected with a modern HF (decametric) direction-finding system is of the order of 3 to 5 degrees.

At distances less than 1200 km the error progressively increases with decrease of distance to values of the order of 5 to 10 degrees; at small distances, less than about 100 km, the error may be even greater than 10 degrees.

The above figures refer to the arithmetic mean of bearings spread over an interval of not more than about 10 minutes.

RECOMMENDATION No. 218 *

PREVENTION OF INTERFERENCE TO RADIO RECEPTION ON SHIPS **

(Question No. 34)

The C.C.I.R., (Geneva, 1951 — Warsaw, 1956)

CONSIDERING

(a) that the Maritime Regional Radio Conference, Copenhagen (1948), recommended that the C.C.I.R. study the question of interference to radio reception caused by electrical installations on board ship;

(b) that the Safety of Life at Sea Conference, London (1948), requested that all steps be taken to eliminate as far as possible the causes of radio interference from electrical and other apparatus on board ship;

(c) that electrical interference is caused by the unwanted excitation of the radio receiving equipment, including the aerial, by fluctuating electromagnetic fields set up by other electrical installations;

(d) that the fluctuation of electromagnetic fields which gives rise to interference is caused by abrupt changes in current in the source of interference, and by abrupt changes in the resistance of conductors situated in electromagnetic fields;

* This Recommendation replaces Recommendation No. 78.

** Interference from radar and other electronic equipment has not been specifically considered in framing this Recommendation. The prevention of radar interference is covered by Recommendation No. 45.

(e) that electrical interference may be transmitted by direct radiation and induction from the source of interference itself, and also by re-radiation and induction from conductors which carry interfering currents;

UNANIMOUSLY RECOMMENDS

1. that the design, construction and installation of electrical equipment in ships should be such that interference is minimised at its source;

2. that electrical equipment installed in ships should be efficiently maintained to prevent any increase in the level of interference which it causes;

3. that aerials used for transmission or reception should be erected as far above and as far away as possible from electrical machinery and from parts of the ship's structure such as funnels, stays and shrouds;

4. that the down-leads of aerials which are used exclusively for reception should be screened; that the screen should extend continuously from the receiver to a point which is as high as practicable above the ship's structure, and that the screen should be effectively connected to the ground terminal of the receiver;

5. that frame or loop aerials used for direction finding should be effectively screened against electrostatic interference;

6. that the radio receiving room should be effectively screened and situated as high as practicable in the ship;

7. that power converting plant within the radio receiving room should be housed in a separate screened enclosure, unless the plant is self-screened;

8. that the radio receiving equipment should be designed so that it is effectively screened;

9. that suppressor filters to prevent the propagation of interference should be fitted at the sources of interference, preferably built into the interference-producing equipment, and that in particular:

(a) The electrical ignition systems of internal combustion engines, including those which may be installed in lifeboats, should be fitted with suppressors;

(b) The navigational instruments and associated equipment which are installed in the neighbourhood of the receiving aerials or the radio receiving room should, if necessary, be fitted with suppressors, be screened, and the screen effectively grounded;

10. that cables in the vicinity of the receiving aerials or the radio receiving room, and cables within the radio room, should be screened by enclosing them in metal conduits, unless the cables themselves are effectively screened;

11. that twin cables should be used wherever possible: if single-core cable is necessary, the " lead " and " return " conductors should be fixed as close to one another as possible to avoid the formation of loops;

12. that suppressors should be fitted to cables at their point of entry into the radio receiving room, unless they terminate close to the point of entry in equipment which itself provides adequate screening and suppression;

13. that cables, ducts and pipes which do not terminate in the radio receiving room, should preferably not be installed in the radio receiving room; if it is essential for them to pass through the radio receiving room, the ducts and pipes and the screening of the cables should be effecively grounded;

14. that a copper earth-busbar should be fixed along the bulkheads and bonded at several points to the ship's structure and to the metal structure or screening of the radio receiving room; the screens of cables within and near to the radio receiving room, as well as the screens of apparatus in the radio receiving room, should be effectively connected to the busbar;

15. that rigging should be either insulated from or bonded to the ship's structure (stays that are subject to considerable tension can more conveniently be bonded);

16. that in the case of smaller vessels and those constructed of wood the principles recommended should be applied as far as is practicable;

17. that particular care should be taken to minimise interference on the frequency bands used for distress, safety and direction finding in the maritime service;

18. that administrations should bring the above recommendations to the attention of naval architects, shipbuilders and those responsible for the manufacture, installation and maintenance of electrical equipment.

RECOMMENDATION No. 219 *

ALARM SIGNAL FOR USE ON THE MARITIME RADIOTELEPHONY DISTRESS FREQUENCY OF 2182 kc/s

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that it is desirable and practicable to establish an internationally agreed alarm signal for use on the calling and distress frequency of 2182 kc/s;

(b) that the alarm signal should be such as to:

1. provide reliable operation of automatic alarm equipment;
2. provide a distinctive signal which is readily recognised aurally when received on a loudspeaker or headphones;
3. be capable of being received through interference from speech transmissions, through other kinds of interference, and through noise;
4. avoid false responses when received either aurally or by automatic means;
5. be capable of being produced by a simple manual device, as well as by automatic means;

(c) that the alarm signal should be such as to permit the construction of an alarm equipment which is rugged, dependable, stable in performance, of low cost, of easy production, of long life with a minimum of maintenance, and which can be used with existing maritime radiotelephone equipment;

(d) that to help in clearing the calling and distress frequency channel of emissions from other stations the alarm signal and detecting device should be effective beyond the range at which speech transmission is satisfactory;

(e) that the automatic alarm equipment should be capable of operating in as short a time as possible, consistent with the avoidance of false responses;

(f) that the results of the further examination of this problem by the administrations participating in Study Programme No. 29 (Geneva, 1951) are sufficiently conclusive to determine the

* This Recommendation replaces Recommendation No. 125.

essential characteristics of the signal including tolerances that should be recommended for international adoption;

(g) that it is possible to specify the minimum performance standards for automatic alarm equipment, for both transmission and reception, to such an extent that future progress and development are not hampered;

(h) that it is undesirable that the specification of performance standards for automatic alarm equipment should exceed in scope the requirements already established by international agreement for automatic alarm devices intended for the reception of the international alarm signal or the international distress signal in radio telegraphy, normally transmitted on the frequency 500 kc/s (Art. 37, § 31, 32, 33, International Radio Regulations, Atlantic City, 1947; and Chap. IV, Regulation 11, Convention for Safety of Life at Sea, London, 1948);

UNANIMOUSLY RECOMMENDS

1. that the alarm signal described below should be adopted internationally for use on the maritime radiotelephony calling and distress frequency of 2182 kc/s;

1.1 the alarm signal shall consist of two substantially sinusoidal audio-frequency tones, transmitted alternately for a minimum period of 6 seconds. One tone shall have a frequency of 2200 c/s and the other a frequency of 1300 c/s. The duration of each tone shall be 250 milliseconds;

1.2 the tolerance of the frequency of each tone shall be ± 1.5%; the tolerance on the duration of each tone shall be ± 50 milliseconds; the interval between successive tones shall not exceed 50 milliseconds; the ratio of the amplitude of the stronger tone to that of the weaker shall be within the range 1 to 1.2;

1.3 when generated by automatic means, the alarm signal shall be sent continuously for a period of at least 30 seconds but not exceeding one minute; when generated by other means, the signal shall be sent as continuously as practicable over a period of approximately one minute;

2. that the automatic devices intended for the reception of the alarm signal in question should fulfil the following conditions:

2.1 the frequencies of maximum response of the tuned circuits, and other tone-selecting devices, shall be subject to a tolerance of ± 1.5% in each instance; and the response shall not fall below 50% of the maximum response for frequencies within 3% of the frequency of maximum response;

2.2 in the absence of noise and interference, the automatic receiving equipment shall be capable of operating from the alarm signal in a period of not less than four and not more than six seconds;

2.3 the automatic receiving equipment shall respond to the alarm signal through intermittent interference caused by atmospherics and powerful signals other than the alarm signal, preferably without any manual adjustment being required during any period of watch maintained by the equipment;

2.4 the equipment shall not be actuated by atmospherics or by strong signals other than the alarm signal;

3. that the automatic alarm equipments, for both transmission and reception on the calling and distress frequency of 2182 kc/s, shall fulfil the following conditions:

3.1 the equipment shall be effective beyond the range at which speech transmission is satisfactory;

3.2 the equipments shall be capable of withstanding vibration, humidity, changes of temperature and variations in power supply voltage equivalent to the severe conditions experienced on board ships at sea, and shall continue to operate under such conditions;

3.3 the equipment should as far as practicable give warning of faults that would prevent the apparatus from performing its normal functions during watch hours;

4. that before any type of automatic alarm equipment for transmission and reception on the calling and distress frequency of 2182 kc/s is approved for use on ships, the administrations having *jurisdiction* over those ships should be satisfied by practical tests, made under operating conditions equivalent to those obtaining in practice, that the equipment complies with the provisions of § 1,2 and 3 of this Recommendation.

RECOMMENDATION No. 220 *

IDENTIFICATION OF RADIO STATIONS

(Question No. 104 (XIII))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that, in order to carry out an efficient monitoring service of radio stations, it is necessary for these stations to be identified as regularly as possible during their transmissions;

(b) that in many types of radio systems the identification procedure used at present is satisfactory to both the operating agencies and the regulating administrations, as is the case for single-channel low-speed telegraphy;

(c) that the Atlantic City Radio Regulations (Art. 13, Section V, § 10) set forth requirements for transmissions of radio call signs, and state that each radio station provided with a call sign from the international series must, unless the Atlantic City Radio Regulations provide otherwise, transmit this call sign during the course of their transmission as frequently as is praticable and reasonable;

(d) that certain types of radio stations are exempted from the necessity of having an international call sign, for example, stations which are easily identified by other means and whose signals of identification, or characteristics of emission, are published in international documents;

(e) that a satisfactory method for identifying multi-channel single-sideband transmissions has been evolved;

(f) that the problem of accomplishing identification of multi-channel telephone and telegraph transmission, except for single-sideband systems, is particularly difficult without the use of costly special apparatus;

(g) that the requirement of frequently transmitting a call sign may impose a difficult and costly hardship on the operating agencies, particularly where heavily loaded multi-channel or high-speed machine operation is employed;

(h) that, when a special call signal is transmitted simultaneously with traffic, it is desirable, for ease of identification, to transmit a signal preceding the call sign to indicate that the call sign which follows is superimposed on another emission;

RECOMMENDS

1.1 that each radio station required to have an identifying signal under the provisions of the Atlantic City Radio Regulations, Art. 19, should send its call sign at the beginning and the end of a transmission, and as often as practicable and reasonable during such transmissions;

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* This Recommendation replaces Recommendation No. 132. The Bielorussian S.S.R., the P.R. of Bulgaria, the Ukrainian S.S.R. and the U.S.S.R. reserved their opinion on this Recommendation.

1.2 that the identifying signal should be in International Morse Code, Five-Unit Code (International Telegraph Alphabet No. 2) or in speech modulation;

1.3 that, when a number of stations work simultaneously in a common circuit, either as relay stations, or in parallel on different frequencies, each station shall as far as is practicable and reasonable, transmit its own call sign; alternatively, each station should transmit the call signs of all stations working as a group on a common circuit;

2. that for the purpose of identification one of the following special call signal emissions should be used:

2.1 a call signal emission employing International Morse Code using class A1, A2 or F1 emission, and transmitted preferably at hand speed;

2.2 a call signal emission employing Five-Unit Code (International Telegraph Alphabet No. 2) using class A1, A2 or F1 emission, at a speed appropriate to single-channel working and preferably at the standardised speed of 50 bauds;

2.3 a call signal emission employing speech in clear;

3. that the identification signal should be transmitted by one of the following methods:

3.1 for class F1 emissions, particularly for high-speed or multi-channel working, the superposition of the call sign in Morse Code by amplitude keying;

3.2 for single-sideband emissions, by amplitude keying of the reduced carrier or of some other pilot frequency;

3.2.1 keying of the reduced carrier with a difference in level of more than 10 db provides satisfactory identification even in the presence of interference; as the difference in level is increased above about 6 db distortion starts to be noticeable in speech transmitted in the sidebands. In the absence of interference, identification is satisfactory for a difference of level greater than about 5 db, particularly if the identification signal is repeated;

3.3 for facsimile transmission employing class A4 emissions, by Morse Code during the intervals of traffic, or alternatively, simultaneously with traffic, by amplitude modulation at a frequency below the lowest used for the facsimile modulation. Where single-sideband transmission is used, amplitude keying, as in 3.2 above, may be used;

3.4 for the transmission of a special call-signal emission simultaneously with traffic, as covered in 3.1, 3.2 and 3.3 above or in other ways, the signal sent to indicate that the call signal which follows is superimposed on another transmission, should be sent in the same manner as the call signal, and the letters QTT should be used and incorporated in the International Q-Code (Radio Regulations Atlantic City 1947, App. 9) for this purpose;

4. that, in order to avoid additional complexity in the equipment and operating of transmitting stations, every effort should be made to provide monitoring stations with equipment suitable for the reception of call signals of all stations, regardless of the type of radio system or class of emission;

5. that, if the call signal cannot be transmitted frequently or continuously, it would facilitate the work of monitoring stations if the call signal were transmitted in the period from 10 minutes before, to 10 minutes after, the hour (G.M.T.);

6. that administrations be encouraged to co-operate directly with one another in carrying out tests of identification methods. Administrations are also invited to inform the I.F.R.B. in advance of such tests of new methods of identification in order to facilitate co-operative observations and also to afford other administrations the opportunity to become acquainted with such new methods for the identification of radio stations.

RECOMMENDATION No. 221 *

ADDITION TO APPENDIX 9 OF THE RADIO REGULATIONS

(Question No. 28)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that a code should not be inserted in the Radio Regulations unless it provides a sufficiently accurate assessment of the quality of transmissions;

(b) that it would be advisable for all the administrations to use the same codes, and that the number of officially recognised codes must consequently be as restricted as possible;

(c) that the abbreviations in the Q code are in general inadequate for obtaining a clear idea of the quality of a transmission;

(d) that the SINPO code has been used for several years by some administrations;

(e) that the FRAME and RAFISBENQO codes have been used for a long time but:
- — the SINPO code gives a more accurate description of the transmission quality than the FRAME code and is easier to use;
- — the SINPFEMO code is derived from the SINPO code by adding three letters relating to speacial features of telephone transmissions and is easier to use than the RAFISBENQO or RISAFMONE code;

(f) that the information which is not included in the SINPO or SINPFEMO code may be transmitted satisfactorily by service message;

UNANIMOUSLY RECOMMENDS

1. that the SINPO and SINPFEMO codes described in the Annex should be included in the Radio Regulations;

2. that, in the meantime, these signal codes may be placed in service by interested operating agencies or administrations at the earliest time that may be mutually arranged between them. In this respect, the Secretary General is asked to circularise all administrations to know if they are prepared to apply these codes by 1st January, 1952.

Special remarks.

(a) A signal report shall consist of the code word SINPO or SINPFEMO followed by a five or eight figure group respectively rating the five or eight characteristics of the signal code.

(b) The letter X shall be used instead of a numeral for characteristics not rated.

(c) Although the code word SINPFEMO is intended for telephony, either code word may be used for telegraphy or telephony as may be desired.

(d) The overall rating for telegraphy shall be as indicated in tables I and II.

* This Recommendation replaces Recommendation No. 141

TABLE I

	Mechanised Operation
5 Excellent	4-channel time-division multiplex
4 Good	2-channel time-division multiplex
3 Fair	Marginal single start-stop printer
2 Poor	BK's, XQ's and call signs readable
1 Unusable	Unreadable

TABLE II

	Morse Operation
5 Excellent	High speed
4 Good	100 wpm
3 Fair	50 wpm
2 Poor	BK's, XQ's and call signs readable
1 Unusable	Unreadable

(e) The overall rating for telephony shall be as indicated in Table III.

TABLE III

	Operating condition	Quality
5 Excellent 4 Good	Signal quality unaffected Signal quality slightly affected	Commercial
3 Fair	Signal quality seriously affected. Channel usable by operators or by experienced subscribers	Marginally commercial
2 Poor 1 Unusable	Channel just usable by operators Channel unusable by operators	Not commercial

ANNEX

SINPO SIGNAL REPORTING CODE

Rating scale	S	I	N	P	O
		Degrading effect of			
	Signal strength	Interference (QRM)	Noise (QRN)	Propagation disturbance	Overall readability (QRK)
5	Excellent	Nil	Nil	Nil	Excellent
4	Good	Slight	Slight	Slight	Good
3	Fair	Moderate	Moderate	Moderate	Fair
2	Poor	Severe	Severe	Severe	Poor
1	Barely audible	Extreme	Extreme	Extreme	Unusable

SINPFEMO SIGNAL REPORTING CODE

Rating scale	S	I	N	P	F	E	M	O
		Degrading effect of				Modulation		
	Signal strength	Interference (QRM)	Noise (QRN)	Propagation disturbance	Frequency of fading	Quality	Depth	Overall rating
5	Excellent	Nil	Nil	Nil	Nil	Excellent	Maximum	Excellent
4	Good	Slight	Slight	Slight	Slow	Good	Good	Good
3	Fair	Moderate	Moderate	Moderate	Moderate	Fair	Fair	Fair
2	Poor	Severe	Severe	Severe	Fast	Poor	Poor or nil	Poor
1	Barely audible	Extreme	Extreme	Extreme	Very fast	Very poor	Continuously overmodulated	Unusable

RECOMMENDATION No. 222

INTER-SHIP RADAR IDENTIFICATION

(Question No. 105 *)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the operational requirements to be met by any inter-ship radar identification device should be formulated by the responsible shipping and administrative authorities;

(b) that no internationally agreed requirement was indicated by the last Safety of Life at Sea conference, London, 1948, nor by the last international meeting on Radio Aids to Marine Navigation, New York, 1947;

(c) that, before a final recommendation can be made by the C.C.I.R. it is most desirable for the operational requirements to be agreed internationally;

(d) that it may be of assistance to the shipping and administrative authorities concerned to be advised of the work that has been done on this form of identification by the C.C.I.R.;

(e) that the operational uses which may be made of these identification devices may have repercussions on the current Regulations for Preventing Collisions at Sea and may also raise new legal problems;

UNANIMOUSLY RECOMMENDS

1. that administrations should consult their responsible shipping and administrative authorities to determine whether there is an operational need for the development of inter-ship radar identification devices; that if there is such a need, then steps should be taken to reach international agreement on the navigational requirements that should be met by inter-ship radar identification devices; and that the responsible authorities should be informed of the work that has already been carried out by the C.C.I.R. and which is described in Documents No. 53 and No. 71 (Warsaw) and summarised in Report No. 92;

2. that in the interval the general study of marine radar identification should be continued **, subject to review after the international navigational requirement has been clarified.

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* This Question has been replaced by Question No. 158 (XIII).

** See Question No. 158 (XIII).

RECOMMENDATION No. 223

TECHNICAL CHARACTERISTICS OF FREQUENCY-MODULATED VHF (METRIC) MARITIME EQUIPMENTS

(Question No. 107)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the Radio Regulations, Atlantic City, Chapter XIII, Article 34, Nos. 830 to 834, stipulate the general procedure for the worldwide use by the maritime mobile service of the frequency 156.8 Mc/s and neighbouring frequencies;

(b) that the use of VHF (metric) equipments in the maritime mobile service could reduce the use of MF (hectometric) maritime bands and thus tend to reduce congestion in these heavily loaded bands;

(c) that the early introduction of the world-wide use of equipments operating on the frequency of 156.8 Mc/s and neighbouring frequencies could contribute to the safety of life at sea;

(d) that it would be desirable to reach agreement upon essential technical characteristics for frequency-modulated VHF (metric) radiotelephone equipments for use in international maritime services in order to expedite the international use of such equipments;

(e) that, in the informal agreement on standardisation of VHF (metric) channels for international maritime radiotelephone services that was reached among certain countries during the Baltic and North Sea Radiotelephone Conference, 1955 (see I.T.U. circular letter 1683/55/R, dated 13 December 1955), it was considered that the equipment should employ frequency modulation and be capable of operating ultimately with a frequency spacing of 50 kc/s;

(f) that, without some further measure of agreement on channel allocations, it is not possible to decide all the technical characteristics needed to facilitate the design of equipment for international VHF (metric) maritime mobile services;

UNANIMOUSLY RECOMMENDS

1.1 that the following characteristics for frequency-modulated VHF (metric) radiotelephone equipments for the international maritime mobile services operating on 156.8 Mc/s and neighbouring frequencies should be adopted by administrations;

1.1.1 at present the frequency deviation should not be greater than $\pm$ 15 kc/s and the maximum deviation should be reviewed later if it is found in practice that unacceptable adjacent channel interference occurs, particularly as the loading of the channels increases;

1.1.2 all receivers should be capable of receiving satisfactorily emissions having a maximum deviation of $\pm$ 15 kc/s;

1.2 vertical polarisation should be used;

1.3 in the absence of fading and local screening, the protection ratio for common-channel operation should be such that the desired signal level exceeds the interfering signal level by at least 10 db. Each administration should provide for a further allowance, where appropriate, for fading and for fluctuations of a local nature (for instance, reflections from the terrain, sea, ships, docks, etc.);

1.4 the equipment should be designed for a frequency separation between adjacent channels of 50 kc/s;

1.5 the frequency separation between the transmitting and receiving frequencies for duplex working should be 4.5 Mc/s*;

1.6 further study is required of means of selective calling. For this purpose reference is made to Question No. 160 (XIII);

1.7 other essential parameters:

1.7.1 frequency modulation with a pre-emphasis of 6 db/octave should be used (phase modulation) with subsequent de-emphasis in the receiver;

1.7.2 the output power of the ships' transmitters should generally not exceed 20 watts except in special circumstances to be determined by individual administrations;

1.7.3 the output of any harmonic or spurious emission should not exceed 50 μW measured at the output terminals of the transmitter when loaded with a resistance equal to the nominal antenna impedance. This figure of 50 μW should be substantially decreased as soon as practicable, particularly in respect of spurious emissions within the VHF (metric) band used by the maritime mobile service (see Question No. 161 (XIII));

1.7.4 the audio-frequency bandwidth should be limited to 3000 c/s;

1.7.5 the frequency tolerance of the transmitter should not exceed 0.002%;

1.7.6 to minimise interference, special attention should be paid to the following receiver characteristics:

i. stability;

ii. selectivity;

iii. receiver radiation;

iv. intermodulation;

1.8 equipments should be designed so that frequency changes between assigned channels can be carried out rapidly, e.g., within a few seconds;

2. that administrations be advised that not all the requirements to be met in the design of equipments for VHF (metric) maritime mobile services can be established until there is a sufficient measure of international agreement on the channel allocation for this service.

Note. — This Recommendation concludes the study of Question No. 107.

RECOMMENDATION No. 224

TESTING OF 500 kc/s RADIOTELEGRAPH AUTO-ALARM RECEIVING EQUIPMENT ON BOARD SHIPS

(Question No. 108)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

that it is important for the safety of life at sea that radiotelegraph auto-alarm receiving installations (including the aerial) are always in good working order on board ships at sea;

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* The Maritime VHF Radiotelephone Conference (The Hague, 1957) was led to adopt a separation of 4.6 Mc/s in order to avoid interference from intermodulation products arising from television transmissions having a spacing of 4.5 Mc/s between the sound and vision carriers. (See Question No. 164 (XIII)).

UNANIMOUSLY RECOMMENDS

in addition to the requirements of chapter IV of the International Convention for the Safety of Life at Sea (London, 1948):

1. that all radiotelegraph auto-alarm receiving equipments for use on the international calling and distress frequency of 500 kc/s should, wherever practicable, be provided specifically with means for automatic warning of the following:

1.1 failure of any valve filament, whether the cathode is directly or indirectly heated;

1.2 major variation or sustained failure of any source of voltage which is used for supplying valve elements where this would seriously affect the proper functioning of the apparatus as laid down in chapter IV, Regulation No. 11 of the said Convention;

1.3 any drop in voltage, or complete failure, of the main power supply to the auto-alarm equipment that would seriously affect the proper functioning of the equipment and where such warning is not already given by other means;

2. that provision should be made for listening to the output of the auto-alarm receiver;

3. that the proper functioning of auto-alarm installations should be checked periodically by listening to signals on the auto-alarm receiver, with its normal aerial connected, and by observing similar signals received on 500 kc/s on the ship's main receiving installations;

4. that measures should be taken to ensure that the auto-alarm aerial is always in good condition;

5. that the design of auto-alarm equipment should be as simple as possible consistent with reliable and efficient operation;

6. that wherever practicable, measures should be taken to permit reception on the auto-alarm installation when the radio direction finder is being used;

7. that live test transmissions of the radiotelegraph auto-alarm signal should *not* be made.

Note. — This Recommendation concludes the study of Question No. 108.

RECOMMENDATION No. 225 *

NOMENCLATURE OF THE FREQUENCY AND WAVELENGTH BANDS USED IN RADIOCOMMUNICATION

(Question No. 73)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that it is appropriate to retain the subdivision of frequencies and of wavelengths adopted by the International Radio Conference of Atlantic City (Radio Regulations, Chap. II, Art. 2, No. 85, § 10), which has been shown to be of considerable practical value, since it is in fair agreement with the criterion of grouping together frequencies with common physical and propagation properties as well as a uniform equipment constructional technique;

* This Recommendation replaces Recommendation No. 142.

(b) that, however, frequency band denomination by means of adjectives, superlatives and adverbs is inconvenient, ambiguous and not readily extended to the ever widening bands employed in radio communication;

UNANIMOUSLY RECOMMENDS

that, by doing away with all frequency band denomination by means of ambiguous terms such as adjectives, superlatives, etc., it is proper to characterise bands by means of progressive whole numbers in accordance with the following table, intended to be substituted, at a later conference of the I.T.U., for that of the Radio Regulations of Atlantic City (Chap. II, Art. 2, No. 85, § 10).

Band number	Frequency range (lower limit exclusive, upper limit inclusive)	Metric subdivision
4	3 to 30 kc/s	Myriametric waves
5	30 to 300 kc/s	Kilometric waves
6	300 to 3 000 kc/s	Hectometric waves
7	3 000 to 30 000 kc/s	Decametric waves
8	30 to 300 Mc/s	Metric waves
9	300 to 3 000 Mc/s	Decimetric waves
10	3 000 to 30 000 Mc/s	Centimetric waves
11	30 000 to 300 000 Mc/s	Millimetric waves
12	300 000 to 3 000 000 Mc/s	Deci-millimetric waves

Note 1. — "Band N" extends from 0.3×10^N to 3×10^N c/s.

Note 2. — When a service adopts a reference number or letter to designate a specific frequency band allocated to it and situated, wholly or for the most part, in " Band N " of the above nomenclature, the prefix N should normally precede the reference in question. For example, for the 41 to 68 Mc/s band, to which broadcast users give the reference " I ", the appropriate designation is " *broadcast band 8-I* ", since it refers to a part of " band 8 ". This practice, applicable in the drafting of C.C.I.R. documents, is generally recommended for all cases where such a definition would obviate the risk of confusion in designating the numerous frequency bands and sub-bands.

RECOMMENDATION No. 226

FACSIMILE TRANSMISSION OF METEOROLOGICAL CHARTS OVER RADIO CIRCUITS

(Question No. 94 (III))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that increasing use is being made of facsimile telegraphy for the transmission of meteorological charts for reception on direct-recording apparatus;

(b) that it is desirable to standardise certain characteristics of the radio circuits for this purpose;

UNANIMOUSLY RECOMMENDS

that when frequency-modulation of the sub-carrier is employed for the facsimile transmission of meteorological charts over radio circuits, the following characteristics should be used:

sub-carrier frequency	1900 c/s
black frequency	1500 c/s
white frequency	2300 c/s

Note. — The normal index of co-operation is 576 associated with a speed of 60 r.p.m. The same index of co-operation is also used in association with speeds of 90 and 120 r.p.m. It is to be observed that whereas with the drum speed of 60 r.p.m. satisfactory reception can usually be expected, the quality of the recording may be impaired at higher drum speeds, depending upon the composition of the circuit and the presentation of the original document.

RECOMMENDATION No. 227 *

STANDARDISATION OF PHOTOTELEGRAPH APPARATUS FOR USE ON COMBINED RADIO AND METALLIC CIRCUITS

(Question No. 58)

The C.C.I.R., (Stockholm, 1948 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that in order to facilitate interworking it is desirable to standardise the characteristics of apparatus employed for phototelegraph transmission over long-distance HF (decametric) circuits;

(b) that it is desirable to standardise certain characteristics of the apparatus in such a way as to make it equally suitable for transmission over metallic circuits;

(c) that the transmission system using direct amplitude modulation is generally unsatisfactory over HF (decametric) radio circuits because of the intolerable fading ratio usually encountered;

(d) that the time-modulation system gives insufficiently good definition;

(e) that the system of direct frequency-modulation of the radio-frequency carrier is not yet widely adopted for the transmission of half-tone pictures owing to the high stability necessary in the frequencies representing the picture tones;

(f) that the system of sub-carrier frequency-modulation (i.e. in which a sub-carrier is frequency-modulated and the resultant is used to modulate in amplitude a radio-frequency carrier) has proved satisfactory but requires standardisation in respect of the sub-carrier and deviation frequencies, taking into account the values of the picture-modulation frequencies to be transmitted;

(g) that, taking into account the degree of distortion that is tolerable, the effect of multipath echoes on long-distance HF (decametric) radio circuits normally limits the maximum admissible picture-modulation frequency to approximately 600 c/s;

(h) that a Joint Study Group of the C.C.I.T. and the C.C.I.R., under the direction of the C.C.I.T., was formed to study certain aspects of the subject of " Transmission of half-tone pictures over combined radio and metallic circuits " and, having met in London in 1956, has prepared a revised draft of Recommendation No. D. 4 (C.C.I.T. Doc. No. AP VIII/6, pages 6 and 7) for submission to the C.C.I.T. VIIIth Plenary Assembly;

(i) that the C.C.I.F. has approved the conditions under which frequency modulation may be used for phototelegraphy over international telephone circuits;

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* This Recommendation replaces Recommendation No. 127.

UNANIMOUSLY RECOMMENDS

1. that over the radio path, the sub-carrier frequency-modulation system should be used with the following characteristics:

(a) sub-carrier frequency 1900 c/s
white frequency 1500 c/s (the 1500 c/s frequency is also used for the phasing frequency)
black frequency 2300 c/s

(b) stability of frequencies such that the variations are less than
instantaneous 8 c/s
during 15 minutes 16 c/s;

2. that for the present, the following alternative characteristics should be used:

index of cooperation	352	264		
speed of rotation of drum in r.p.m.	60	90	45	(Lower speed for use when radio propagation conditions demand it);

3. that frequency modulation or amplitude modulation may be used in the metallic portions of the combined circuit. When conversion from amplitude modulation to frequency modulation (or vice versa) is required the conversion should be such that the deviation of the frequency-modulated carrier varies linearly with the amplitude of the amplitude-modulated carrier.

The standards for both amplitude-modulated and frequency-modulated transmissions will be found in C.C.I.T. Recommendations Nos. D. 1 and D. 3. Recommendation No. D. 3 applies only to the metallic portion of the combined circuit.

The location of the modulation converters, where these are necessary, should be decided by each administration. To facilitate telephone communication it is desirable to place the modulation converters at the terminal phototelegraph stations or at the picture-control station in the case of transmissions over combined radio and metallic circuits.

Note. — The provisions of the paragraph 2 above do not imply the imposition of such standards on private users who use their own equipment for the transmission of pictures over private circuits.

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REPORTS

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REPORT No. 14 *

HIGH-FREQUENCY BROADCASTING RECEPTION

(Question No. 38 (X))

(Geneva, 1951)

This report has been prepared utilising the available results of past research regarding the short and long term variability of high-frequency broadcasting signals, atmospheric noise and industrial noise intensities, together with the results of subjective tests of the acceptable ratios of steady desired to undesired signals and of steady signal to atmospheric and industrial noises.

Although it is believed that further theoretical and empirical work should be carried out in this field, it is felt that available material makes it possible to supplement provisionally the existing information and to estimate allowances which should be made to take into account the short and long term variability of signal and atmospheric noise intensities in order to provide acceptable service for any specified percentage of the time.

The table sets forth, for purposes of information, the fading safety factors which are necessary to assure a specified signal-to-interference ratio for particular percentages of the time **.

Consideration has not been given to the allowances to be made when there is more than one interfering signal or a combination of interfering signals and noise. This is known to be an exceedingly complex problem, and, although some theoretical investigations have been performed, there is no available information on the subjective aspect involved.

Table

	1	2	3	4
Desired signal to undesired signal	10 db	13 db	23 db	16 db
Desired signal to atmospheric noise	6 db	16 db	22 db	17 db
Desired signal to industrial noise	6 db	10 db	16 db	12 db

Column 1 This is the short-term fading allowance which must be made to ensure that the steady state ratio is achieved for 90% of any given hour.

Column 2 This is the long-term fading allowance which must be made to ensure that the steady state ratio is achieved for 90% of the hours in any one month at a particular time of day in 90% of the cases.

Column 3 By adding the values in Columns 1 and 2, this is the overall variability allowance which must be made to ensure that the steady state ratio is achieved for 90% of any hour in 90% of the hours in any month at a particular time of day and in 90% of the cases. This represents an assured steady state ratio for 96% of the overall time.

Column 4 By taking the square root of the sum of the squares of the values in Columns 1 and 2, this is the overall variability allowance which must be made to ensure that the steady state ratio is achieved for 90% of the overall time.

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* This Report was adopted unanimously.

** Refer to Doc. Nos. 43 and 66 of Washington, and Doc. Nos. 160, 178 and 215 of Geneva.

The figures in the table relating to the time availability of service were selected on a theoretical basis and on experience derived principally from medium-wave broadcasting. Some doubt exists as to the practicability of achieving these percentages, since recent calculations of the transmitter power required to provide this time availability at the present accepted steady state conditions have produced quite unrealistic results.

The C.C.I.R. is of the opinion that Question No. 39 should remain on the agenda, and that further theoretical and empirical work should be carried out on this question. These studies should include the gathering of data on the time availability versus signal-to-interference ratio for services which are regarded as being normally acceptable under actual operating conditions.

REPORT No. 17 *

HARMONICS AND PARASITIC EMISSIONS

(Question No. 1.b (I) — Study Programme No. 2 (I))

(London, 1953)

After consideration of the various London documents supplied to the C.C.I.R. on this question:

Doc. No. 65	United States of America
Doc. No. 80	United States of America
Doc. No. 101	Report of the Chairman of Study Group No. I
Doc. No. 124	Belgium
Doc. No. 130	Japan
Doc. No. 340	U.S.S.R.,

the VIIth Plenary Assembly of the C.C.I.R. considers that insufficient information has been received to permit revision of App. No. 4 of the Radio Regulations (Atlantic City, 1947). However, the discussions and the documentation received show that the tolerances given in that App. No. 4 can be met in practice.

A study of several approaches to the problem of measurement of harmonic and parasitic emissions indicates that the problem can be attacked by two methods:

1. tests on the transmitters in respect of the power of harmonic or parasitic frequencies delivered to the load;

2. field intensity measurements at a distance from the transmitter to determine the interfering possibilities of the complete installation.

The first method would generally precede operation on normal traffic and is a laboratory method based on power measurements. The power measurements may be by the substitution method, direct power measurement, or other methods. The field intensity measurement at a distance will provide a practical means of determining the overall effect and expressing the intensity of interfering signals due to harmonic parasitic radiations.

The direct power measurement method as described in London Doc. No. 130 can be used while the transmitter is in operation even when it is one of a group of transmitters operating simultaneously. The method used is based on the measurement of the current, voltage and phase of each harmonic.

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* This Report was adopted unanimously.

When necessary, an improvement in the reduction of harmonics may be obtained by the use of filters at the output of the transmitter. One specific type of filter is described in London Doc. No. 340 which provides a reduction of 32 db in the level of the harmonics. The effectiveness of the filter is assessed by comparing the harmonic field intensity at a distance of over 100 metres from the transmitter aerial with and without the filter.

Another type of filter, mentioned in London Doc. No. 124, makes it possible to obtain harmonic levels of 70 or 75 db with respect to the fundamental for high-power MF (hectometric) transmitters. These results were obtained by the substitution method. Attention must be given to proper screening of the transmitter in order to prevent direct radiation of harmonic and parasitic emissions.

As regards the combination frequencies produced by interaction between high-power MF (hectometric) transmitters situated in the same transmitting centre, attenuation of 45 to 50 db has been obtained by high-quality series rejector filters (London Doc. No. 124).

With respect to the particular harmonics falling within television channels, information is given in London Doc. No. 65 which indicates the present limitation of harmonic and parasitic radiations applied in U.S.A. for the various services.

The study of the measurement and reduction of harmonics and parasitic emissions should be continued.

REPORT No. 19 *

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(Question No. 43 (III))

(London, 1953)

The C.C.I.T. in answer to Question No. 43 (III) has carried out certain studies concerning voice-frequency telegraphy on radio circuits.

These studies have shown that it is not yet possible to give a complete answer to the question. However, as regards radio circuits using frequencies below 30 Mc/s, a recommendation has been made dealing with diversity reception. Moreover, the C.C.I.R. would draw the attention of the C.C.I.T. to the following points in respect of reception below 30 Mc/s:

1. the voice-frequency system which radiates one frequency for one signalling condition and suppresses the radiation for the other signalling condition does not give satisfactory results when applied to radio circuits;

2. systems which radiate one frequency for one signalling condition and a different frequency for the other signalling condition (using two oscillators or one frequency-shift oscillator) have in general to be modified for this special use. For instance:

   — the range of linear amplification of the audio amplifier common to all channels in the receiving equipment has to be much greater than is necessary on land-line circuits because of the large changes in amplitude of the received signals due to fading;

   — for the same reason the limiter preceding each channel discriminator should operate over a large range of input signal amplitudes;

   — many filters used in equipment designed for land-line circuits do not have suitable characteristics;

* This Report was adopted unanimously.

— to obtain good diversity results it is not sufficient merely to connect the outputs of separate channels of standard voice-frequency equipment in series or in parallel, but special provisions have to be made;

3. notwithstanding all precautions taken, it should be realised that the use of voice-frequency equipment on radio circuits may become impossible when reception conditions are poor.

REPORT No. 21 *

GROUND-WAVE PROPAGATION OVER IRREGULAR TERRAIN

(Question No. 6) **
(Study Group No. IV)

(Geneva, 1951 — London, 1953)

In addition to the documents submitted at the VIth Assembly at Geneva in 1951, further contributions, all London documents, relating to Question No. 6, items 2, 3, 4 and 5 have been received from the Chairman of the Study Group (Doc. No. 104), from Austria (Doc. No. 379), Japan (Docs. Nos. 139 and 160), the Netherlands (Doc. No. 242), the United Kingdom (Docs. Nos. 95 and 154) and from the United States (Docs. Nos. 10 and 11). The study of this subject has now reached a stage where the following statements can be made:

1. *Question No. 6***, *§ 2.*

Effects of hills and other obstacles in diffracting the waves in either the horizontal or vertical plane.

1.1 *Single obstacles of definite shape.*

(a) Bare hills of approximately knife-edge shape.

When the terminal points are well removed from the obstacle, it is adequate to apply the classical Fresnel treatment for optical diffraction at a knife-edge profile, but when they are on or near the obstacle, a more rigid approach is necessary. The hill is regarded as a sharp edge at which the direct and ground reflected waves comprising the incident radiation are diffracted. The diffracted field at the receiver can be similarly resolved into the direct and ground reflected components.

A number of experiments have shown that small irregularities of the ground before and behind the obstacles may give rise to multiple transmission paths and can have a particularly favourable influence upon the field-strength at the receiving site if the components are in phase.

It appears that where Fresnel diffraction theory is applicable, there is no distinction in behaviour between horizontal and vertical polarisation.

(b) Bare hills of approximately cylindrical shape.

When the transmitter and receiver are placed close to and on opposite sides of the obstacle, the theory of diffraction around a cylindrical or spherical surface is applicable.

When the transmitter and receiver are not very distant from the obstacle, the joint method of reflection and diffraction may be used. The diffraction around the obstacle between

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* This Report was adopted unanimously. It replaces Report No. 2.

** This Question has been replaced by Question No. 134 (IV).

the tangents from the transmitter and the receiver is calculated as the associated exponential attenuation given by the diffraction formula.

When the two terminal points are very remote from the obstacle, the two treatments described in *(a)* and *(b)* give approximately the same answer, since the effect of the obstacle in any case becomes small under these conditions.

The cases of propagation along and across valleys have not yet been analysed to the same extent and they are therefore, together with the most general case of very irregular terrain, recommended for further theoretical and experimental investigation in Study Programme No. 53 *.

1.2 *Multiple obstacles.*

In the case of transmission over a path containing multiple obstacles, e.g. undulating country or mountain ranges, the field strength varies considerably with change of path length and direction. Experiments have shown that small movements of receiving location also give rise to marked changes of the received field strength.

For these reasons the variation of field strength has to be considered by statistical methods.

2. *Question No. 6, § 3.*

The siting of aerials for very high frequencies.

The problem of the siting of aerials is closely connected with the question of obstacles discussed above. It is advantageous to raise the aerials where possible, e.g. by placing them on hill tops, in order to reduce the effect of an intervening obstacle and to increase the visibility. Where the receiver is to be located on a hill top, a greater received signal may often be obtained by siting the aerial on the forward face rather than at the highest point of the hill. In simple cases it is useful to study the ground profile with regard to the avoidance of unwanted reflections; in such cases it may be possible to place the receiving aerial so that it is screened from such reflections. Unfortunately in most practical cases conditions are exceedingly varied and complex and the experimental results cannot easily be explained. At this stage, therefore, the most appropriate method for siting a VHF aerial is usually the empirical one of trying it in various positions and at different heights on the desired receiving site.

3. *Question No. 6, § 4.*

The relative effects obtained with horizontal and vertical polarisation.

The question of the relative merits of vertical and horizontal polarisation is closely connected with the siting of the aerials in relation to irregularities of the terrain. Here again there is, except in the simplest cases, a similar lack of reliable experimental data. Therefore in this case also no precise general rules can be given, and it is best to adopt an empirical method of choosing the type of polarisation.

REPORT No. 32 **

HIGH-FREQUENCY BROADCASTING

Directional antenna systems

(Question No. 23 (X))

(London, 1953)

Question No. 23 (X) is concerned with the reduction of subsidiary lobes in high-frequency broadcasting directional antenna systems for the purpose of avoiding interference in frequency sharing. This interference is generally caused by the radiation pattern of the transmitting antenna

* This Study Programme has been replaced by Study Programme No. 88 (IV).

** This Report was adopted unanimously.

having subsidiary lobes in unwanted directions, or by scatter of the energy of the main lobe, due to propagation anomalies. Reduction in intensity of the subsidiary lobes is possible by correct antenna design, while the propagation scatter in unwanted directions presents a complex problem, and its effect should be treated statistically.

A large amount of work has been done on the properties of directional antennae and on the elimination of subsidiary lobes. Foster (1) has shown that by proper choice of rhombic antenna parameters, optimum subsidiary lobe reduction can be obtained, within a limited frequency range, without significant impairment of the main lobe. A convenient method of design of such an antenna is presented by Laport (2). Further improvements in subsidiary lobe reduction can be achieved by stacked or coplanar arrays as shown by Christiansen (3) (4) (5). Such arrays, although more complex, will provide a more satisfactory pattern than a single antenna.

In broadside arrays reduction of subsidiary lobes is in general accomplished to a higher degree than in the rhombic arrays; utilising the binomial distribution (6), the subsidiary lobes can be eliminated to a large extent although the main beam is slightly broadened. A narrower beam with small subsidiary lobes is possible by applying the Dolph-Tchebyscheff distribution (6) (7). Thus, for a maximum subsidiary lobe intensity 20 db below that of the main lobe, it is possible to get a beam width of 27°. It should be noted that Christiansen (5) attains results from a four-unit array of rhombics which are equivalent to large arrays of tuned elements. He confirmed this on radiotelegraph circuits over a period of some years.

Reduction of subsidiary lobes when the main beam is slewed is a difficult problem as the angle of slew, type of antenna, and distortion of its radiation pattern must be considered. This makes it more difficult to give general rules for subsidiary lobe reduction.

A type of array commonly used (8) consists of four rows of radiating elements, each containing four elements with the lowest row one wavelength above ground. The array is normally provided with a reflector, and the feeder arrangements usually allow for reversing or slewing. The slewing in azimuth of the direction of maximum radiation of this type of array is achieved by the adjustment of the relative phase of the current distribution between the left and right halves of the array. The limit of effective slewing by this means can be taken as 17° on either side of the normal direction, but the amount of slew commonly used does not as a rule exceed 15°.

While this method of slewing does not appreciably affect the horizontal width of the main lobe of radiation, it does increase its asymmetry and at the same time produces a principal subsidiary lobe of considerable intensity. The ratio of the field strength of the main lobe in a slewed array compared with that in the unslewed condition has been determined theoretically; for the type of aerial under discussion the ratios for 0°, 5°, 10° and 15° of slew would be 1.0, 0.98, 0.94 and 0.84. Similarly the ratio of the field strength of the principal subsidiary lobe to that of the main lobe can also be determined and for the same angles of slew would be 0.18, 0.27, 0.45 and 0.7 respectively. These theoretical figures are in close agreement with measured values (9).

Although it is possible, as described in the publications mentioned above, to achieve a substantial degree of suppression of side lobes with either rhombic or curtain arrays, the methods so far employed introduce mechanical difficulties and increase the cost. It is therefore proposed that further consideration be given to the best method of specifying a degree of suppression, for example:

(a) by limiting radiation in a specified direction, so as to avoid interference in the reception area of another transmission, to a certain proportion of that given by an omnidirectional aerial;

(b) by limiting the radiation over a wide angle, which excludes the main lobe and any neighbouring strong subsidiary lobes, to a certain proportion of that given by an omnidirectional aerial;

(c) by limiting radiation in all directions other than those comprised in the main lobe to a certain proportion of that given by an omnidirectional aerial.

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REPORT No. 33 *

QUESTIONS Nos. 14 AND 15 OF THE C.C.I.F.

(Study Group No. X)

(London, 1953)

Question No. 14.

Many administrations consider that the most significant parameter to monitor at the input of a radiotelephone circuit during transmission is the peak value of the programme voltage. Since distortions of very short duration may generally be tolerated, however, a peak voltmeter with an integration time of up to about 30 milliseconds is commonly used.

Other administrations consider that several parameters ought to be monitored at the input, amongst others the peak value, the mean value and the minimum value, and that the VU type of meter with an integration time of about 300 milliseconds gives an indication that bears a relationship to these values and has been found satisfactory in practice.

The level indicated by a VU type of meter will generally differ from that indicated by a " peak " type of meter by an amount that varies according to the type of programme and which may be 10 db or more.

Question No. 15.

Although there is evidence to show that the present provisional psophometer curve is not entirely satisfactory, it is considered untimely to change it until more comprehensive data are available.

When such data are available it is desirable that a new weighting curve should be formulated, extending to the higher and lower frequencies and if possible in a form that could be obtained by reasonably simple electrical networks.

It is also considered desirable to establish a method of measuring disturbances, the energies of which are concentrated at discrete frequencies.

Note. — This report is to be transmitted to the C.C.I.F.

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* This Report was adopted unanimously.

REPORT No. 37 *

DECIMAL CLASSIFICATION

(Question No. 72 (XIV))

(London, 1953)

1. *Present state of the question as from the initial conditions.*

1.1 It is the function of the International Federation for Documentation (F.I.D.) to ensure, when necessary, the revision of questions out of date or no longer adequate in respect of the Universal Decimal Classification (U.D.C.).

1.2 With respect to the whole range of electrical technology the F.I.D. has entrusted this task to a committee consisting of specialists in this field, the International Committee for the Application of Decimal Classification in the Field of Electrical Technology (C.I.C.E.).

1.3 With respect to the subdivisions appropriate to telecommunication, the C.I.C.E. has set up a further group of specialists, the International Sub-Committee for the Classification of Telecommunications (S.C.I.C.T.), composed of telecommunication documentalists and technicians.

1.4 The F.I.D. has secured the following aid from the Specialised Secretariat of the C.C.I.R. in respect of the task allotted to the S.C.I.C.T.: jointly with the Directors of the C.C.I.T. and the C.C.I.F., and with the concurrence of the International Chairman of Study Group XIV, the Director of the C.C.I.R. has helped the F.I.D. to obtain from several administrations, members of the I.T.U., the nomination of competent personalities for this task; the three Directors of the C.C.I.s have jointly requested the F.I.D. to seek a united plan of classification within the entire field of telecommunications. They abstained from entering into any commitments vis-à-vis the F.I.D. in respect of the method of possible utilisation of the U.D.C. for the needs of the C.C.I.s.

1.5 Duly noting this reservation, this initiative on the part of the Director of the C.C.I.R. has launched the study of Question No. 72 (XIV), due account being taken of its complexity and of the consequent desirability of avoiding undue haste; it has provided the most suitable means for drawing from the U.D.C. the maximum help to be expected from this system.

2. *New conditions relating to the question.*

2.1 The C.C.I.T. has recently informed the C.C.I.R. (London Doc. No. 406) of the stand taken on this subject by the last plenary session (Arnhem, June 1953, Recommendation I.5 modifying Recommendation No. 241). Due consideration having been given to the importance of the problem of classification and the fact that the solution adopted by the U.D.C. has been put into practice, the text adopted, nevertheless, reopens the question of the very principle of this solution, pointing out that: the resources which can be expected from it seem to be more suitable to the needs of librarians and to the classification of general works, and that they are much less suitable for the needs of technicians; they become less useful as the subjects concerned become more precise and more detailed, noting also that the desired classification is not only to avoid unfortunate juxtapositions, but more especially to provide a maximum of facilities and usefulness when searching for documents with one or several given aspects.

The Recommendation which follows it expresses the view that the three C.C.I.s should take a common stand in respect of this question and declare their intention of following the work of the S.C.I.C.T. as observers and without commitments.

* This Report was adopted unanimously.

2.2 The French Administration has put forward (Doc. No. 354 of London) a proposition inspired with the same considerations as those set forth in the preceding paragraph. It draws attention to the fact that the problem of classification allows of approaches towards other solutions than those which, as in the case of the U.D.C. and almost all systems so far proposed, recognise no other principle than that of a hierarchy of ramifications which distort the reality of the matter instead of being in keeping with it. It points out that some of the documentalists of the French Union of Documentary Organisations tend to move away from the U.D.C. in seeking a solution to the problem starting from a fundamentally different conception, and that an attempt at classification with a combinatory structure is under study at the (French) National Scientific Research Centre. It suggests to the C.C.I.R. that it might give its attention to these new approaches.

3. *Conclusions.*

the VIIth Plenary Assembly of the C.C.I.R. considers that the line of action to be followed until the next Plenary Assembly should be as follows:

3.1 in its relations with the F.I.D. or its specialised groups, the C.C.I.R. should avoid any official participation in the work of the S.C.I.C.T.;

3.2 the Director of the C.C.I.R. should keep himself informed of the progress of this work and submit the results to Study Group No. XIV so that the latter may consider the possibility of applying it to the needs of the C.C.I.R., using in this study any comparable material which may be available to it;

3.3 a future Plenary Assembly will have to decide on its possible use by the C.C.I.R.

REPORT No. 38 *

DETERMINATION OF THE TYPE OF EMISSION PRODUCING MINIMUM INTERFERENCE

(Questions Nos. 1 (I) and 133 (III))
(Study Group No. I)

(Warsaw, 1956)

1. *Shape of the spectrum of random signals.*

In practice, interference results from transmission of information. Consequently, interference by random signals has to be considered. 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 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 elementary signal could be a

* This Report was adopted unanimously.

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 signal can be represented with a root-mean-square errror as small as desired.

It will immediately be seen that the 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.

The second spectrum 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 vectors whose length is equal to the coefficients and whose phase is proportional to the frequency and the times of switching.

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 which number increases with the integration time. The phases of these vectors, however, are uniformally distributed around the phase circle and under certain conditions their amplitudes, equal to the mean values of the signal during the quantising 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 Liapounoff and Paul Lévy [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 signal such as in telephony, or television, the amplitude of which is always limited.

In the case of telegraphy of the usual type, the position is even simpler. The elementary signal can be the usual unit signal of the telegraphists, the 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 quantising instants. The problem is then reduced to that of the random walk which was originally studied by Lord Rayleigh. The statistical distribution of the overall amplitude and the overall voltage still tend towards Rayleigh and Gaussian distributions respectively, which can be approached with a fair degree of approximation if about 10 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 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, following the variations of the random signal if they are not followed by an indicator with a high degree of inertia, preferably a quadratic integrator.

However, the switching spectrum is a periodic function of the frequency with a mean of zero 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 pass-band of a receiver subject to interference and if this band is not too narrow, 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.

The sampling of the signal on which the above considerations are based has a general application in spite of the special shape of the rectangular pulses used. If the spectrum is expressed as a product of functions, it will be seen that the transformation of the signal by a linear quadripole is equivalent to the transformation of the elementary pulse only. At the output of the quadripole, the spectrum of the transformed signal is still expressed as the product of two functions. The switching spectrum is unchanged (consequently the same applies to the coefficients of the series of functions representing the transformed signal); the elementary pulse spectrum is replaced by the spectrum of this pulse transformed in the quadripole. In the limit, when the width of the pulse is decreased indefinitely, the transformed pulse tends towards the pulse response of the quadripole. Any signal transformed by a quadripole can thus be expanded in a series of staggered functions, the function of origin being the pulse response of the same quadripole.

The inverse transformation, by a quadripole which is the " inverse " of the above, which would reconstitute the original signal is in general physically possible. Supposing that the position of the two quadripoles is reversed, i.e. that the original signal is applied first to the " inverse " quadripole and then represented by a succession of short staggered rectangular pulses before being applied to the original quadripole, it will be seen that any given physical signal can be expanded with the help of an elementary pulse which is the pulse response of any quadripole.

From the above considerations three very important conclusions can be drawn, the first is a fundamental property of spectra of actual signals, the second is applicable to the measurement of spectra and the third to the reduction of interference:

(a) The spectrum of any actual signal must extend to infinity and cannot be zero in any frequency interval. The elementary signal spectrum, which is the response of a quadripole to a short impulse, has this property, as shown in the theory of quadripoles.

The switching spectrum of an actual signal—which is itself entirely determined by a finite number of data—is the sum of a finite number of exponentials which are integral functions of the complex angular frequency $j\omega$. This sum is also an integral function which cannot be zero in any interval. The product of the two spectrum functions thus cannot be zero in any interval; it can only be zero at definite points.

(b) It is possible to analyse the spectra of random signals and to obtain stable results, readily comparable with those obtained by measuring the spectrum of the unit signals or of the periodic unit 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.

Laboratory measurement of spectra is generally effected by means of periodic unit signals; this provides isolated points of the spectrum of the single impulse, which is the envelope of the line spectrum of the periodic impulses.

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

In telegraphy of the usual type, the unit 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 unit 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 unit signal is the basic pulse.

In systems such as frequency modulation, in which the transmitters by their very nature cannot be linear, the elementary signal to be used for sampling an output signal 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.

2. *Reduction of out-of-band radiation.*

It is well known that the fullest demonstration of the Hartley-Shannon theorem on the capacity of a channel [2] 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. 1 above; but the elementary function used is Whittaker's interpolation function $\frac{\sin \omega_1 t}{t}$, which does not fulfil the previously set condition 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 as a larger number of instants.

This is paradoxical, because any signal can be represented in this way, but it then no longer produces any interference outside a certain band. This is because the signal is well represented in a certain time interval, but its spectrum is completely transformed, since to it has been added another signal which exists outside the limited interval in which, in practice, this signal is emitted. 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.

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 often fulfilled for actual 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 quantising instants should be non-correlated and independent [3].

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 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 here 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 to all intents and purposes have only two distinct levels, cannot approximate to a Gaussian distribution; they are thus 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 quantification 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] show how a Gaussian signal can be obtained in this way: the total 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, each of these signals should show in time a Gaussian distribution of its amplitude if the overall signal is to have a Gaussian distribution (Cramer's Theorem). Such a signal could not be exactly achieved, since it would be discontinuous: for a Gaussian distribution the probability of an infinite amplitude is not zero. The preceding signal, with a large number of combinations, seems to be more easily achievable than this latter.

3. *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 task reduces to that of finding the best elementary signal, without, at least as a first approximation, there being any need to take into account 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 a given instant when they begin, subsequently to be prolonged indefinitely and vanish progressively in accordance with an exponential 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 " rise time " lower than a given value or a limited effective duration. Such a condition, even if physically accurate for a category of signals of a certain general shape, cannot be easily 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 " rise time " or " significant duration " or " bandwidth " must be used. Gabor [4], by transposing methods of wave mechanics, seems to be the only author to have dealt with the problem in a general sense; he has given a definition of " effective duration " and " effective spectral width ". These effective values are the r.m.s. of the signal and 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 the uncertainty relation in physics, 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.

This value 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 branches tending towards infinity.

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 [5] uses simple resistance capacity time constants separated by vacuum tubes; he proves that if the input signal in such a system is a very short pulse, the output signal tends towards the Gaussian signal when the number of time constants 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 time constants 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 [7] 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 [12]. In the United Kingdom, Roberts and Simmonds [7] had already described its properties as long ago as 1943 and 1944. Chalk [8] 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, the circuits no longer play a part, 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 [9], after examining, in a similar way, the case of signals with Gaussian half-curve sides, came to the conclusion that they offered no marked advantages over other shapes, and in particular over $\sin^2$ 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 of the signal along the maximum is weak.

In a more recent contribution [10], the same author, by 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. The signal delay, on the other hand, increases with the degree of that term. 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 fairly few sections, but a sufficiently low value of the product of rise 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.

Authors like Chalk, by integrating their functions between two finite limits, have eliminated from their theories the notion of delay by doing away with the tails of the signal, which are nevertheless indispensable if out-of-band radiation is to be reduced.

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, an order of delay which is obtainable with the mechanical devices in certain existing multiplex systems.

This principle of necessary delay can, moreover, be found in completely different ways by considering 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 draft of a C.C.I.R. question on information theory [11].

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. But such signals have as yet no physical form: Gabor remarks that $\sin^2$ signals, also called " raised cosine " signals, give substantially similar results. Use of this $\sin^2$ shape is justified in television by power considerations, and it is closer to the Gaussian optimum. Wheeler and Loughren [12] were the first to propose the use of clipped sine-wave signals for television, but their justification was empirical.

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 the most satisfactory process, both from the theoretical and the practical point of view.

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REPORT No. 39 *

ARRANGEMENT OF CHANNELS IN MULTI-CHANNEL RADIOTELEGRAPH SYSTEMS FOR LONG-RANGE CIRCUITS OPERATING ON FREQUENCIES BELOW ABOUT 30 Mc/s

(Question No. 74 (I))

(Warsaw, 1956)

Classification of the systems.

Due to the rapidly increasing use of multi-channel radiotelegraph systems for long-range radio circuits operating on frequencies below about 30 Mc/s, and to the desirability of interconnecting the different systems for international operation, it was thought necessary to classify the various

* This Report was adopted unanimously.

systems into a number of categories.

At the end of the meeting held in Brussels (1955), Study Group No. I asked the Director of the C.C.I.R. to send a questionnaire to administrations requesting information concerning the different multiplex systems in use and those under development.

Replies to this questionnaire have been received (Doc. No. 359 of Warsaw), and the following classification should be adopted as a result.

Classification of multi-channel systems.

1. *Time-division multiplex.*

   For example: double-current cable-code synchronous systems.

2. *Frequency-division multiplex.*

   2.1. Constant frequency arrangements of significant conditions.

   2.2. Variable frequency arrangements of significant conditions. For example: four-frequency diplex, polyplex.

3. *Combination of multiplex processes.*

   3.1 Frequency-division, constant frequency arrangement, combined with time-division multiplex.

   3.2. Four-frequency diplex combined with time-division multiplex.

REPORT No. 40 *

FREQUENCY-SHIFT KEYING

(Recommendation No. 92 **, paragraph 6)
(Study Group No. I)

(Warsaw, 1956)

On the question of para. 6 of Recommendation No. 92 ** all administrations and operating agencies have been prepared to adopt the choice of working conditions to meet the requirements of the agencies operating at the other end of their circuits. Since 1951 all have been agreed that a clear statement of frequency-shift keying operating conditions should be available as a Recommendation of the C.C.I.R. In 1953, at London, a note was added in the text of para. 6 in an attempt to clarify the Recommendation. However, a still clearer text is desirable.

On the other hand, taking account of the importance of multiplex telegraph systems employing frequency-shift keying, it is desirable to extend the study of this question to such systems with a view to adopting an analogous convention between the significant conditions and the emitted frequencies applicable to all systems considered.

In the case of teleprinter operation, the following points should be noted:

1. Certain discrepancies exist in the relation between the words used in English and in French for the two binary conditions and it is accepted completely that the C.C.I.T. definitions for the two binary conditions for the Morse code and for the International Alphabet No. 2 code, as expressed in both languages, are unchangeable and are used in this text.

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* This Report was adopted unanimously.

** This Recommendation has been replaced by Recommendation No. 150.

2. If it is agreed that the interchange of higher and lower frequencies is unimportant, there are two different ways of arranging two binary codes. These are shown in the table below as arrangements I and II.

		Morse code	International Alphabet No. 2 code
I Arrangement (Disposition) (Disposición)	Higher frequency . . . . . . (Fréquence supérieure) . . . . (Frecuencia superior).	mark working (travail) (trabajo)	space working (travail) (trabajo)
	Lower frequency . . . . . . (Fréquence inférieure) . . . . (Frecuencia inferior)	space resting (repos) (reposo)	mark resting (repos) (reposo)

		Morse code	International Alphabet No. 2 code
II Arrangement (Disposition) (Disposición)	Higher frequency . . . . . . (Fréquence supérieure) . . . . (Frecuencia superior).	mark working (travail) (trabajo)	mark resting (repos) (reposo)
	Lower frequency . . . . . . (Fréquence inférieure) . . . . (Frecuencia inferior)	space resting (repos) (reposo)	space working (travail) (trabajo)

The proposal in Doc. No. 297 of Warsaw gives rise to arrangement II.

It can be seen in the table that arrangement I has the " resting " condition in the same position in the spectrum for both codes which have been considered specially.

In arrangement II the " resting " condition is lower in frequency for Morse code and higher for the International Telegraph Alphabet No. 2 code.

If one considers the wording, it will be seen that in arrangement I " mark " corresponds to the higher frequency for the Morse code and to the lower frequency for the International Alphabet No. 2 code.

In arrangement II " mark " corresponds to the higher frequency for both the Morse and International Alphabet No. 2 codes.

REPORT No. 41 *

CHOICE OF INTERMEDIATE FREQUENCY AND PROTECTION AGAINST UNDESIRED RESPONSES OF SUPER-HETERODYNE RECEIVERS

(Question No. 78 (II))

(Warsaw, 1956)

1. Contributions relating to Question No. 78 (II) have been received from the Federal German Republic (Doc. No. 6) and from the United Kingdom (Doc. No. 157).

2. The study of this subject has now reached a stage where the following statement can be made:

* This Report was adopted unanimously.

(a) The principal factors contributing to the production of undesired responses of superheterodyne receivers are inadequate image and intermediate-frequency response ratios and the generation of intermediate-frequency and frequency-change oscillator harmonics. Measured values of the undesired responses occurring in receivers of various types are given in Doc. No. 157.

(b) In the case of long-wave, medium-wave and short-wave sound-broadcast receivers, the only method of improvement not requiring an undue increase in cost is the choice of a suitable value of intermediate-frequency; no single value of intermediate-frequency is completely satisfactory for all parts of the European zone. Intermediate frequencies in the range of 420 to 475 kc/s are commonly used.

(c) For mobile receivers it is difficult to relate the choice of intermediate-frequency to geographical locations since such receivers may be required to operate in the vicinity of any one of a large number of transmitters. Double superheterodyne reception is often employed in mobile receivers operating in the VHF (metric) range to obtain good image rejection. In the case of marine mobile receivers the commonly used intermediate frequencies of 420 to 475 kc/s are clearly unsuitable for receivers required to operate in the 500 kc/s maritime band and higher values, e.g. 530 to 700 kc/s, are used. The results of watches in this frequency band (530-700 kc/s) show that the chosen intermediate frequencies for maritime mobile receivers are often very close to the fundamental frequencies of high power (100 kW or more) broadcast transmitters. In certain maritime areas of high density traffic this results in interference which can be extremely serious if occurring during distress traffic.

3. Further study is required before a complete answer to Question No. 78 (II) can be given. The case of maritime mobile receivers should be carefully examined since their performance affects the safety of life at sea.

REPORT No. 42 *

USE OF RADIO CIRCUITS IN ASSOCIATION WITH 5-UNIT START-STOP TELEGRAPH APPARATUS

(Question No. 83 ** — Study Programme No. 50 (III))

(London, 1953 — Warsaw, 1956)

The principal factors determining the error rate in a radiotelegraphy transmission arise from the fact that:

1) radio propagation is essentially variable,

2) unwanted signals caused by noise or interference appear at the receiving end.

1. As a result of variations in propagation a complex signal is supplied to the receiver, consisting of superimposed signals from several transmission paths, with, in certain cases, widely different delays, the paths providing attenuation and phase characteristics varying with the frequency.

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* This Report replaces Report No. 30. It was adopted unanimously.

** This Question has been replaced by Question No. 129 (III).

As a result the telegraph signal appearing at the output of the demodulator suffers random distortion, which becomes more pronounced as the telegraph speed increases, the rounding of the signal emitted possibly being also a contributory factor.

2. When this complex signal is further disturbed by noise or interference of any sort, two phenomena occur simultaneously: modification of the distortion of the demodulated signal and the appearance of telegraph signals alien to those of the original modulation.

Whereas, at least for relatively low speeds (50 bauds), the distortion due to propagation phenomena (§ 1) has a limited amplitude and rarely, in itself, gives rise to errors in translation, the attenuation of the signals received emphasises the effect of the unwanted signals. This effect can be reduced by increasing the transmitter power.

Consequently, the signals received seem in general to undergo a natural random distortion which cannot be reduced below a certain threshold by increasing the transmitter power, whereas such a measure does in general make it possible to lower the error rate.

An element to be considered in assessing the expected quality of a given code is the correlation existing between the instants of appearance of incorrect signals, which depends firstly on the type of noise or interference in question and secondly on the variable characteristics of propagation.

A further factor to be considered is the improvement resulting from diversity reception, taking into account the combination method thereof.

In the case of relatively high telegraph speeds (200 bauds), when the appearance of errors may correspond with an increase in the distortion of the signal received, synchronised systems are more reliable because of the wider margin they provide.

In the case of lower speeds, the chief disadvantage of start-stop systems lies in the risk of a transient loss of synchronism during the mutilation of a start or a stop signal.

REPORT No. 43 *

REVIEW OF PUBLICATIONS ON PROPAGATION

(Recommendation No. 14)
(Study Group No. IV)

(Geneva, 1951 — Warsaw, 1956)

Recommendation No. 14 served to focus attention on the extraordinary amount of effort which is being expended in learning the facts of radio propagation and in applying them to radio operations and to international control and adjustment of the various radio services. This great field of effort is illustrated by the reviews prepared by eleven members in response to Recommendation No. 14, which appear as Annexes ** to Doc. No. 115 of Washington. These reviews in most cases report on the period 1938 to 1948 inclusive. The field of radio propagation was sum-

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* This Report replaces Report No. 3.

** The reviews of radio propagation work submitted by various countries appear as the following Annexes to Doc. No. 115 of Washington:

Annex " A "	Belgium
Annex " B "	U.S.A.
Annex " C "	France
Annex " D "	Italy
Annex " E "	New Zealand
Annex " F "	United Kingdom
Annex " G "	Sweden
Annex " H "	Switzerland
Annex " I "	Union of South Africa
Annex " K "	Netherlands
Annex " L "	Canada

marised under C.C.I.R. auspices in 1937, covering progress up to that time. The results were given in " Report of Committee on Radio Wave Propagation ", which was distributed by the Bureau of the International Telecommunication Union before the 1938 Cairo Conference, and was published in *Proceedings, Institute of Radio Engineers*, **26**, pp. 1193-1234 (October, 1938).

Since 1937, work on radio propagation has been exceedingly active and extensive. The phenomena of the ionosphere have been intensively studied and the results increasingly applied to the practical determination of optimum frequencies for long-distance transmission over any transmission path at any time. Propagation via the troposphere has been vigorously explored and much has been learned, particularly regarding propagation at VHF and higher frequencies. Microwave propagation has been pioneered. Ground-wave propagation has been reduced to quantitative calculation.

The publications on radio propagation are scattered through many scientific and engineering periodicals and books. References to these papers are given monthly in the lists of " Abstracts and References " published in *Wireless Engineer* and *Proc. I.R.E.*

It is thus clear that a vast amount of work on radio propagation has been going on and is continuing. This field is now recognised as fundamental to radio operations and engineering. The work in progress is undertaken for a variety of motives and objectives. Some of it is on basic physical phenomena, some directed closely to specific engineering applications, and all of it is of interest.

The extent and value of the work on radio propagation is further illustrated by its extensive use in recent international conferences. Many compilations of methods of using ionospheric propagation data and an extraordinary number of charts have been prepared for and by recent international conferences. These have been indispensable in conference work and will be needed even more in the future. As they were prepared hurriedly to meet specific needs, a valuable service could be rendered by reviewing them and, if necessary, supplementing them.

It is believed that no other worth-while specific guidance " regarding desirable future work " could be given in any overall manner by the C.C.I.R. or any other body. On the other hand, the questions established and the studies made by the C.C.I.R. do provide incentives and objectives which are taken into account by the administrations, companies, research institutes and individuals engaged in radio propagation work. The effect of the C.C.I.R. work as a whole upon the various programmes of radio propagation work will therefore provide the real answers to Recommendation No. 14. The means by which the C.C.I.R. enables the various people in this field to work together is a valuable means of furthering and co-ordinating the work.

The C.C.I.R. Secretariat may be requested to distribute to Study Group chairmen contributions which, in the view of an administration, may be of interest to other administrations on the subject of radio propagation and which may be sent to the C.C.I.R. Secretariat for that purpose.

The choice of new questions and other acts of future Plenary Assemblies will in fact be the " regular recommendations " envisaged in Section B 7 of Recommendation No. 1 adopted by the International Radio Conference, Atlantic City, 1947.

REPORT No. 44 *

GROUND-WAVE PROPAGATION OVER IRREGULAR TERRAIN
Addendum to Report No. 21

(Question No. 6; Study Programme No. 54) **
(Study Group No. IV)

(Warsaw, 1956)

Summary of documents submitted to the VIIIth Plenary Assembly, Warsaw.

Docs. Nos. 21 and 416 (Czechoslovakia) give a bibliographical notice and an abstract of an article published in " Slaboproudy Obzor " Prague 1954. In this article the knife-edge diffraction formula is presented in a form especially suitable for engineers. Account is taken of cases where the diffracting screen is not perpendicular to the direction of propagation and the effect of tropospheric refraction is also considered. Field measurements in mountainous areas and on artificial obstacles confirm the validity of the formulae.

Doc. No. 22 (United Kingdom) stresses the importance of the phenomenon of obstacle gain. The small field-strength of the diffracted field for propagation over a smooth spherical earth observed far beyond the horizon is explained in a qualitative way by a cancellation effect between that part of the wave front well within optical range both from the transmitter and the receiver, and the lower part of the wave front. The presence of a mountain cuts out the lower part, thus leading to higher field-strengths. The question arises, whether a relatively small obstacle or irregularity of the ground can cause a disturbance of the lower part of the wave front and thereby lead to an increase of the field-strength.

Doc. No. 96 (Federal German Republic) deals with propagation in the 100, 200 and 500 Mc/s bands over various types of irregular terrain, e.g. propagation along highways following smoothly the irregularities of the ground, over hilly country, over mountain ridges and across valleys. A theory based on the assumption of multiple reflections at the ground and an adequately modified knife-edge diffraction formula is in good agreement with numerous experiments, even in complicated cases. Certain results of these investigations might be used for siting problems.

Doc. No. 183 (France) examines the effect of irregular terrain on propagation in the following respects: influence of obstacles (obstacle gain), influence of ground reflection, influence of absence of obstacles around the antennae, influence of profile, and the nature of ground, vegetation and temperature inversions near the ground, duct effects in the streets of a town, in valleys, underground galleries and mine shafts. The main results are:

— good agreement between theory and experiment for measurements of obstacle gain;

— proposals for eliminating ground reflected components by high-gain antennae with appropriate antenna characteristics and correspondingly better stability of field-strength;

— proposals concerning the siting of antennae above the level of surrounding roofs. Elevation of antennae several metres above the roofs gives gains of about 10 db;

— observation of focussing effects by certain types of ground contours around the antennae;

* This Report was adopted unanimously.
** These texts have been replaced by Question No. 134 (IV) and Study Programme No. 89 (IV).

Propagation measurements in the 80 Mc/s band in underground galleries (Paris Metro) show large attenuation and practicable communication distances of less than 400 m.

Doc. No. 274 (Netherlands) investigates especially the influence of obstacles in the neighbourhood of the receiving site, e.g., of towers, buildings, woods, etc., the influence of tidal movements at the sea shore, and seasonal variations of the field caused by changes in the vegetation.

Doc. No. 323 (Japan) gives a mathematical analysis of the field-strength of waves diffracted by a spherical or cylindrical surface. The formulae derived are especially convenient for numerical calculations in the vicinity of the line of sight. Charts calculated by this method for a useful range of parameters are given in an Annex. This method, when applied to diffraction by a mountain, takes account of the radius of curvature of the mountain ridge, of the electric constants of the ground and the polarisation of the waves. The difference between the new formulae and the knife-edge formula is explicitly shown, and the limits within which the knife-edge formula is valid, are given.

Doc. No. 393 (Compagnie Générale de T.S.F.) is an abstract of a paper published in the " Annales de Radioélectricité ", Vol. IX, No. 37, July 1954, in which the author refers to the knife-edge diffraction theory and uses it to determine the field beyond the horizon of a spherical earth.

Doc. No. 474 (U.S.S.R.). After a systematic classification of propagation paths over diffracting edges (referred to in the document as open, half-open and closed paths) general formulae are given first for the open case, including the presence of several reflected waves, and then for the closed path. In the latter case, practical diffraction formulae are derived, based on the exact calculation of diffraction round spherical and cylindrical objects, as given by V.A. Fock (Uspyekhi fizicheskikh naukh, Vol. X, III, April 4, 1951) and C. Domb and M. Pryce (Journal of the I.E.E., Part III, 94, 1947). These formulae provide means for simple calculation of the attenuation factor from the geometrical data of the path. The effect of atmospheric refraction is also taken into account. The variable gradient of the refractive index is included in a series of formulae for the computation of optimum transmitter-receiver distances and optimum antenna heights. Some statistical considerations are given concerning the reliability of a system comprising a number of sections.

REPORT No. 45 *

EFFECTS OF STANDARD TROPOSPHERIC REFRACTION ON FREQUENCIES BELOW 10 Mc/s

(Study Programme No. 51) **
(Study Group No. IV)

(Warsaw, 1956)

Some work is described in Doc. No. 196 of France in connection with item 1 of Study Programme No. 51 which suggests that the effect of tropospheric refraction is still significant in ground-wave propagation on a frequency of 1554 kc/s at a distance of 230 km over sea.

It is difficult, however, to be certain that the effect of the ionosphere was entirely eliminated, although the experiments were carried out around mid-day. In the report of the Chairman of Study Group No. IV (Doc. No. 104) an example is chosen in 6.3 of Annex I to correspond to the

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* This Report was adopted unanimously.

** This Study Programme has been replaced by Study Programme No. 87 (IV).

conditions given in Doc. No. 196 and a calculation is made of the field-strength based on Bremmer's theory for the inclusion of the troposphere.

The agreement with the experimental results is reasonably good, but in making such a comparison it is really necessary to know what effective radius of the earth should be chosen for the conditions of the experiment.

It is clear, therefore that further work is needed before the question of the effect of the troposphere on propagation on frequencies below 10 Mc/s can be answered even partially by experimental evidence.

From the theoretical angle the problem can be approached by assuming that the refractive index of the atmosphere has a specific form as a function of height, chosen to be amenable to mathematical analysis while corresponding to the real atmosphere in its essential features.

It is clear that the effect of tropospheric refraction is still marked at 10 Mc/s but that its effect is probably negligible at 10 kc/s where the wave-length is large compared with the height above the ground at which the refractive index of the atmosphere ceases to decrease linearly with height. The mathematical analysis should reveal the nature of this transition and provide a method of modifying the propagation curves in Recommendation No. 52 accordingly.

When the frequency is made to approach zero the formula given by Bremmer (see the reference in the footnote to Study Programme No. 51) does not degenerate exactly to the formula for an atmosphere for which the refractive index is everywhere unity, though the residual difference is very small. This formal difference may arise from the fact that, in the model used, the refractive index approaches, at large heights, a value that is about 0.9 instead of unity, as pointed out in Warsaw Doc. No. 23 (United Kingdom).

It appears that at a frequency of 10 kc/s the difference using this model may still be appreciable and it would be interesting to use another model that satisfies the required conditions at the surface of the earth and also at great distances from the earth, assuming that it is amenable to mathematical analysis over the whole frequency range.

However, the model used by Bremmer is probably amply adequate for the study of the transition region between approximately 10 Mc/s and 10 kc/s as is borne out by the calculations made in Annex I of the Chairman's Report (Doc. No. 104, Warsaw).

REPORT No. 46 *

TEMPORAL VARIATIONS OF GROUND-WAVE FIELD STRENGTH

(Study Programme No. 52)
(Study Group No. IV)

(Warsaw, 1956)

Contributions to this study which were submitted to the VIIIth Plenary Assembly, Warsaw 1956, are summarised below:

Doc. No. 24 (Federal German Republic) deals with a series of measurements made to observe the temporal variations of the field strength of various medium-frequency broadcast transmitters and to observe also the actual variations of the effective electrical constants of the soil. It was concluded that the observed field variations were not caused by variations in effective soil constants since, seasonally, a period of high field values (in winter) occurred at the same time as low values of the soil constants were observed, and vice versa. Some preliminary correlation between the variations of the soil constants and the level of subterranean water was, however, obtained.

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* This Report replaces Report No. 20. It was adopted unanimously.

Doc. No. 140 (United Kingdom) confirms previous observations which showed high values of field strength in winter months and correspondingly low values during summer months. It is concluded that although changes of conductivity of the soil and absorbtion due to vegetation could both account for the effects observed, the latter is the more probable explanation.

Doc. No. 182 (France) refers also to measurements reported in Doc. No. 196 (France) which were made over a sea path. The field was found to remain constant within a range of 6 db and showed no seasonal trend.

Doc. No. 220 (F. P. R. of Yugoslavia) presents a discussion on the effect of temperature variations on the soil conductivity and the field strength.

Doc. No. 274 (Netherlands) makes two brief references to the temporal variation effect. It was observed in the VHF (metric) band that field strengths in winter were 1 to 2 db higher than in summer over medium distances and that the presence of leaves in summer time increased the absorbtion.

This Report completes the work of Study Programme No. 52.

Note. — The above Report should be brought to the attention of the U.R.S.I. by the Director of the C.C.I.R. with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of its study.

REPORT No. 47 *

GROUND-WAVE PROPAGATION OVER MIXED PATHS

(Study Programme No. 53) **
(Study Group No. IV)

(Warsaw, 1956)

The various rigorous theories dealing with the problem of mixed paths lead to results represented in different mathematical forms; nevertheless, these forms prove to be equivalent. None of the theoretical contributions gives simple analytical expressions covering a wide range of the parameters concerned; special phenomena, however, such as the so-called recovery effect, are explained in general terms.

Special cases such as those represented in Fig. 5 of Warsaw Doc. No. 563 (U.S.S.R.) (1) have been computed for comparison with experimental results, and in the following papers graphical presentations have been given which enable the engineer to construct curves for certain conditions of mixed path propagation:

(a) by J. R. Wait (2). This paper contains graphs of the ratio of the actual field to the corresponding field for propagation over a perfectly conducting earth. It applies to the plane earth two-section problem in the case of long and medium waves (neglecting the effect of the displacement current) for short and moderate numerical distances;

(b) by Z. Godzinski (3). A graphical representation in this paper enables a straightforward computation of the two-section problem to be made, especially if one of the two sections has a geometrical length small compared to that of the other;

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* This Report was adopted unanimously.

** This Study Programme has been replaced by Study Programme No. 88 (IV).

(c) Warsaw Doc. No. 322 (Japan) (4). Three diagrams at the end of this document refer to the plane two-section problem for long waves and various ratios of the conductivities of the two sections. An additional diagram applies to special cases of the plane earth three-section problem in which two adjacent sections are of equal length;

(d) An annex to a paper by K. Furutsu (5). The tables and the diagram of this annex enable a simple computation of the field corresponding to a transmission path consisting of an arbitrary number of homogeneous sections; the length of each section should be such that a single term of Watson's residue series suffices for the determination of the propagation along this section alone.

The extension of the above mentioned representations to other ranges of the parameters concerned, especially for the many section problem, is proposed as a programme for future work. The results obtained so far show a reasonable agreement with those derived from Millington's semi-empirical method. The additional determination of the phase of the ratio of the actual field to the corresponding field for propagation over a perfectly conducting earth also enables the computation of the refraction observed in coastal refraction phenomena. Some graphical representations for practical use, referring to coastal refraction for wavelengths of 300 and 600 metres are given in a paper by Feinberg (6) (see also Fig. 7 of Doc. No. 563, Warsaw 1956).

The mixed-path problem is related to the problem dealing with the effect of horizontal stratifications inside the earth. According to Wait (7), such a stratification may be approximately taken account of by an equivalent value of the so-called surface impedance in Sommerfeld's numerical distance.

Another paper by Grosskopf (8), using equivalent electrical constants, gives the essential features of the work by Wait, but is less extensive and general.

LIST OF REFERENCES

1. FEINBERG, E. L., " Theory of mixed-path propagation of radio waves and engineering methods of calculation ", Doc. No. **563**, Warsaw, 1956.

2. WAIT, J. R., " Mixed-path ground-wave propagation ", Part I, short distances, *N.B.S. Journal of Res.*, July 1956.

3. GODZINSKI, Z., " Extension of Feinberg's Theory on the case of electromagnetic wave propagation over inhomogeneous spherical earth and introduction of approximate method of computation based on equivalent secondary sources ", Doc. No. **454**, Warsaw, 1956.

4. " Ground-wave propagation over mixed paths ", Doc. No. **322**, Warsaw, 1956.

5. Annex to " Propagation of electromagnetic waves over the spherical earth across boundaries separating different earth media ", *Journ. Radio Res. Lab.*, **2**, No. 10, 345-398 (1955).

6. " Investigations of propagation of radio waves ", ed. by *B. A. Vvedensky*, a symposium; publ. by *Ac. Sci. U.S.S.R.*, Moscow-Leningrad, 1948, Contribution No. **5**, 97-215 (in Russian).

7. WAIT, J. R., " Radiation from a vertical electric dipole over a stratified ground ", *Trans. I.R.E.*, Vol. AP-1, **9-11** (1953), No. **1**.
WAIT, J. R., " Radiation from a vertical antenna over a curved stratified ground ", *N.B.S. Journal of Res.*, **56**, 237-244 (1956).

8. GROSSKOPF, J., " Das Strahlungsfeld eines vertikalen Dipolsenders über geschichtetem Boden " *Hochfreq. u. El. Ak.*, **60**, 136-141 (1942).

REPORT No. 48 *

FIELD-STRENGTH MEASUREMENT

(Question No. 8)
(Study Group No. V)

(Geneva, 1951 — Warsaw, 1956)

In the following considerations of Question No. 8 of the C.C.I.R., particular attention is given to the ultimate purpose for which radio field-strength measurements are made. Usually they are to serve one of two purposes, as follows:

1. To provide an index of the serviceability of the radio signal for a given service;

2. To provide an index of its interference-producing capabilities.

To provide a serviceable signal at a given point, a radio station must produce a radio field at that point such that the ratio of the radio field strength to the interference field strength is sufficiently large for a given percentage of time. Under such conditions the signal-to-interference ratio at the receiver output will exceed a given minimum value during the specified percentage of time. Specification of this minimum signal-to-interference ratio will determine the grade of service obtained. The minimum ratio will, in general, vary with the type of service.

To determine the transmitter power output needed to maintain the prescribed signal-to-interference ratio at the receiving point will require taking account of both the radio noise field-strength measurements and wave propagation data. The determination is complicated by the fact that there is a variation with time of the intensity of the signal field as well as of the interference field.

In some cases, a much more direct approach to the problem may be made which does not require separate measurements of the field intensity of either the desired station or of the interference, nor interpretation of wave propagation phenomena. In this approach, only signal-to-interference ratio measurements are made at the output of the receiver, with constant transmitter power. With this method, the power required for various grades of service may be directly determined.

Field-strength measurements have not only the fundamental use indicated in the foregoing, but also the following uses: study of radio-wave propagation; study of the efficiency, radiation patterns, and other characteristics of radio antennae; study of tropospheric and ionospheric phenomena; and measurements of the electrical properties of the ground.

The following three paragraphs taken from the 1948 Report of the U.R.S.I. Commission on standards and measurements, summarise current thought with regard to field-strength measurements:

> " In recent years little improvement in field-strength measurements up to 30 Mc/s has taken place. Accuracies of $\pm 20\%$ are achieved. Considerable advances have taken place in the higher frequency range up to 10 000 Mc/s. Between 30 Mc/s and 600 Mc/s the equipment is usually calibrated by establishing a known radiation field from a local source: while above 600 Mc/s a comparison is made between the power radiated and the power received at a fixed distance. Identical antenna systems of the waveguide horn type are used at both stations. Such field-strength measurements depend upon reference standards of current, voltage or power and the resulting precision is based upon these standards.
>
> Facilities for radio field-strength measurements are needed for many operations. Atmospheric and radio noise studies are becoming more important. This requirement,

* This Report was adopted unanimously. It replaces Report No. 4.

together with the need for field-strength measurements from radar signals and unwanted electrical system interference, has been met in the United Kingdom by development of equipment suitable for pulse modulated fields betwen 20 Mc/s and 650 Mc/s for a wide range of pulse widths and recurrence frequencies.

Many of the foregoing problems are of an international character and an exchange of knowledge of progress is desirable. There should also be an arrangement for the inter-comparison of methods used by different countries. A method for the exchange of reference apparatus would be valuable and would result in an improvement of the international consistency of standards."

Response to most of the points of Question No. 8 are given in separate Recommendations and Reports of the VIth Plenary Assembly of the C.C.I.R.

REPORT No. 49 *

METHODS OF MEASURING FIELD STRENGTH

Respective merits of the two main types of equipment now in use

(Question No. 8, § A.6)
(Study Group No. V)

(Geneva, 1951 — Warsaw, 1956)

The two main types given in § A.6 of Question No. 8 of the C.C.I.R. are:

(a) that in which the locally generated signal is injected directly into the receiving circuit;

(b) that in which a locally generated field is applied to the wave collector of the measuring equipment.

It is believed that the same degree of accuracy of field-strength measurements may be obtained by either method, provided that equipment of suitable design is used and that careful installation and operating procedures are employed.

The current state of measurement technique generally dictates the particular arrangement and type of measuring equipment employed in a particular frequency range. Methods employing direct injection of a locally generated signal into the receiver or the receiver-antenna circuit are most applicable for mobile measurements. Methods employing either a locally-generated field or direct injection of a locally-generated signal into the antenna are most applicable for primary calibration purposes.

The locally-generated field may be produced by the use of a loop antenna or dipole, the measurements being made close enough to the antenna so that the induction field constitutes an appreciable or a predominant portion of the total field. Alternatively, the use of a standard field produced by a transmitting antenna at distances sufficiently large so that the field is primarily a radiation field is generally preferred for calibration of a receiving equipment by the substitution method. In this method the use of horizontal polarisation, rather than vertical polarisation, is to be preferred where feasible. The method can, however, be more subject to site irregularities, and thereby give erroneous indications on waves arriving from a distance.

Equipment also exists in which the reference voltage is introduced into the antenna, even when this antenna is distant from the rest of the equipment. This method eliminates errors due

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* This Report was adopted unanimously. It replaces Report No. 5.

to mismatching and possible attenuation in the transmission line between the antenna and the receiver. It also avoids possible errors due to site irregularities.

Finally, it is noted that it is often necessary to take into consideration, in choosing a method, the convenience and availability of equipment.

It is believed that the methods now in use may be better described as follows:

(a) those in which the locally-generated signal is applied directly to the receiver;

(b) those in which the locally-generated signal is applied to the antenna of the receiver;

(c) those in which use is made of a locally-generated standard radiation field.

REPORT No. 50 *

METHODS OF MEASURING FIELD STRENGTH

Merits of a standard noise generator as the source of the locally generated signal

(Question No. 8, § A.7)
(Study Group No. V)

(Geneva, 1951 — London, 1953 — Warsaw, 1956)

The major advantage of a standard noise generator as a calibrator for a field-strength meter is its simplicity of operation. The generator needs no tuning; therefore, there are no tracking problems.

The response of a receiver to a noise signal is a function of the receiver bandwidth, the gain, the overload characteristic, and its transient response. Care must therefore be exercised in using a standard noise generator as a field-strength meter calibrator. If the bandwidth is governed by the intermediate-frequency amplifier over the entire frequency range of the receiver, the ratio of the response of the receiver to a sine wave to its response to a noise signal may be established for a single frequency, and the standard noise generator may be used to standardise the gain at all other frequencies.

The use of a standard noise generator as a calibrator is not recommended for field-strength meters in the following cases:

— if for some reason the bandwidth of the receiver is not likely to remain constant over the entire frequency range;
— if the receiver has any significant spurious responses (e.g. image-frequency response);
— if the receiver response is to any degree non-linear or has an unsuitable transient response.

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* This Report was adopted unanimously. It replaces Report No. 22.

REPORT No. 51 *

INVESTIGATION OF MULTIPATH TRANSMISSION THROUGH THE TROPOSPHERE

(Study Programme 57 (V))

(Warsaw, 1956)

A theoretical investigation has been carried out in Italy on the propagation between two points at the ends of a path which is non-optical for normal atmospheric conditions, taking into account the fact that in Italy a state of super-refraction frequently occurs at heights of less than 500 m above sea level. Doc. No. 351 is an abstract of a published paper ** on this subject, in which it is pointed out that under conditions of super-refraction, the effective curvature of the earth becomes concave, with the result that there may be three points of reflection of the waves transmitted between sender and receiver. Under these conditions the coefficient of divergence is transformed into one of convergence, which, under particular conditions, results in the possibility of a focusing effect of the waves arriving at the receiver. The paper describes the parameters necessary for calculating the field resulting from the interference between the direct ray and the reflected rays with the aid of the abac annexed to Doc. No. 352.

Two documents from Japan (Nos. 330 and 366) describe experiments performed with a multi-ray measuring device with a frequency sweep of 3850 $\pm$ 250 Mc/s, and also a useful method of extracting the mean signal level and its variance from a mass of observations. It is suggested that statistical values of the amplitude ratio ρ and the path difference l, obtained independently, are not suitable for assessing distortion due to multipath transmission. It is more appropriate to use the product ρl *** in designing microwave multi-channel radio relay systems. If the quantity ρl is known, the amount of distortion due to multipath transmission can be estimated from the magnitude of the fading, which can be easily measured. This deduction was confirmed by the results of experimental tests made during the summer, when multipath transmission was expected to occur most frequently.

Some information relating to sections 4 and 5 of the Study Programme has resulted from tests carried out in the United Kingdom using a frequency of 4000 Mc/s on two oversea paths, 58 km and 88 km long respectively. Observations on diversity reception and selective fading were made and the results illustrate some of the effects of multipath transmission on micro-wavelengths.

It is clearly necessary for more extensive investigations to be made on all aspects of this Study Programme and for further tests to be carried out for longer periods and over a variety of paths in different parts of the world.

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* This Report was adopted unanimously.

** Sacco, L. — « Il Collegamento Radio in Regime Superrefrazione Atmosferica »; Alta Frequenza, December 1955, 6, 436-469.

*** Alberscheim, W. J. and Schafer, J. P. — "Echo distortion in the FM transmission of frequency-division multiplex" Proc. I.R.E., March 1952, p. 316.

REPORT No. 52 *

TROPOSPHERIC PROPAGATION ACROSS MOUNTAIN RIDGES

(Study Programme No. 79 (V))

(Warsaw, 1956)

Mountain ridges, and particularly those which act as single knife-edges, can effectively reduce both the transmission loss and the fading below the values which would be expected in the absence of the obstacle.

The measured values of transmission loss and the lobe structure, which can be measured by raising the receiving antenna, agree well with values calculated by diffraction theory for paths which lend themselves to relatively simple calculation (References 1 and 2).

It is also found that when the field strength obtained is high, it is relatively stable and the fading is slight, whereas in a region where the field is normally weak, it fluctuates very much with variations in refractive index (References 1, 2, 3, 4 and 5). Since the high fields are produced by the addition in phase of fields received over several paths, relatively large effects of the troposphere on the individual components are required in order to produce an appreciable change in the amplitude of the resultant field. Conversely, the weaker fields, which are produced by partial cancellation of the individual field components, are greatly affected by changes in these components. This conclusion is supported by the fact that the high fields become less stable as the frequency is increased from the VHF (metric) to the SHF (centimetric) band (Ref. 1). On the basis of the information now at hand, it appears that the VHF (metric) band is likely to be more suitable than the higher frequencies for communication by waves diffracted over mountain ridges.

For propagation over high mountain ridges, a large part of the path may be above the regions of the troposphere in which rapid changes in the index of refraction occur. Also, there may be marked differences in the weather on the two sides of a mountain ridge, so that the conditions which give rise to fading may occur only on one half of the path at a time. Both of these features may limit the effects of the troposphere on the individual components of the diffracted wave and tend to minimise the fading which occurs at a receiving point where a high value of field is found (References 3 and 4). While all these investigations are yielding very useful results, it is clearly necessary that studies should be continued in those countries which have the desired topographical features, so that the radio paths under investigation include mountain ridges. Also, since this mode of propagation is of primary interest to the fixed service, receiving sites should not be picked at random, but sites should be selected which give a high value of field strength and an expected low value of fading.

REFERENCES

1. *Japan*, Docs. Nos. **324**, **325** of Warsaw.
2. Kirby et al., *Proc. I.R.E.*, Oct. 1955.
3. *Federal German Republic*, Doc. No. **30** of Warsaw.
4. *C.C.I.R. Secretariat*, Doc. No. **167** of Warsaw.
5. Dickson et al., *Proc. I.R.E.*, August 1953.

* This Report was adopted unanimously.

REPORT No. 53 *

PROPAGATION DATA REQUIRED FOR WIDE-BAND RADIO SYSTEMS

(Question No. 85) **
(Study Group No. V)

(Warsaw, 1956)

Information on this subject has been received from the United Kingdom (Doc. No. 142 of Warsaw), France (Doc. No. 170 of Warsaw); Italy (Docs. Nos. 353 and 354 of Warsaw) and Japan (Doc. No. 367 of Warsaw).

The United Kingdom contribution comprises an account of experience obtained over various sections of television radio relay links on a frequency of about 4000 Mc/s, together with results obtained on experimental links on the same frequency. Additional information is given on a 500 Mc/s link over a 120 km path.

The contribution from France contains the results of measurements made over paths from 70 to nearly 250 km in length, on various frequencies from 87 to 3640 Mc/s. All the paths are optical, some are over sea and others are in mountainous terrain.

The Italian contribution gives the results of measurements made over two optical paths, one of 72.5 km at a frequency of 2500 Mc/s, and the other of 54 km at a frequency of 4000 Mc/s.

Doc. No. 367 from Japan relates to studies of a special case of the diffracted field behind obstacles in the frequency band 3000 to 4000 Mc/s, and at distances ranging from 100 to 160 km. The range of fading passes through a maximum for an angle of diffraction of about 4 milliradians and steadily decreases for greater angles (i.e. within the shadow of the obstacle).

There is obviously insufficient information yet available for a complete answer to the question and it should remain under study. However it is felt that a summary of the data relating to § 1 of the Question, which comprises the major part of the information given in the documents, would be of use to the designer of radio links. Accordingly the following table has been prepared, relating specifically to overland optical paths in temperate climate on frequencies between 2500 and 4000 Mc/s.

Country	Path length in km	Frequency in Mc/s	Excess of path attenuation over free-space loss (db) for quoted percentage of time			Period of recording
			50%	1%	0.1%	
U.K.	46	4000	0	8	11	30 months
	56	»	0	9	17	30 »
	63	»	0	6	12	24 »
	64	»	0	10	18	7 »
	75	»	0	11	18	24 »
France	97	3640	2	12	18	summer
	146	»	4	19	25	»
	160	3000	3	12	18	6 months
Italy	54	4000	2.6	9	12.5	summer
	72.5	2500	0	5.5	12	5 months

* This Report was adopted unanimously.

** This Question has been replaced by Question No. 136 (V).

The distributions given in the above table were all obtained over lengthy periods of time, ranging from 3 to 30 months. From the information in the documents it is clear that shorter time distributions show diurnal and seasonal variations, the fading being, in general, greatest in the early hours of the morning and during the summer months.

It must be emphasised that the figures given in this report cannot be considered as more than a general guide and that it may be desirable in any practical cases to make measurements over the path.

REPORT No. 54 *

LONG DISTANCE PROPAGATION OF WAVES OF 30 TO 300 Mc/s BY WAY OF IONISATION IN THE E AND F REGIONS OF THE IONOSPHERE

(Question No. 7, Section 3)
(Study Group No. VI)

(Geneva, 1951 — Warsaw, 1956)

I. *Introduction.*

Question No. 7 of the C.C.I.R. asked that a study be made for the frequency band indicated above:

1. for ground-wave transmission;
2. for transmission through the troposphere;
3. for transmission to long distances by way of ionisation in the E and F regions of the ionosphere.

This study has now been made, in so far as section 3 is concerned, and this Report, together with Doc. No. 124 of Washington and Doc. No. 72 of Geneva, form an answer to this part of the Question.

This Report summarises the information, contained in Doc. No. 124 of Washington and in Doc. No. 72 of Geneva, as to long-distance propagation of waves of 30 to 300 Mc/s, and as to their interfering potentialities at considerable distances. These two documents contain the detailed information obtained from studies made in the United States of America and in the United Kingdom respectively. This report also embodies information from Doc. No. 136 of Geneva, compiled by the U.R.S.I., and may therefore be regarded as a summary of the information contained in all three of the above documents.

II. *Survey of problems.*

A survey of the problems presented is given in Section II of Doc. No. 124 of Washington and they are also generally surveyed in pages 2 to 12 of Doc. No. 72 of Geneva. They fall under six headings:

1. transmission by way of regular E-layer ionisation;
2. transmission by way of regular Fl-layer ionisation;
3. transmission by way of regular F2-layer ionisation;
4. transmission by way of sporadic E ionisation;

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* This Report replaces Report No. 7. It was adopted unanimously.

5. transmission by way of meteoric ionisation;

6. transmission by way of anomalous and irregular ionisation of other kinds.

It is not intended in the present Report to go into the details of the nature of the problems presented, but rather to summarise the results obtained. For detailed information as to the nature of the problems, reference should be made to those sections of the documents already quoted. A summary of the results of the studies now follows, appropriate reference to the documents being given.

III. *Summary of results.*

1. *Transmission by way of regular E-layer ionisation.*

   A study of regularly made vertical incidence measurements indicates that it is unlikely that transmission of waves of 30 to 300 Mc/s would ever occur by way of the regular E-layer.

2. *Transmission by way of regular Fl-layer ionisation.*

   A study of the vertical incidence measurements indicates that it is unlikely that transmission of waves of 30 to 300 Mc/s would ever occur by way of the regular Fl-layer, except near noon at maximum solar activity in tropical regions only. Since the F2-layer MUF values would, under the same conditions, exceed those for the F1-layer, this fact is of little importance.

3. *Transmission by way of regular F2-layer ionisation.*

   A study has been made of the vertical incidence measurements for a number of widely distributed ionospheric stations and, in addition, a considerable amount of observational evidence has been collected from actual transmissions, both in the United States and the United Kingdom. These data relate mainly to the years 1946-1948, when solar activity was high. They indicate that during certain seasons of the year long-distance transmission by way of the regular F2-layer ionisation can occur in temperate latitudes on waves of up to about 50 Mc/s, although the percentage of the total time during which such transmission is possible is small, being, for example, of the order of 4.5% on 50 Mc/s over the London-New York circuit during the most favourable month of the year at sunspot maximum. In the tropics, however, such transmission can occur on waves of up to 60 Mc/s, with almost regular transmission on waves of 30 to 40 Mc/s. The field strengths observed on these waves are very variable, ranging from values exceeding the inverse-distance value to these near or below the receiver noise level, over very short periods of time. However, since the radio noise fields on these waves are also very low, reception is often continuous for long periods of time and serious interference may result to services which are designed to provide communication at relatively low field strengths.

   It is clear that, for several years around the solar maximum, intolerable long-range interference may be expected on frequencies below about 50 Mc/s during daylight hours in the equinox and winter seasons. The lowest frequency at which such interference becomes so infrequent as to be inappreciable is about 50 Mc/s for stations in temperate latitudes, and about 60 Mc/s for stations in the tropics.

   World-wide predictions of F2-layer MUF are given in monthly charts published by the C.R.P.L. in the U.S.A., by the D.S.I.R. in the U.K. and by other authorities.

   In connection with transmission by regular layers, attention is drawn to the possibility of long-distance transmission on frequencies well above the classical MUF by the mechanism described in Czechoslovakia Doc. No. 122 of Warsaw, whereby the wave can remain for a considerable distance between an upper and lower level in a single ionospheric layer.

4. *Transmission by way of sporadic E ionisation.*

Because of the nature of sporadic E ionisation, implicit in its name, transmission by way of it is ordinarily confined to a single hop and is thus limited to a maximum distance of about 2300 km. Since, in the most intense form of sporadic E ionisation, the skip-distance is about 650 km., the transmission range is, in practice, restricted to distances between about 650 and 2300 km.

It exists in different forms in different latitudes, the most clearly distinguished types being the auroral-zone type and that occurring at temperate and low latitudes. The auroral-zone type occurs most frequently at night and the studies indicate that transmission by way of it may occur on frequencies up to about 90 Mc/s and, infrequently, even higher. The temperate and low latitude type can occur at any time of day, but has a broad peak around midday and a subsidiary peak around sunset.

The studies indicate that transmission may occur by way of it on frequencies up to about 80 Mc/s and, infrequently, up to 100 Mc/s.

It is to be noted that this type of sporadic E exhibits a marked seasonal variation, which is especially prevalent during the months of May to September inclusive (in the Northern Hemisphere) and of relatively small importance during the remaining months. Doc. No. 124 of Washington contains some evidence that there is a variation in its occurrence over the sunspot cycle, suggesting that a maximum of sporadic E may occur at sunspot minimum, and vice-versa, but this evidence can hardly be regarded as conclusive.

During the months of May to September inclusive and during the hours of 0700-2000 L.T. (period during which temperate and low-latitude sporadic E is most prevalent) the studies indicate that transmission at 2300 km may occur in accordance with the following frequency/time distribution:

Frequency	Percentage of total time
30 Mc/s	22.0%
40 Mc/s	6.0%
50 Mc/s	1.5%
60-80 Mc/s	<1.0%

This frequency/time distribution is given in the graph in Fig. 3 of Doc. No. 72 of Geneva.

Field strengths for transmission by way of sporadic E may be high, and Doc. No. 124 of Washington indicates that the peak fields would occur at distances between about 1600 and 1800 km.

The expected world distribution of sporadic E is indicated in world charts published monthly by the C.R.P.L., in the U.S.A. and by other authorities.

5. *Transmissions by way of meteoric ionisation.*

A study has been made both in the United States and the United Kingdom of the reflections which occur from meteor trails. On 30 Mc/s such reflections have been found at times to occur as often as one per minute, and on 70 Mc/s at a rate of about two per hour. They were found to last from a fraction of a second to about 10 seconds. The field strength of the signals obtained from the meteoric ionisation was found to be very low. Because of these facts these reflections are considered to be of negligible importance from the interference point of view, such interference being generally limited to scanty occasional bursts of signal from stations normally out of range.

6. *Transmission by way of anomalous and irregular ionisation of other kinds.*

The studies indicate that there may at times occur bodies of ionisation at virtual heights different from those of any of the recognised ionospheric layers. Such ionisation patches may occasionally give rise to reflections of waves in the 30 to 300 Mc/s range, the principal case being that of reflection from the edges or sides of such patches which occur within or near the auroral zone. It is not considered, however, that such reflections would constitute a serious source of interference to stations working on waves of 30 to 300 Mc/s.

IV. *Summary.*

A tabular summary of the main causes of interference to stations working on waves 30 Mc/s to 300 Mc/s is given below.

Type of interference	Zone	Period of maximum effect	Highest frequency with severe interference, and range of distances affected	Lowest frequency with slight interference
Regular F2 layer reflection	Temperate latitude	Midday period Equinox-winter Solar cycle maximum	45-50 Mc/s 3200-4800 km E/W 3200-9600 km N/S	50 Mc/s
Regular F2 layer reflection	Tropics	Midday period Equinox-winter Solar cycle maximum	50-55 Mc/s 3200-4800 km E/W 3200-9600 km N/S	60 Mc/s
Sporadic E auroral type	High magnetic latitude	Night (associated with local magnetic disturbances)	Night 80 Mc/s Day 45-50 Mc/s 650-2300 km	Night 90-100 Mc/s Day 50 Mc/s
Sporadic E temperate type	Temperate latitude	May-Sept inclusive Day	55 Mc/s 650-2300 km	80-100 Mc/s
Meteoric ionisation		During meteoric showers	Seldom severe 650-2300 km	Varies with power used

V. *Bibliography.*

An extensive bibliography concerning the matter is given at the ends of Doc. Nos. 124 of Washington and 72 of Geneva.

REPORT No. 55 *

PRACTICAL USES AND RELIABILITY OF IONOSPHERIC PROPAGATION DATA

(Question No. 50)
(Study Group No. VI)

A. PRACTICAL USES

(London, 1953 — Warsaw, 1956)

1. *Introduction.*

Propagation in the band 3 to 30 Mc/s over any but the shortest distances is practicable mainly because of the possibility of obtaining ionospheric reflections which suffer only small attenuation. Satisfactory communication on a given circuit can generally be obtained,

* This Report replaces Report No. 23. It was adopted unanimously.

however, if the operating frequency lies between a lower and an upper frequency limit (LUF and median MUF respectively) determined by ionospheric characteristics. Since only a limited range of frequencies can be used it is desirable to have, as far in advance as possible, information on the probable values of these upper and lower limits.

In recent years many administrations operating services in the HF (decametric) band have tended to place greater reliance on ionospheric forecasts and less on past experience. This is due to the realisation that it is essential to make the most economical use of the limited resources both in equipment and frequency channels. It is clear from the documents submitted to Study Group No. VI at Stockholm (1952) and London (1953) that many operators are making great use of ionospheric forecasts either prepared in their own countries or obtained from abroad.

2. *Long-term forecasts.*

Organisations in several countries now make forecasts of ionospheric conditions up to twelve months in advance, and the following table gives some information concerning those known to exist. In addition to those mentioned, it is understood that forecasting services exist in Peru and Spain but insufficient details of these are available.

In most of the cases described in the table, the information is issued in the form of charts available for use in any part of the world; but in some cases, indicated by the sign †, the information refers only to specific radio circuits in which the organisation concerned is chiefly interested. All the forecasts are available for free interchange between organisations undertaking this service, while in the case of C.R.P.L. the prediction bulletins are available on a subscription basis.

Organisation	*Title and address*	*Time in advance at which prediction made*
C.R.P.L.	Central Radio Propagation Laboratory, Boulder, Colorado, U.S.A.	6 months
R.R.S.	Radio Research Station, Slough, England	6 months
S.P.I.N.	Section de Prévisions Ionosphériques Nationale, Paris, France	6 months
I.P.S.	Ionospheric Prediction Service, Sydney, Australia	3 months †
T.R.L.	Telecommunication Research Laboratory, Johannesburg, Union of South Africa	1 month †
R.R.L	Radio Research Laboratories, Kokubunji, Tokyo, Japan	3 months †
F.T.Z.	Fernmeldetechnisches Zentralamt, Darmstadt, Federal German Republic	3 months †
N.I.S.M.I.R.	Scientific Research Institute of Terrestrial Magnetism, Ionospheric and Radio-wave Propagation, Ministry of Communications, Moscow, U.S.S.R.	12 months and 1 month

The usual applications of these forecasts are:

(a) allocations, in advance, to specific circuits, both fixed and mobile, of the most suitable of the available frequency assignments, for the time of day, season, and level of solar activity;

(b) choice of times of frequency changes during the day and night;

(c) selection of times for maximum traffic density on difficult circuits;

(d) selection of suitable equipment and frequency for circuits in temporary use for special purposes including the operation of relays;

(e) selection of the most suitable geographical terminals and relay points for long distance communication services;

(f) design of antenna systems;

(g) monitoring of spectrum usage.

3. *Short-term forecasts of disturbances.*

As far as is known the following sources of short-term forecasts exist:

Australia	Mt. Stromlo Observatory
France	Warnings radiated from Pontoise
Japan	Warnings radiated from JJY
U.S.A.	Warnings radiated from WWV and WWVH
U.S.A.	C.R.P.L. Series J
U.S.A.	R.C.A. Inc.
New Zealand	Carter Observatory
India	Kodaikanal Observatory
Germany	Darmstadt (F.T.Z.)

Both long and medium term forecasts are intended to refer to normal ionospheric conditions. The occurrence of ionospheric disturbances may considerably modify the frequency range within which satisfactory operation can be maintained on a particular circuit. Under these circumstances reliable notification of impending ionospheric disturbances may be of considerable value, as follows:

(a) making temporary adjustments to operating frequencies or transmitter powers;

(b) arrangements for the use of relay stations;

(c) re-routing of priority traffic;

(d) assessment of direction-finder fixes;

(e) investigation of reasons for interference;

(f) deployment of operating staff.

4. *Propagation calculations for long-term planning.*

The following sources of MUF, FOT and field-strength data are available:

(a) P.F.B. (Provisional Frequency Board) (Geneva) Charts and Tables produced by C.R.P.L. at the request of the Atlantic City Conference (1947);

(b) I.H.F.B.C. (International High-Frequency Broadcasting Conference) (Mexico City) Graphs (1949);

(c) Australian I.P.S. Contour Maps (1947 & 1951);

(d) I.F.R.B. curves produced for the International Telecommunication Union (1955-56).

During previous conferences the basic propagation data were used for the preparation of international frequency assignment plans. Other uses within certain administrations for such data are:

(a) fixing of frequency range and power output of new equipment for specific circuits;

(b) design of aerials;

(c) selection of location of terminal and relay stations;

(d) assessment of field-strength in connection with interference problems.

As the above mentioned data were produced some years ago when there was less basic understanding of the physical properties of the ionosphere, their accuracy is, of course, less than that of the current long-term forecasts. Discretion should therefore be exercised in their further use.

B. RELIABILITY OF FORECAST IONOSPHERIC DATA

1. *Introduction.*

The following C.C.I.R. documents and published data have been examined and provide most of the information on which this survey of the reliability of ionospheric forecasts is based.

Stockholm Documents (1952)	Nos. 20 (United Kingdom), 21 (Sweden), 41 revised (Provisional Report).
London Documents (1953)	Nos. 25 and 26 (New Zealand), 144 (Japan), 224 (United States of America), 231 (Japan), 233 (Spain), 248 (Switzerland), 257 (Australia), 280 and 281 (Spain), 303 (Switzerland), 309 (France) and 345 (Italy).
Wilkins and Minnis	Proceedings of the Institute of Electrical Engineers (I.E.E.), May 1951
Mlle G. Pillet	Note préliminaire du Laboratoire National de Radioélectricité, No. 166, 1953.
Warsaw Documents (1956)	Nos. 74 (United Kingdom), 81 (Japan), 148 (United Kingdom), 251 (Switzerland), 301 (Poland), 326 (Japan), 346 (U.S.A.), 430 (Spain).

Some of these sources refer to the accuracy of the forecasts over fairly short periods when applied to circuits; others deal with what may be called typical samples of all possible circuits over fairly long periods. When drawing conclusions on the accuracy of predictions from information obtained from operational sources, it is necessary to ensure that the signals were in fact propagated substantially over the great circle path assumed in making the prediction and not by scattering.

2. *Median MUF.*

It seems fair to say that, when a sufficiently representative sample of circuits is examined, the differences between the observed and forecast values of the median MUF tend to be spread fairly evenly on either side of zero. Any bias which may exist appears to be in the direction which makes the forecast median MUF less than the observed one. On the other hand, examination of reports on individual circuits for particular periods suggests that at certain times and for circuits in certain parts of the world, rather large errors can exist.

For example, circuits between Europe and the Far East have a median MUF in summer which is higher than that forecast, assuming that only F2 propagation is effective.

It is well known that in the preparation of the charts of basic forecasts from which the median MUF curves used by operating organisations are drawn, numerous sources of possible error exist. Some of these are due to errors made by the forecaster in estimating the future value of the sunspot number; such errors will give rise to differences between the forecast and observed values of median MUF of the same sign in all parts of the world. Another major source of error lies in the use of the existing system of dividing the F2 region into three zones. This leads to positive or negative errors depending on the geographical location of the control points, and also on the way in which the forecaster has chosen the " typical " values for foF2 in each of the zones.

With the exception of one or two administrations, it is usual for operating agencies to compute the median MUF for long distance circuits assuming propagation via the F2 layer only. It seems likely that, at certain seasons in some parts of the world, propagation may be controlled, not by the F2 region, but by some mechanism within the E region. This form of propagation will tend to increase the median MUF to a value higher than that forecast when taking into account only F2 layer propagation and may account for part of the discrepancies observed in summer on circuits between Europe and the Far East.

The conversion of vertical incidence critical frequencies to MUF values at oblique incidence is achieved by the use of the MUF factor calculated on the assumption of a simple relation between electron density and height of the F2 layer. Oblique incidence soundings show that in many cases this assumption is not correct; further, there is some experimental evidence which, though limited at present, suggests that the MUF factor as measured directly is in disagreement with the calculated value.

It is clear therefore that there are a sufficient number of known causes of error in median MUF forecasts to account for the discrepancies which have been reported even under conditions of correct solar predictions. An estimate of the relative importance of these errors suggests that the following are the major contributory factors:

— oversimplified picture of the modes of propagation,
— use of the present zonal system,
— inadequate coverage, both in location and number, of ionosphere sounding stations.

So far as is known the contribution from errors in calculating MUF factors is of secondary importance.

Assuming that the considerations outlined above are correct, it follows that, in general, the accuracy of median MUF forecasts cannot be much improved by removing any single source of error but rather that a simultaneous attack needs to be made in an effort to reduce them all. Where, in specific cases, it is known that observed errors are predominantly due to a particular cause then, of course, appropriate steps may be taken to deal with this; however, in the majority of cases it seems possible that the error source responsible may not be easily identifiable. Pending the development of better methods of making median MUF forecasts, the desirability of making temporary empirical corrections has been recognised. This has been partially successful, for example, on the London-Australia circuit where the I.P.S. has introduced an empirical factor. A second example occurs in the Tasman Sea area where an empirical correction to the MUF factor appears to be required.

3. *Gea method.*

The foregoing discussion refers to the generally accepted method of forecasting the median MUF from which the FOT may be deduced. The Gea method however takes no account of the changes in solar activity which are known to play a predominant role in determining ionospheric characteristics; further it implies a constant value for foF2 at sunrise and sunset, and also a constant rate of change of foF2 with time. In practice measured values of these parameters are found to vary over wide limits depending on geographical location. In consequence of these facts it is difficult to see how this method can be relied on to give accurate results for other than a few specific circuits at certain times.

4. *LUF.*

The main methods of forecasting the lower limiting frequency are those employed by C.R.P.L. and S.P.I.N. Insufficient work has been published on the use in practice of these methods to allow any worth while assessment to be made of their reliability.

There also exists the Absorption Limiting Frequency (ALF) produced by the I.P.S. of Australia; as this method takes no account of such obviously important factors as noise, transmitter powers or gains of aerials it can be considered to be a first approximation only.

5. *Short-term forecasts.*

Short-term forecasts of ionospheric disturbance are made in a number of countries. Near sunspot minimum these appear to be fairly accurate on account of the strongly developed recurrence tendency of disturbances; during high solar activity the reliability is considerably less. The problem of assessing the value of disturbance forecasts is bound up with the nuisance caused by false alarms which at present are inevitable. In spite of this, several organisations consider such services to be worth while.

REPORT No. 56 *

QUESTIONS SUBMITTED BY THE I.F.R.B.

(Study Group No. VI)

(London, 1953 — Warsaw, 1956)

In Warsaw Docs. No. 442 and No. 507, the I.F.R.B. has made known its continuing need for up-to-date propagation data and for more complete answers to the questions submitted by the I.F.R.B. to the VIIth Plenary Assembly and contained in the Annex to this Report, and has referred to its desire to bring its propagation curves to correspond more closely with operational experience.

The I.F.R.B. also requested advice to assist it in deciding whether its propagation data should be modified and in selecting the curves which may need modification.

The C.C.I.R. however is not yet in a position to supply direct and unequivocal answers to these questions. The basic information may never be so complete and definite that strictly authoritative curves of general applicability can be set forth. Nevertheless some assistance can be provided to the I.F.R.B. at any given time and the accumulation of information in publications and in the C.C.I.R. Study Programme provide the basis.

Study Programme No. 60 (VI), which replaced Question No. 50, makes clear the reasons why question *(a)* of the Annex cannot be fully answered at present. The following may however be of some assistance to the I.F.R.B.

* This Report replaces Report No. 24.

According to Warsaw Doc. No. 284, the master FOT curves used by the 1948 High-Frequency Broadcasting Conference were prepared by the C.R.P.L. just following the sunspot maximum, but since then considerable experience and more reliable data have been collected concerning periods of intermediate and low solar activity, and have been made available to the I.F.R.B. in the U.S. Signal Corps Radio Propagation Agency Report No. 8 and in the monthly C.R.P.L. Basic Radio Propagation Predictions.

Warsaw Doc. No. 219 (Czechoslovakia) presents a method of rapid calculation and gives the possibility of determining the median MUF under different conditions (different months, different phases of solar activity, geomagnetic and geographical coordinates).

Comparisons made between the F2 median MUF curves in I.F.R.B. Standards B-2 and C-1, derived directly from the master FOT curves referred to in question *(a)*, and the data taken from the Signal Corps Report No. 8, have revealed considerable differences. Similar comparisons between the I.F.R.B. standards and F2 median MUF data obtained by the methods of Warsaw Doc. No. 219 have revealed similar differences. Time has not allowed a full appreciation to be made of the extent to which these differences may reflect on the reliability of the MUF data now used by the I.F.R.B.

Until Study Programme No. 60 (VI) is completed, the relative merits of the prediction methods used in Doc. No. 219 and in preparing the data referred to in Doc. No. 284 cannot be definitely determined, but an interim appreciation could be obtained by comparison of these predictions with suitable operational data on selected circuits.

The operational data, such as are submitted in connection with Study Programme No. 60 (VI)- should comprise statistics of fade-in and fade-out times and should include appropriate explana tions in cases where these times are determined by considerations of traffic rather than propagation·

Question *(b)* is included in Study Programme No. 99 (VI) which replaces Recommendation No. 115 and is related to Recommendation No. 178 (Estimation of sky-wave field strengths on frequencies above 1500 kc/s).

Question *(c)* is included in Study Programme No. 63 (VI), to which Report No. 63 (Radio propagation below 1500 kc/s) relates.

ANNEX

Questions submitted by the I.F.R.B.

Ionospheric propagation

Question (a)

What modification, if any, should be made to the master FOT curves used by the Mexico City High-Frequency Broadcasting Conference in order to take into account experience acquired in subsequent years ?

Question (b)

What is the best method of calculating the field strength produced by a transmitter working on frequencies above 1500 kc/s by means of ionospheric propagation (distances up to 25 000 km) ?

Note. — In studying this question the material already submitted to the C.C.I.R. in answer to:

(a) C.C.I.R. Question No. 50 (Practical uses of radio propagation data);

(b) C.C.I.R. Question No. 69 * (Best method for calculating the field strength produced by a tropical broadcasting transmitter);

(c) the draft recommendation (green sheet) ** in C.C.I.R. Vol. I of Geneva should be taken into account.

Question (c)

What modification, if any, should be made to the C.C.I.R. long and medium wave night propagation curves adopted at Cairo in 1938 ? In particular they appear to need extension:

i) as a function of magnetic latitude,

ii) as a function of season,

iii) as a function of solar activity.

Note :

1. In revising and extending these curves attention should be paid to the shorter distances below 500 km (to allow, for example, for the evaluation of the effect of special vertical transmitting aerials designed to reduce fading in the outer part of the service area) and to distances beyond 2000 km (to allow for the evaluation of interference between regions).

2. While a long term study will be necessary for part iii), information regarding i) and ii) might possibly be available in order to allow an early answer being given to this urgent question.

REPORT No. 57 ***

CHOICE OF A BASIC INDEX FOR IONOSPHERIC PROPAGATION

(Study Programme No. 92 (VI))

(London, 1953 — Warsaw, 1956)

1. *What are the desirable characteristics of a solar index which render it most applicable to ionospheric propagation ?*

A satisfactory index based on solar measurements must be related simply to some index of ionospheric ionisation from which seasonal and diurnal cyclic effect have been removed. It is also desirable that the correlation coefficient between corresponding pairs of the solar and ionospheric indices should be high, although this is difficult to achieve on a daily or three hourly basis owing to the varying time lag between the solar and related ionospheric disturbances.

In addition, it is desirable that the solar index should permit short-term forecasts of changes in propagation conditions to be made.

The index should preferably refer to a property of the sun, such as radiation flux, which has direct physical relationship to the ionosphere.

The index should be measurable objectively.

As far as short-term variations are concerned, it should be borne in mind that some of the short-period variations in ionospheric conditions are the result of complicated dynamical

* This Question has been replaced by Question No. 154 (XII).

** This draft Recommendation became Recommendation No. 115, which has been replaced by Study Programme No. 99 (VI of Warsaw.

*** This Report replaces Report No. 25. It was adopted unanimously.

phenomena taking place in the upper atmosphere. A solar index, therefore, which can only reflect conditions taking place in the sun itself cannot portray quantitatively variations of ionospheric conditions over periods shorter than the minimum over which these dynamical effects are averaged out.

2. *What solar phenomena, which can be observed in a sufficiently objective manner, will provide a more useful index of activity for application to ionospheric propagation than relative sunspot numbers ?*

Solar phenomena which are useful as indices of activity for application to ionospheric propagation, may be divided into two groups:

(a) solar phenomena which can be observed by optical methods;

(b) solar phenomena which can be observed on radio frequencies.

For group *(a)* the total area of hydrogen or calcium flocculi or the total intensities of Hα or other emission lines can be measured objectively. Ionospheric conditions appear to be slightly better correlated with the total area of hydrogen or calcium flocculi than with the sunspot number. On the other hand, such spectroscopic observations require better conditions of visibility than sunspot observations. This limits to some extent the availability of up-to-date data.

The total intensity of emission lines has not yet provided a useful index.

As far as is known at present, none of the solar phenomena mentioned above can be used as an index of short-term variations of ionospheric propagation conditions.

As far as group *(b)* is concerned, an index of solar activity based on radio-frequency observations, although it has been the object of several important researches, cannot be considered as perfectly defined at present. However, it has been shown recently that the intensity of solar radiation on 3000 Mc/s is a linear function closely linked with the area of spots visible on the sun and that a close correlation exists between the intensity of solar radiation on metric waves and the appearance of groups of active sunspots.

3. *What ionospheric characteristics, which can be determined in a sufficiently objective manner whenever observed, may be usefully employed as a basic index for ionospheric propagation ?*

No agreement has yet been reached as to what ionospheric characteristic might be most usefully employed as a basic index for ionospheric propagation. There is hope, however, that even were it is not possible to construct an index based on an exact knowledge of the mechanism of formation of the ionospheric layers, it may still be possible to derive an index based on empirical relations.

Until further knowledge is available one of the following might be considered for use as an ionospheric index:

(a) region character figure of the E and F1 layer respectively:

$$A_E = \frac{(foE)^4}{\cos \chi} \text{ is proportional to } \frac{I_E}{\alpha_E}$$

$$A_{F1} = \frac{(foF1)^4}{\cos \chi} \text{ is proportional to } \frac{I_{F1}}{\alpha_{F1}}$$

where:

A = region character figure
fo = critical frequency
χ = zenith angle of the sun
I = intrinsic intensity of ionising radiation
α = effective recombination coefficient of E and F1 layer respectively.

The regular E and F1 layers are observable only in the daylight hours and are not sufficiently sensitive to disturbances to yield a character figure of great significance.

(b) Smoothed values of the critical frequency of F2 layer.

Changes in foF2 cannot be simply related to cos χ as for foE and foF1. For various reasons it is desirable to use noon values of foF2, or the mean of a group of hours centred on noon, and to average out daily fluctuations by computing the monthly mean. Having eliminated daily changes in this way, the removal of seasonal changes may be achieved by several methods:

b.1 the simplest procedure is to compute the 12-month running mean of the monthly values. This not only removes the annual cycle but also smooths out any short-period changes in the true monthly value of the index, and this may not always be desirable. A further disadvantage of 12-month running means is that the most recent available value at any time always refers to a date six months earlier;

b.2 an index depending only on individual months can be derived by a method due to Allen (1) (2) who first deduced, for a given observatory, the monthly mean values of noon foF2 for zero sunspot number. The index for any actual month is then obtained by dividing the mean for foF2 for that month by the value for the corresponding month for zero sunspot number. The agreement between indices of this kind calculated for a series of observatories was found to be good. There are, however, certain complementary features in the behaviour of the indices in the northern and southern hemispheres. Consequently it would be advisable to combine the indices from a suitably selected group of observatories to form a reliable index completely free from any seasonal effects. Also, in view of the anomalous behaviour of foF2 at Huancayo, discussed by Ratcliffe (3), care would be necessary when using data from equatorial observations for constructing an index intended to reflect the general level of solar activity;

b.3 when an observatory has been in operation for a complete solar cycle or longer, it is possible to deduce the relation between a monthly mean foF2 and some solar index such as sunspot number. Once this relation has been determined, it can then be used in reverse to convert an observed value of foF2 into an ionospheric sunspot number or, more correctly, an ionospheric index.

As to the choice of the ionospheric layer on which to base an index, two factors are relevant: the sensitivity of the critical frequency to change in solar activity, and the magnitude of irregular fluctuations in the critical frequency. Expressions given by Allen (2) allow the sensitivities of the three principal layers to be compared, the Table gives values $\frac{100}{f} \cdot \frac{df}{dR}$ where f = the critical frequency, and R = the sunspot number for each layer.

Table

Sensitivity of the critical frequency (f) to the change of sunspot number (R)

Layer	R	
	0	100
E	0.24	0.12
F1	0.31	0.14
F2	1.0	0.33

In the F2 layer the critical frequencies are two or three times more sensitive than those of the E and F1 layers to change in sunspot number and, therefore, to solar activity. This advantage must be balanced against the greater irregularity of foF2, particularly during disturbed conditions; nevertheless, it seems likely that in spite of this defect, the F2 layer would provide a better index than either of the others.

A three-hourly I-index based on F2 critical frequencies and virtual heights has been evolved and found useful (4). Daily, monthly or annual indices can be formed from such an index and these could be developed for use in other latitudes with varying conversion tables. A world index * could then be obtained from results of a widespread network of observatories.

It is also concluded (5) that monthly mean values of an index (I_{F2}) based on the characteristics of the F2 region of the ionosphere can be constructed. It is possible that this index will provide a more accurate index of solar activity, as measured by the response of the ionosphere, than that obtained from the monthly mean values of sunspot number (R). The month-to-month continuity of the index I_{F2} is high, and this fact would simplify its extrapolation for ionospheric forecasting purposes.

A further reason for choosing the F2 layer would be that long-distance communications depend mainly on the F2 layer; an index based on this layer rather than the E layer would therefore be the most likely to be capable of accurately defining ionospheric conditions on long communication circuits.

4. *Conclusion :*

It appears to be premature to make a final decision on this matter. For long term forecasts (month, year or cycle) in the future, the index R will continue to be used as the simplest and most homogeneous index characteristic of the ionosphere. In the meantime, the possibilities should be explored of using an index such as I_{F2}, which appears to have some advantages for the future. It seems desirable that all the work described in Study Programme No. 92 (VI) should be continued.

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5. Minnis, C. M., *Atmos. Terr. Phys.*, 1955, Vol. **7**, p. 310-321.

REPORT No. 58 **

EXCHANGE OF INFORMATION FOR THE PREPARATION OF SHORT-TERM FORECASTS AND THE TRANSMISSION OF IONOSPHERIC DISTURBANCE WARNINGS

(Recommendation No. 59)
(Study Group No. VI)

(London, 1953 — Warsaw, 1956)

For many years past scientific information of direct interest to those concerned with ionospheric forecasts and disturbances has been broadcast by certain countries in programmes known as Ursigrams arranged by the International Scientific Radio Union.

* The U.R.S.I. (1952) meeting at Sydney suggested that this index could be refined further by eliminating the lunar variation, but it is doubtful if this would improve the quality of the index sufficiently to warrant the extra work involved. The use of true heights instead of virtual heights is another point to be considered, but again too much time would be consumed in first calculating the true heights.

** This Report replaces Report No. 26. It was adopted unanimously.

These programmes provide a means of exchange of summary information needed within 48 hours for the preparation of short-term forecasts and for similar urgent purposes. The exchanges are accomplished through regional networks connecting observatories, laboratories, and communications agencies with a regional centre. Regional centres in turn exchange 30 groups of summary data about once a day. The summaries include information on solar flares, sudden ionosphere disturbances, solar corona, solar radio noise, sunspots, ionospheric and magnetic activity, as well as forecasts. More detailed information is, in some instances, exchanged by weekly airletter.

1. The regional centres from which details, codes, schedules, etc. may be obtained are:

(a) United States of America:
Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado,
North Atlantic Radio Warning Service, Box 178, Fort Belvoir, Virginia,
North Pacific Radio Warning Service, Box 1119, Anchorage, Alaska.

(b) France:
Département Propagation du Centre national d'étude des télécommunications, 196, rue de Paris, Bagneux (Seine), France. TELEX address: Gentelabo Paris.

(c) Japan:
Radio Research Laboratories, Ministry of Postal Services, Kokubunji, Tokyo.

(d) New Zealand:
Carter Observatory, Wellington.

(e) Netherlands:
P.T.T. Receiving Station, Nederhorst-den-Berg.

(f) Federal German Republic:
Fernmeldetechnisches Zentralamt, Darmstadt.

(g) Scientific Research Institute of Terrestrial Magnetism, Ionospheric and Radio-wave Propagation, Ministry of Communications, Moscow, U.S.S.R.

2. The French station at Pontoise daily carries out broadcasts of Ursigrams by radio.

The type and source of the information broadcast by Pontoise are as follows:

CHROM: (solar chromosphere) Austria, Federal German Republic, France, Japan, Netherlands, Sweden;

CORON: (solar corona) Austria, Federal German Republic, France;

SOLER: (solar radio noise) France, Japan, Netherlands;

CORAY: (cosmic rays) Federal German Republic;

ESFRE (critical frequency Es) and FODEU (foF2) Federal German Republic, France, Morocco, Netherlands;

MAGNE: (terrestrial magnetism) Federal German Republic, France, Japan, United States;

PERTU: (ionospheric disturbances) Federal German Republic, France, Morocco, Netherlands;

PROPA: (quality of propagation) Federal German Republic.

The Ursigram codes, times of transmission and frequencies used, can be obtained from the Secretariat of the U.R.S.I., 42 Rue des Minimes, Brussels, Belgium.

REPORT No. 59 *

FADING OF HF (DECAMETRIC) AND MF (HECTOMETRIC) SIGNALS PROPAGATED BY THE IONOSPHERE

(Study Programme No. 66 (VI))

(London, 1953 — Warsaw, 1956)

Doc. No. 92 (U.R.S.I.) supports the intention of C.C.I.R. to continue studies *(a)* on the mechanism of fading, especially at oblique incidence, and *(b)* on frequency and space diversity.

Doc. No. 298 (Poland) points out, that two statistical distributions can be observed especially for large distances, a Rayleigh distribution for weak fields and another with a different law for strong fields. These facts are proved by plotting the distribution for several short duration recordings into a Rayleigh diagram. A diagram is given for the diversity effect based on the assumption of Rayleigh distribution. Some formulae are derived, by which the ratio of field strengths can be determined when the values of the corresponding probabilities are known, or by how many times the radiated power must be increased to obtain a desired reception probability.

Doc. No. 147 (United Kingdom) gives a study of the time and space distribution of the amplitude by means of the autocorrelation function

$$\rho(\tau) = e^{-\tau^2/2\sigma^2} \text{ and } \rho(d) = e^{-d^2/2\chi^2}$$

respectively where σ and χ denote characteristic parameters for the time and space structure, σ being called the fading speed and χ the space structure size. Tests were made in the frequency range from 6 to 18 Mc/s over distances from 2000 to 17 000 km, and σ and χ were calculated from experimental measurements of the number of fades per minute and from the measured values of the correlation coefficients $\rho(d)$. It has been found that σ is reasonably independent of signal level and frequency with values between 0.5 and 2.5 seconds. The value of χ was found to lie between 150 and 400 m. Correlation measurements with polarisation diversity gave values of between 0.14 and 0.33 corresponding to an equivalent spaced aerial separation of 240 to 480 m. The diversity gain, when correlation is not zero, is considered to suffer a loss of about 2 db, when $\rho = 0.6$.

Doc. No. 82 (Federal German Republic) summarises the results of several years recording time of WWV on 15 Mc/s at Darmstadt and of other radio links with shorter recording time. The median value of the field strength F_m, and the deviation σ for 30 minutes periods were measured and were statistically treated over every sun rotation cycle. In the German document the deviation σ refers to the difference between the 10% and 50% or the 50% and 90% values. The corresponding median value F_M of the half-hour median values F_m and the deviations σ_{Fm} for one sun rotation cycle were determined as well as the median values σ_M of the half-hour median values of the deviation σ. The deviation σ_σ of the half-hour deviations was also calculated. It was found that $\sigma_M = 6.5$ db (average of 28 sun rotations) with the rather small deviation $\sigma_\sigma = 1.55$ db. These two values for statistical short-time variability (half an hour) seem to be independent of field strength, frequency or season. F_M and σ_{Fm} on the contrary show a marked seasonal and sunspot cycle variation which has not yet been fully analysed. The average value of σ_{Fm} is ≈ 9 db (averaged over 45 sun rotations) with a deviation of 2.5 db. The deviation

* This Report replaces Report No. 27. It was adopted unanimously.

σ_{Fm} can be regarded as a measure of the magnitude of day-to-day field-strength variations. (This concerns Study Programme No. 66 (VI), § 2 and 3). Besides the random variation of F_m over a sun rotation, there exists a long period, non-random variation with a high maximum in winter and a second lower maximum in the early summer. As a measure of fading speed, the number of times the 90% field-strength level is exceeded per minute has been averaged over 28 sun rotations. The average obtained was 11.25 times per minute.

Docs. Nos. 76, 330, 331 (Japan) deal with the advantages of a new two parameter time-distribution function, the so-called m-distribution. The m-distribution includes the Rayleigh distribution and approximates the log-normal distribution for longer observation times and under certain conditions. The m-distribution stands on a firm theoretical basis, and is equally well adapted for short and long-time intervals, for tropospheric as well as for ionospheric propagation. A simple transformation allows the influence of long periodic absorption effects to be included.

By measuring the variance V (x) and the arithmetic mean $\bar{X}$ two parameters m and X_0 of the new distribution can be calculated and thereby the distribution completely determined. An apparatus has been developed and is described, by which an immediate measurement of V (x) and $\bar{X}$, and thereby of m and X_0, is effected. Diagrams have been plotted, from which the corresponding fading range N(p) [e.g. F(99%) – F (1%)] can be read. Tests in the 7-12 Mc/s frequency range show m varying between 0.9 and 1.2. This corresponds to distributions which could be declared to be approximately log-normal. Further statistics of tests show how the m-value varies with time for particular frequencies and locations. Numerous short-time observations of the distribution for 1500 to 10 000 km propagation paths over 3 to 7 minutes, performed by a photometric method, support the theoretical statements and show that the m-distribution is well qualified as a general distribution for short time intervals.

Doc. No. 475 (U.S.S.R.) reports field-strength measurements over a number of years and states the following facts:

(a) the distribution over periods not exceeding five minutes follows the Rayleigh law;

(b) the distribution of median values for a particular hour of every month is closer to log-normal with a standard deviation of $\sigma = 8$ db $\pm$ 1 db;

(c) over paths mainly crossing polar areas the distribution is not always log-normal. When it is, the standard deviation is about $\sigma = 12$ db $\pm$ 5 db.

Conclusions

Since the last Plenary Assembly, London 1953, progress has been made in the following directions:

(1) the rapidity, severity and time distribution of short period field-strength variations is undergoing further elucidation by short-time distribution measurements and the measurement of the time and space correlation coefficients. A time structure parameter $\sigma = 0.5$ to 2.5 sec. and a space structure parameter $\chi = 150$ to 400 m have been derived from the measurements of correlation coefficients in the 6 to 18 Mc/s range. A new distribution formula has been proposed, which is especially appropriate, in that it covers both short-time and long-time distributions;

(2) and (3) the severity of day-to-day variations of hourly median field strength given as 10 db in Report 27 has been confirmed. New measurements over a period of several years gave variations of about 10 db $\pm$ 2 db, which seem to be reasonably independent of season and frequency. The figure 10 db represents, for a given hour, the difference between the hourly median exceeded on 10% of the days and the monthly median;

(4) the effects produced by field-strength variations on different receiving systems, such as time, space. frequency and polarisation diversity systems have been studied in an increasing number

of documents both theoretically and experimentally. The influence of non-zero correlation on the diversity effect has been included. There still seems to be some discrepancy between the results of various workers with regard to the loss of diversity effect, when the correlation coefficient is not zero. Further studies are therefore necessary;

(5) and (6) at the present time there are no documents available concerning items 5 and 6 of Study Programme No. 66 (VI).

REPORT No. 60 *

CENTRALISING AGENCIES FOR THE RAPID EXCHANGE OF INFORMATION ON PROPAGATION

(Study Group No. VI)

(Geneva, 1951 — London, 1953 — Warsaw, 1956)

The following have been designated by their respective countries as the official agencies for the reception, co-ordination, liaison and exchange of information relating to radio propagation.

Federal German Republic

Fernmeldetechnisches Zentralamt
(Arbeitsgemeinschaft Ionosphäre)
Rheinstrasse 110
Darmstadt
Federal German Republic
Telegraphic address: Ionosphäre Darmstadt

Australia

Officer in charge
International Section
P.M.G. Dept., Treasury Gardens
Melbourne C2
Australia
Telegraphic address: Gentel Melbourne

Belgium

Chef du Service du Rayonnement
Institut Royal Météorologique
3, Avenue Ciculaire
Uccle — Bruxelles
Belgium

Spain

Departemento de Servicios Técnicos de Telecomunicación
Dirección General de Correos y Telecomunicación
Madrid
Spain

United States of America

Central Radio Propagation Laboratory
National Bureau of Standards
Boulder, Colorado,
U.S.A.

France

Département propagation du centre national d'études des télécommunications
196, rue de Paris
Bagneux (Seine)
France
Telegraphic address: Gentelabo Paris

India

The Secretary
Radio Research Committee
National Physical Laboratories
Hillside Road
New Delhi
India

Italy

Istituto Nazionale di Geofisica
Città Universitaria
Rome
Italy
Telegraphic address: Geofisica Rome
Note: All messages should begin with the word " Ionosphere ".

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* This Report replaces Report No. 28. It was adopted unanimously.

Japan

Radio Research Laboratories
Ministry of Postal Services
Kokubunji
Tokyo
Japan

New Zealand

The Superintendent
Geophysical Observatory
P. O. Box 1171
Christchurch
New Zealand

Netherlands

Afdeling: " Ionosfeer en Radio-Astronomie "
Kortenaerkade 12
The Hague
Netherlands

United Kingdom

Director
Directorate of Radio Research
Radio Research Station
Slough, Bucks
England
Telegraphic address: Radsearch Slough

Switzerland

Laboratoire de Recherches et d'Essais
Direction Générale des P.T.T.
Speichergasse 6
Bern
Switzerland

Union of South Africa

Telecommunications Research Laboratory
C.S.I.R.
Department of Electrical Engineering
University of the Witwatersrand
Johannesburg
Union of South Africa

U.S.S.R.

Scientific Research Institute of Terrestrial Magnetism, Ionospheric and Radio-wave Propagation
Ministry of Communications
Moscow
U.S.S.R.

REPORT No. 61 *

EXTENSION OF THE C.C.I.R. PROPAGATION CURVES BELOW 300 kc/s

(Resolution No. 10)
(Study Group No. VI)

(Warsaw, 1956)

The request of the I.F.R.B. in London Doc. No. 346, Question (d), that the propagation curves given in Recommendation No. 52 be extended to distances above 2 000 km for frequencies between 10 kc/s and 300 kc/s has been fulfilled in accordance with Resolution No. 10 by the Secretariat of the C.C.I.R. in Addendum No. 2 to Vol. I of the London documents.

The Resolution drew the attention of the I.F.R.B. to the fact that the sky-wave, on frequencies below 300 kc/s and for distances larger than 2 000 km may, even in daytime, be predominant. The United Kingdom Doc. No. 20 stresses this limitation to the use of the extended ground-wave curves, pointing out that in much of the extended region of these curves, even where the field-strengths given refer to large and workable signals, the effect of the ionosphere may be predominant, and that this should be borne in mind in any application of the curves to practical problems of communications planning and frequency sharing.

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* This Report was adopted unanimously.

It was also resolved (see point 2 of Resolution No. 10) that information should be sought from Study Group No. VI concerning the expected values of the field-strength of the sky-wave on these frequencies and distances. Doc. No. 431 of the Federal German Republic describes some experiments made in the very low frequency (myriametric) range at distances from 1000 to 7800 km, which indicate the predominance of the sky-wave over the ground-wave at distances beyond 2 000 km, even during the summer when the ionospheric attenuation is greatest.

Field-strength measurements made on frequencies between 16 kc/s and 40 kc/s over long sea paths of up to 17 000 km are described in Doc. No. 506 of the U.S.A. These also show the predominance of the sky-wave at distances greater than 2 000 km where the ground-wave curves have begun to depart considerably from the inverse distance curve on account of diffraction losses round the curve of the earth.

Thus, although the curves represent an accurate solution of the ideal ground-wave problem, they can be applied only to a few specific situations in which special conditions justify their use. They have, however, a practical significance in cases where the ground-wave can be isolated from the ionospheric reflections by the use of pulses, as pointed out by the Chairman of Study Group No. IV in Doc. No. 104.

REPORT No. 62 *

INVESTIGATION OF CIRCULARLY POLARISED EMITTED WAVES PROPAGATED VIA THE IONOSPHERE

(Resolution No. 14)
(Study Group No. VI)

(Warsaw, 1956)

1. In accordance with Resolution No. 14 of London, the U.R.S.I. has informed the C.C.I.R. (Warsaw Doc. No. 89) that this subject is under active study in the Netherlands and the United States of America. Accordingly, Resolution No. 14 has served its purpose and may be deleted.

2. A contribution from the Netherlands on the subject of the measurement of the polarisation of radio waves reflected by the ionosphere has been received by the C.C.I.R. (Warsaw Doc. No. 256).

3. Further consideration of this subject by the C.C.I.R. should depend on the nature of the results of investigations now in progress in the U.R.S.I.

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* This Report replaces Resolution No. 14. It was adopted unanimously.

REPORT No. 63 *

RADIO PROPAGATION AT FREQUENCIES BELOW 1500 kc/s

(Study Programme No. 63 (VI))

(Warsaw, 1956)

In the annex of Report No. 56 of the C.C.I.R. (Questions submitted by the I.F.R.B.), question *(c)* asks:

" what modification, if any, should be made to the C.C.I.R. long and medium wave night propagation curves adopted at Cairo in 1938? In particular, they appear to need extension:

i) as a function of magnetic latitude,

ii) as a function of season,

iii) as a function of solar activity."

Doc. No. 418 of Warsaw is a progress report on a measurement campaign carried out under the auspices of the European Broadcasting Union on ionospheric propagation on long and medium waves as a contribution to Study Programme No. 63 (VI). Particular reference is made to consideration *(d)* and point 7 of this study programme concerning the needs of the I.F.R.B. expressed in question *(c)* of Report No. 56.

In graph 4 of Annex A-VII of Doc. No. 418 a comparison is made between the curve according to the A 6 standards of the I.F.R.B. and the curve derived from the E.B.U. measurements.

The two curves show good agreement out to a distance of 2000 km, but there is an indication that beyond this distance the E.B.U. curve falls away more steeply than the I.F.R.B. curve.

It may be therefore be concluded that the E.B.U. curve supports the use of the I.F.R.B. curve out to a distance of 2000 km and for the conditions to which the E.B.U. measurements apply, namely for propagation paths in Western Europe during periods of low solar activity.

The E.B.U. report discusses the correlation of the field-strength with solar activity, ionospheric data, geomagnetic activity, the luminosity of the moon and atmospheric pressure, but, so far, no very significant results have been obtained. The work is being continued into the period of high solar activity now beginning, so that it is hoped that by the next Plenary Assembly data will be available for extending the propagation curve to include the effect of the solar cycle.

In Warsaw Doc. No. 289 (U.S.A.) which refers to night field-strength in the frequency range 540 kc/s to 1600 kc/s based on data obtained in the U.S.A. in 1944, i.e. during the previous period of low solar activity, curves are given for a number of frequencies and geographic latitudes. It is pointed out that caution should be used in applying these curves to areas other than the United States and that it might be better to draw such curves with respect to geomagnetic rather than geographic latitude.

It is therefore not considered advisable at the present time to modify the I.F.R.B. curve, as substantiated by the E.B.U. measurements, in the light of the curves in Doc. No. 289, but attention is drawn to the value of this information towards the future extension of the I.F.R.B. curve, in particular with respect to the effect of geomagnetic latitude which the U.S.A. curves indicate to be considerable.

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* This Report was adopted unanimously.

One notable feature of these curves is that their slope beyond a distance of 2000 km is largely independent of latitude and of frequency over the range of values considered. This feature is therefore proposed for further study, remembering that the slope of the curve in this region may be a function of the solar activity.

Some further information is contained in Warsaw Docs. Nos. 77 (Australia) and 387 (Federal German Republic). Doc. No. 77 gives some results on frequencies between 550 kc/s and 1220 kc/s for distances from 400 to 820 miles. A comparison with the Federal Communications Commission (F.C.C.) curves suggests that there is agreement up to a distance of 400 miles but that at greater distances 6 db should be added to the F.C.C. curves. Doc. No. 387 is concerned with pulse tests on 971 kc/s over a distance of 380 km. The figures quoted in this document for Es reflection are in agreement with the 10% quasi-maximum yearly mean values of the Australian recordings for approximately the same frequency during 1953, 1954 and 1955.

It is clear, however, that further work will have to be done over a wide range of conditions before the confirmation of the I.F.R.B. curve can be extended to other parts of the world and for the wide range of seasonal and solar variations.

REPORT No. 64 *

REGULAR LONG-DISTANCE TRANSMISSION IN THE VHF (METRIC) BAND BY MEANS OF SCATTERING FROM INHOMOGENEITIES IN THE LOWER IONOSPHERE

(Study Programme No. 95 (VI))

(Warsaw, 1956)

1. *Introduction.*

The matter of *regular* long-distance transmission in the VHF (metric) band by means of scattering from inhomogeneities in the lower ionosphere was first introduced into C.C.I.R. work in a somewhat indirect fashion in Study Programme No. 64 ** of London and in connection with transmission by way of meteoric ionisation in Report No. 7 It is clear that a number of multi-channel telegraph communication circuits of exceptionally high reliability are now in operation employing this type of radio transmission. These circuits, which are operating principally in the Arctic and sub-Arctic, employ frequencies between 30 and 40 Mc/s and operate mainly over distances from 1000 to 2000 kilometres. Highly directional antennae are used and the transmitter output powers are of the order of 40 kilowatts.

2. *Summary of design information available.*

With regard to the design and operation of communication systems employing ionospheric scattering, information is now available in the published material referred to below on such subjects as the following:

— choice of polarisation (usually horizontal);
— scattering height assumed for purpose of antenna design (usually 85 km);
— practical criteria for choice of sites for antennae;

* This Report was adopted unanimously.
** This Study Programme has been replaced by Study Programme No. 95 (VI).

— desirable antenna characteristics;
— diversity spacing (usually about 15 wavelengths, transverse to the path);
— selection of suitable operating frequencies;
— useful range of path lengths;
— transmitter output power requirements

3. *Bibliography.*

A bibliography showing all early work having a bearing on the subject of this report would be quite long. Much of it is of a scientific nature and therefore of greater interest to such bodies as the U.R.S.I. rather than the C.C.I.R. The following published accounts cover the subject in its modern context and are considered to be of principal interest to the C.C.I.R. at this time. These papers themselves contain extensive references which may be consulted for more specific details of earlier work and related topics such as meteoric studies:

(a) D. K. BAILEY, *et al.*, " A new kind of radio propagation at very high frequencies observable over long distances ", Phys. Rev., **86**, pages 141-145, 1952.

(b) D. K. BAILEY, R. BATEMAN and R. C. KIRBY, " Radio transmission at VHF by scattering and other processes in the lower ionosphere ", Proc. I.R.E., **43**, pages 1181-1230, 1955.

(c) W. G. ABEL, J. T. de BETTENCOURT, J. H. CHISHOLM and J. F. ROCHE, " Investigations of scattering and multipath properties of ionospheric propagation at radio frequencies exceeding the MUF ", Proc. I.R.E., **43**, pages 1255-1268, 1955.

(d) W. J. BRAY, H. G. HOPKINS, F. A. KITCHEN and J. A. SAXTON, " Review of long-distance radio-wave propagation above 30 Mc/s ", Proc. I.E.E., part B, 1955, pages 87-95.

In addition to the above, attention is drawn to entire issues of journals as follows:

(e) Proc. I.R.E., vol. 43, No. 10, October 1955, and

(f) I.R.E. Transactions on communications systems, Vol. CS-4, No. 1, March 1956,

in which much material of interest, not only in connection with ionospheric scattering but also with tropospheric scattering, is presented. Mention should also be made of Warsaw Docs. Nos. 155 and 378, which relate to Study Programme No. 95 (VI).

REPORT No. 65 *

REVISION OF ATMOSPHERIC RADIO NOISE DATA

(Recommendation No. 120 — Study Programme No. 96 (VI))

(Warsaw, 1956)

1. *Introduction.*

The determination of the minimum signal level required for satisfactory radio reception in the absence of other undesired radio signals necessitates a knowledge of the noise with which the desired signal must compete at the receiving location. Studies of radio noise levels have been in progress for a number of years.

* This Report was adopted unanimously.

The initial research leading to the first publication of predictions of world-wide radio noise levels was carried out in 1942 by a group in the United Kingdom at the Interservices Ionosphere Bureau and in the United States at the Interservice Radio Propagation Laboratory (1).

Predictions of world-wide radio noise have been published subsequently in R.P.U. Technical Report No. 5 (2) and NBS Circular 462 (3). In these publications noise grade maps and prediction curves were given, indicating the noise level in terms of the minimum required signal strength to assure radiotelephone communication for ninety per cent of the time in the presence of atmospherics.

A more recent publication, NBS Circular 557 (4), presents the same noise grade maps as used in the previous publications. However, the prediction curves have been revised to show the expected median levels of radio noise during four-hour time blocks for each season instead of the required field strength for 90 per cent intelligibility. The method of interpreting the earlier predictions was not entirely clear and the present method of presenting that data has been used to remove the ambiguities so that further data can be compared with them more readily.

The compilation of more recent data indicates that, although the predictions presented in Circulars 462 and 557 have been found useful by many administrations, large discrepancies appear between measured values and the expected values from the predictions for some locations and times. For this reason, the preparation of entirely new predictions was undertaken.

These new predictions show primarily the expected values of a selected parameter of the atmospheric noise passed by a narrow-band filter. Values are given on a world-wide basis for all frequencies from 10 kc/s to about 30 Mc/s for all times of the day and night and all seasons of the year.

In preparing this report, slightly more emphasis was placed on data recorded during periods of high sunspot activity than on data recorded during periods of low sunspot activity when both were available. Also, the expected effect of high sunspot activity was to a small extent considered in determining the diurnal variations of the noise at locations where no data were available. Since a period of high sunspot activity is approaching, this method should give the best estimates of the expected noise in the near future. While it is felt that the phase of the sunspot cycle will affect the amount of received noise, it has not been possible to show satisfactory sunspot correlation with the available noise data. Therefore, no further account, other than the above, has been taken of the phase of the sunspot cycle.

Wherever possible, the predictions are based on actual measurements. Unfortunately, even measurements in recent years have been made by a number of different methods and many are difficult to interpret. Also, measurements are often vitiated by the presence of man-made noise or by lack of sensitivity in the equipment.

2. *The basic parameters.*

The basic parameter, F_a (4), used to describe the noise is related to the noise power available from a short, vertical, grounded, loss-free aerial. If the aerial is short compared with the wavelength, the available power is independent of its length.

The noise power shows large, rapid fluctuations, but if it is averaged over several minutes, the average values are found to be nearly constant during a given hour; the variations of the average seldom exceed 2 or 3 db except during sunrise or sunset periods or during a local storm. The basic parameter used is, therefore, the median value of the average power during a period of one hour—called the hourly value. In using the noise measurements where the noise was sampled for only a few minutes each hour, it is assumed that the result represents the hourly value.

The hourly value, in terms of F_a, is expressed in decibels relative to the thermal noise power which would be available from the aerial if it were at a specified temperature, T. F_a may, therefore, be regarded as an effective aerial noise figure. The reference power level is kTB watts where:

k = Boltzmann's constant $= 1.38 \times 10^{-23}$ Joules per degree Kelvin,
T = reference room temperature = 288°K,
B = effective noise bandwidth in cycles per second.

In this report, the value of T has been chosen as 288°K so that with the value of k given above, $10 \log_{10} kT$ will equal 204 db below 1 Joule per c/s. If the noise figure measurements are made at significantly different temperatures, they can be adjusted to this value for convenience and uniformity.

Since the available noise power from all sources is assumed to be proportional to bandwidth, as is the reference power level, F_a is independent of bandwidth.

F_a in db is simply related to the r.m.s. field strength at the aerial by the following equation:

$$E_n = F_a - 65.5 + 20 \log_{10} f$$

where

E_n = the r.m.s. field strength for a 1 kc/s bandwidth in db above 1 μV/m
f = the frequency in Mc/s

It should be noted particularly that this is an effective field strength; the conformation of the incident waves may be complex, and cannot be deduced from measurements on a single vertical aerial. Therefore, E_n represents only the vertically polarised component.

3. *The plotted parameters.*

It is not practicable to quote the hourly values F_a and E_n for all times and places. The presentation of the data has been simplified by considering the four seasons and six four-hour periods of the day. The time period defined by a given four-hour period of the day and a season is a time block. Thus, there are, in the year, 24 time blocks each consisting of about 360 hours (four hours on each of about 90 days).

For the purpose of this report, the year has been divided into four seasons of three months each, as follows:

Months	Seasons	
	Northern Hemisphere	Southern Hemisphere
December, January, February	Winter	Summer
March, April, May	Spring	Autumn (Fall)
June, July, August	Summer	Winter
September, October, November	Autumn (Fall)	Spring

The plotted parameter is the median hourly value for each time block, and the variations in this parameter show the diurnal and seasonal variations of the noise. In the present state of our knowledge, the variations of the hourly values within a time block must be treated as random, and their extent is indicated by the ratios of the upper and lower decile values to the medians (see Section 6).

4. *Factors involved in the predictions.*

For convenience, the factors involved in the preparation of the predictions are summarised below:

(a) Type of aerial

A vertical grounded monopole, short compared with the wavelength, is assumed.

(b) Basic parameter

The hourly median value of the available noise power expressed in terms of an effective noise figure, F_a, is used as the basic parameter. The effective field strength at the aerial, E_n, is also given.

(c) Plotted parameter

The plotted parameters used in these predictions are the median values of F_a and E_n, denoted by F_{am} and E_{nm}, for a time block. The time block is defined as the aggregate of all hours within a given four-hour period of the day and a given season.

(d) Time variations

As an indication of random variations of the hourly values within a time block, typical figures are given for the ratios of upper and lower decile values to the median.

(e) Location

Results of actual noise measurements are available for only a few places. The data used were obtained from references 4, 5, 6, 7, 8 and 9. Additional data were obtained from the following reports:

Herman V. COTTONY, " Memorandum report on observations of atmospheric radio noise in arctic regions ", U.S. Department of Commerce, National Bureau of Standards, C.R.P.L., Jan. 1948.

H. E. DINGER, W. E. GARNER, G. E. LEAVITT, " Measurements of some low and very low frequency atmospheric noise in the Alaskan area ", N.R.L. Report No. 3958.

Statements of K. A. NORTON, R. BATEMAN, C. A. ELLERT; Ship Power Hearing, Federal Communications Commission, Report No. 30539, November 14, 1938.

Edward W. ALLEN, Jr., Report of Committee No. 1, Part III, FCC Clear Channel Hearing, Docket 6741, February 15, 1946.

Data were also used from additional measurements made in the United States by the Central Radio Propagation Laboratory and in the United Kingdom by the Radio Research Station. Values for other parts of the world are deduced by interpolation, based on a knowledge of thunderstorm distribution (10) and of radio propagation characteristics.

(f) Frequency

The charts are drawn with contours of estimated noise at 1 Mc/s. Values at other frequencies are obtained from those for 1 Mc/s by means of sets of curves.

(g) Bandwidth

Values of F_a are independent of bandwidth. Values of E_n are for a 1 kc/s bandwidth and it may be assumed that the r.m.s. noise field is proportional to the square root of the bandwidth.

5. *Description of the data.*

Figures 1 to 20 inclusive are of charts showing the estimated median values of F_a in db at a frequency of 1 Mc/s for each of the 24 time blocks of the year. Corresponding values of E_{nm} in db above 1 μV/metre may be derived by subtracting 65.5 db from the plotted values. The differences between the time blocks 0000 to 0400 and 2000 to 2400 do not appear to be significant, as far as is known at present. Therefore, one chart is used for these two time blocks for each season.

Noise values at frequencies other than 1 Mc/s are derived by the use of figures 21 and 22 for F_{am} or figures 23 and 24 for E_{nm}; the 1 Mc/s noise grade is obtained from a chart and the curves are used to extrapolate to the desired frequency. Figures 21 or 23 are used for daylight at the receiving point and figures 22 or 24 for night-time. While the variation of noise with frequency is found to vary to some extent from place to place, these curves appear to represent the variations as well as is justified by the accuracy of the data available at present.

The differences between the law for daytime and night-time frequency curves result primarily from changes in propagation conditions, and these have been allowed for by using different sets of curves according to the predominance of daylight or darkness during a given time block. The sunrise (0400 to 0800) and sunset (1600 to 2000) times have varying percentages of daylight and darkness depending on latitude and season, and this complicates the presentation of the data. However, it has been decided that the existing data do not justify subdivision of these time blocks into dark and daylight hours and, therefore, the daylight curves are used for the whole time block in spring and summer and the night-time curves for autumn and winter. Further comments on the use of the curves for these periods, and on the particular difficulties involved at the equator are given in Section 8.

A curve of galactic noise at frequencies above 1 Mc/s is shown (4). There are small variations with time about this curve, but they are less than $\pm$ 2 db. Galactic noise is significant only at frequencies above the vertical-incidence critical frequency at any given time, which is normally much higher than 1 Mc/s except in polar regions.

In many locations man-made noise will be a limiting factor in radio communication for at least part of the time. Although this type of noise must depend on local conditions, a curve of expected values at a quiet receiving location has been added. The values plotted are typical of the lowest values at sites chosen to insure a minimum amount of man-made noise and much lower values will seldom be found at sites which are not several kilometres from power lines and electrical machinery. Man-made noise may arise from any number of sources such as power lines, industrial machinery, ignition systems, etc. with widely varying characteristics. Propagation of man-made noise is principally by conduction over power lines or by ground wave and is thus relatively unaffected by diurnal or seasonal changes in the ionosphere. However, there is experimental evidence that man-made noise may also be received from distant sources by ionospheric propagation; for example, values of man-made noise of a few decibels above kTB at 2 Mc/s have been attributed to a large city at a distance of 65 kilometres (40 miles) when the receiving site was exceptionally free from local man-made sources and very few atmospherics and radio signals were being received (11). The only trend considered in this report is the variation with frequency; the level decreases with increasing frequency, owing partly to the characteristics of the radiated spectrum and partly to propagational factors.

It will be observed that values of noise at 1 Mc/s are indicated which are below the expected levels of man-made and galactic noise. These values should be used with caution, as they represent only rough estimates of what atmospheric noise would be recorded if other types were not present. They are useful mainly as reference levels for low-noise locations, a 1 Mc/s noise grade being assigned by plotting data at other frequencies on the noise curve.

6. *Noise level variations within a time block.*

The hourly values for a given time block vary from hour to hour and from day to day. The extent of these variations is shown in figure 25, on which are plotted the ratios in db of the upper decile to the median values, D_u, and of the median to the lower decile values, D_l. These ratios depend on a number of parameters, but the frequency has been found to be the most significant. D_u has its highest values at sunrise and sunset owing to the change from daytime to night-time propagation conditions and also during the afternoons owing to the occurrence of local storms.

Figure 26 is an example of the distribution of the hourly values within a time block. It may be noted that the curve, typical of a large number of curves of this type, can be represented on normal probability paper with reasonable accuracy by two straight lines, one of which passes through the upper decile and median and the other passes through the median and lower decile. Thus, a knowledge of these three values which can be obtained from the predictions will enable a good estimate to be made of any percentile value between 1% and 99%.

At those locations where man-made noise from local sources has been studied, it has been found that the variations are similar in extent to those of atmospheric noise.

7. *The fine structure of atmospheric noise.*

The variations of the noise envelope in periods of the order of milliseconds depends on the bandwidth of the receiver. The noise is partly impulsive, and the wider the bandwidth the higher and narrower are the peaks. The following remarks, therefore, apply to bandwidths normally used for radio services—say 300 c/s at a frequency of 10 kc/s increasing to several kc/s for frequencies of 300 kc/s and above.

At the lowest frequencies the noise consists largely of impulses separated by periods of relatively low noise. The larger peaks have a shape characteristic of the pass-band of the receiver, but the smaller ones, which are more numerous, run into one another and constitute more continuous noise. The large peaks, though relatively few in number, contribute substantially to the noise power, which could, therefore, be much reduced by amplitude limitation in the receiver. Such amplitude limitation will often take place in operational types of receivers in current use.

The structure of atmospheric noise at medium and high frequencies is more complex. In temperate latitudes, noise at 10 Mc/s consists of bursts, of the order of 10 to 100 milliseconds long, with relatively quiet periods in between. The noise during a burst closely resembles fluctuation noise. In the periods between bursts the noise may be mainly of galactic origin, around mid-day, but at other times the minimum atmospheric noise level is above that of galactic noise.

8. *Use of the data.*

The data may be used in the form of either the r.m.s. noise field strength E_n, or noise figure, F_a. In Recommendation No. 161 (12), the required signal-to-noise ratios for various services under steady conditions are given, the noise being expressed as the rms value in a 6 kc/s bandwidth. The noise values for a 1 kc/s bandwidth given in this report should be increased by 8 db to give the noise in a 6 kc/s bandwidth.

Since the signal-to-noise ratios in Recommendation No. 161 are for steady conditions, allowance must be made in practical problems for the random temporal variations of noise. Intensity fluctuation factors are given in Recommendation No. 164 where the upper decile intensity of noise is assumed to be 10 db above the median. From figure 25, it is seen that the allowance should be a function of frequency and that it should be greater than 10 db in the MF (hectometric) band but less than 10 db in the HF (decametric) band.

Considering shorter-term variations, reference has already been made to the variations over an hour of the noise averaged over a period of a few minutes (Section 2). These variations are normally of only two or three decibels and are small compared with the allowances for fading of the signals (see Report No. 27). It is also found that fluctuations of noise averaged over periods of the order of ten seconds are small compared with fluctuations in signals, if these follow the Rayleigh distribution.

The difficulties in presenting the data for the sunrise and sunset periods (0400 to 0800 and 1600 to 2000) have already been mentioned. These are periods when large changes in noise level occur at some frequencies and the median value may be expected to depend rather critically on whether the receiving point is in daylight for more or less than half the period. In practical problems it will usually be necessary to reconstruct the diurnal curve of noise level and if this is done, having regard to both the median levels derived from the curves and the times of occurrence of sunrise and sunset, the final values should not be much in error. The equator, which has no seasons in the sense in which they are defined here, presents a special problem. To obtain uniformity in interpretation it is suggested that the average of the two values derived from the daylight and the night-time curves be used for locations on the equator. In future revisions of the data, it may be possible to deal with this problem in a more elegant manner, but the necessary data do not at present exist.

If a more complete analysis of a receiving installation is required, for example to determine whether or not reception is limited by external noise or by noise sources within the receiving system, the method described in references 4 and 13 may be used as follows.

Figure 27 is a block diagram in which the various elements that contribute to the resultant noise level are shown. Block A represents a loss-free antenna receiving external noise with an effective noise figure F_a. The losses in the antenna and associated circuit are represented in block C, whose noise figure is F_c. Similarly, the transmission-line loss will determine a noise figure, F_t, for the transmission line. The receiver noise figure is designated by F_r. Using Friis' (14) method of combining the noise figures (expressed as power ratios) of several networks in cascade, the effective noise figure (also expressed as a power ratio) at the input of the aerial is given by

$$F = F_a - 1 + F_c F_t F_r$$

The minimum signal power available from the aerial that is required to provide satisfactory reception is:

$$P = F + R - 204 + 10 \log_{10} B$$

where P = available signal power in db above 1 watt

F = overall effective noise figure in db

R = required signal-to-noise ratio in db

B = bandwidth in c/s.

For example, using values of R given in Recommendation No. 99 where B is taken as 6 kc/s, then

$$P = F + R - 166$$

In making a system evaluation as described above, the value of F_a that is used can be the median, upper decile, or some other percentile, depending upon the protection required.

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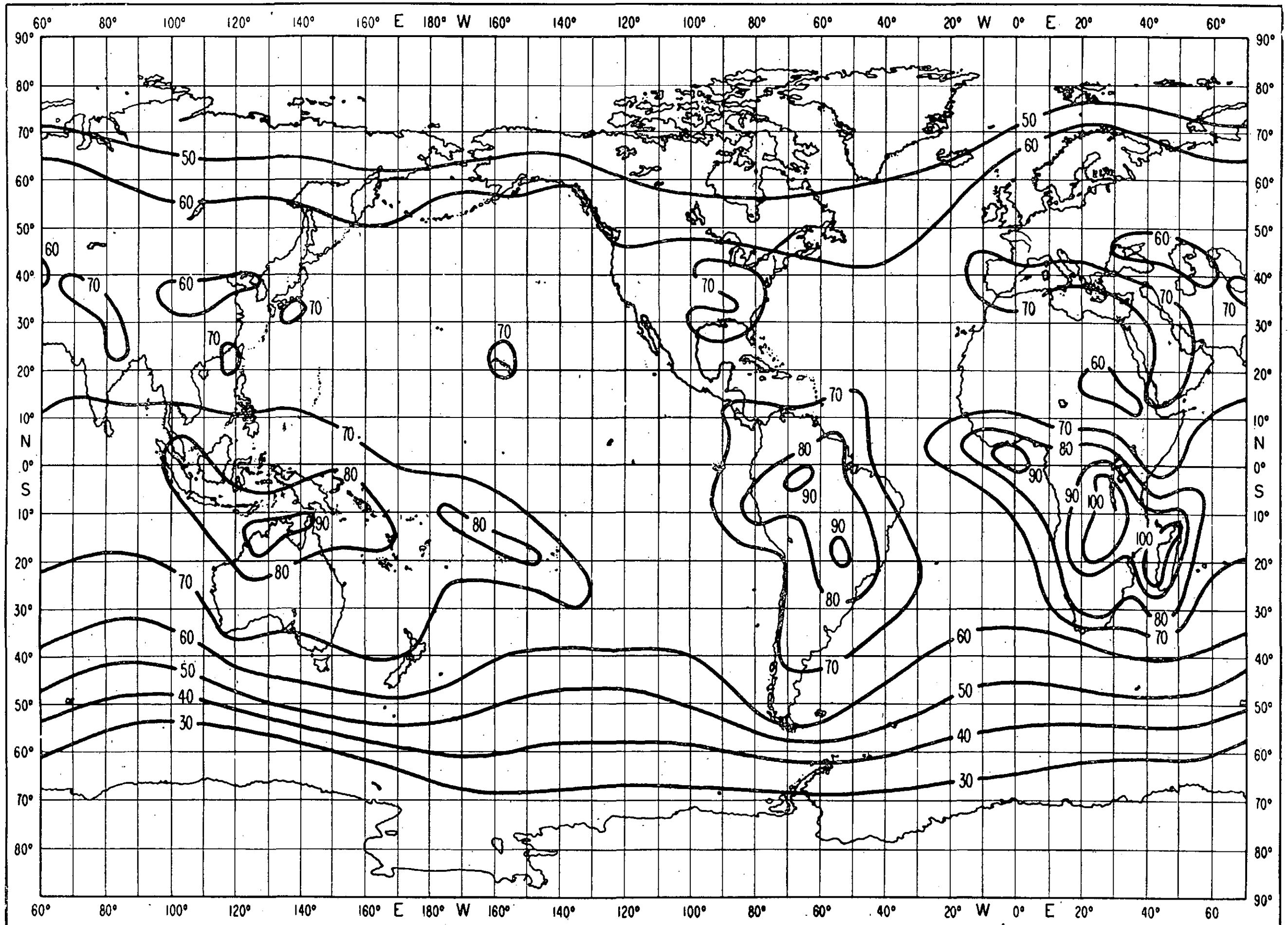


FIGURE 1

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0000—0400 hrs and from 2000—2400 hrs, for December, January and February

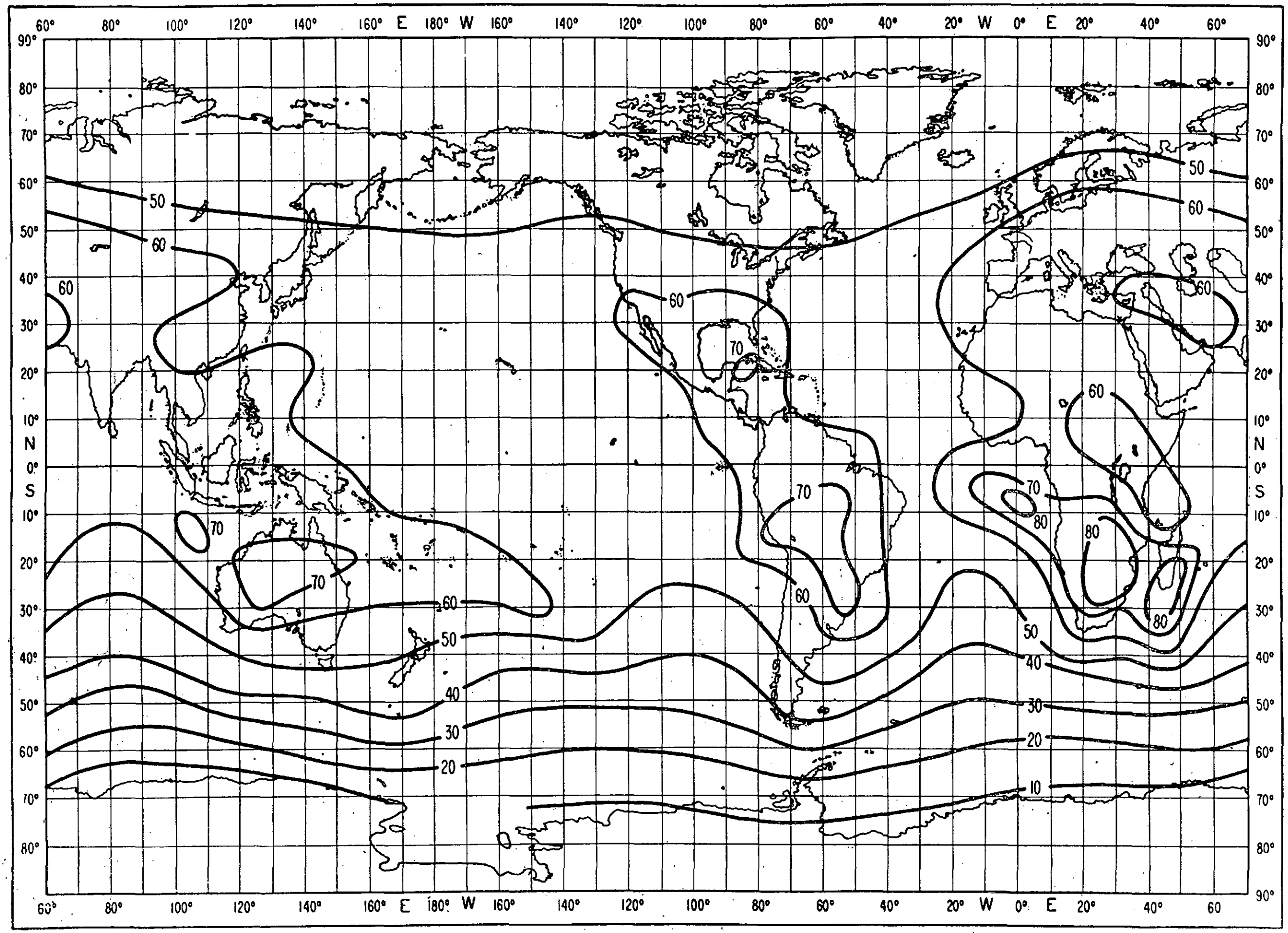


FIGURE 2

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0400—0800 hrs, for December, January and February

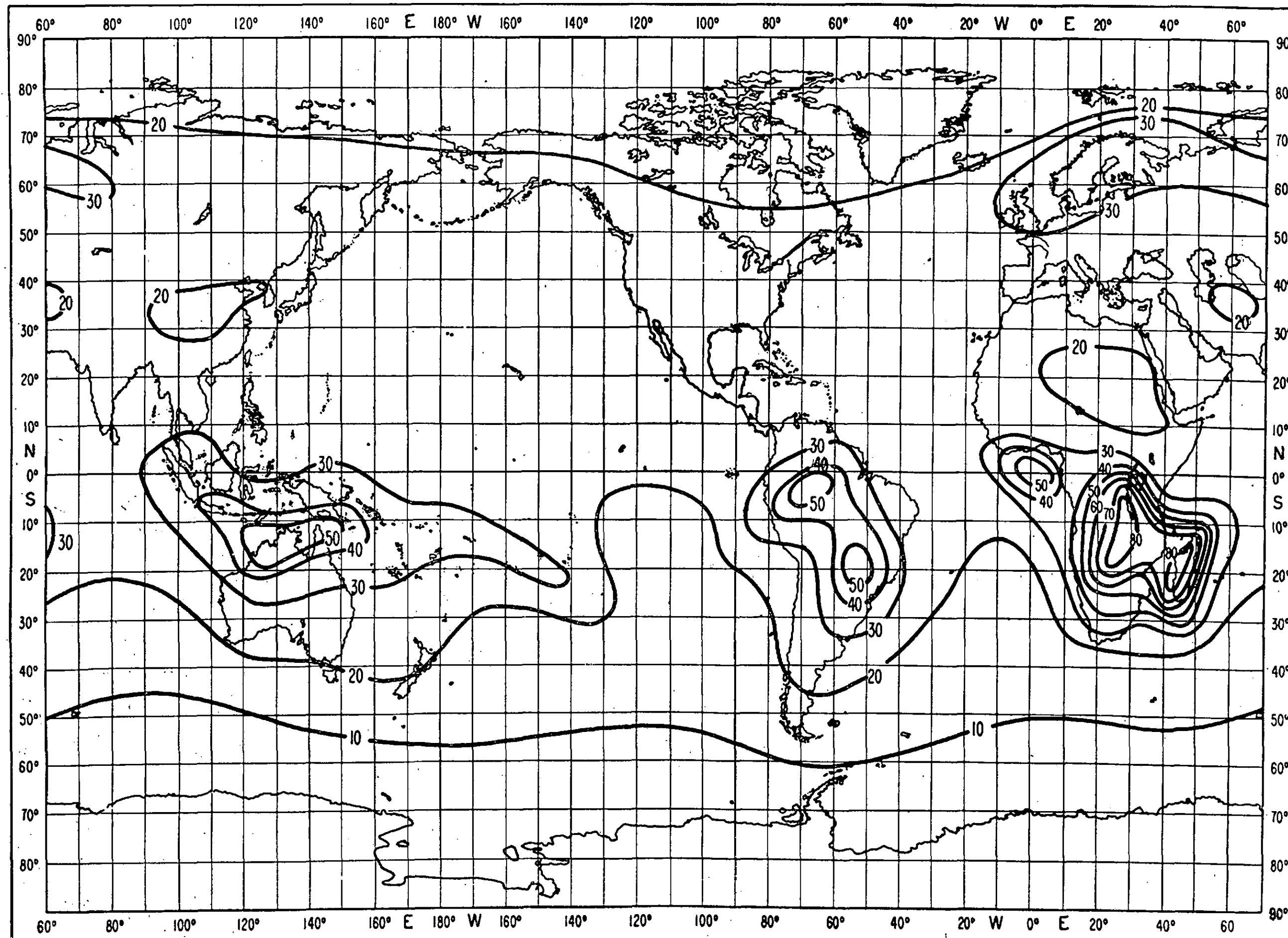


FIGURE 3

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0800—1200 hrs, for December, January and February

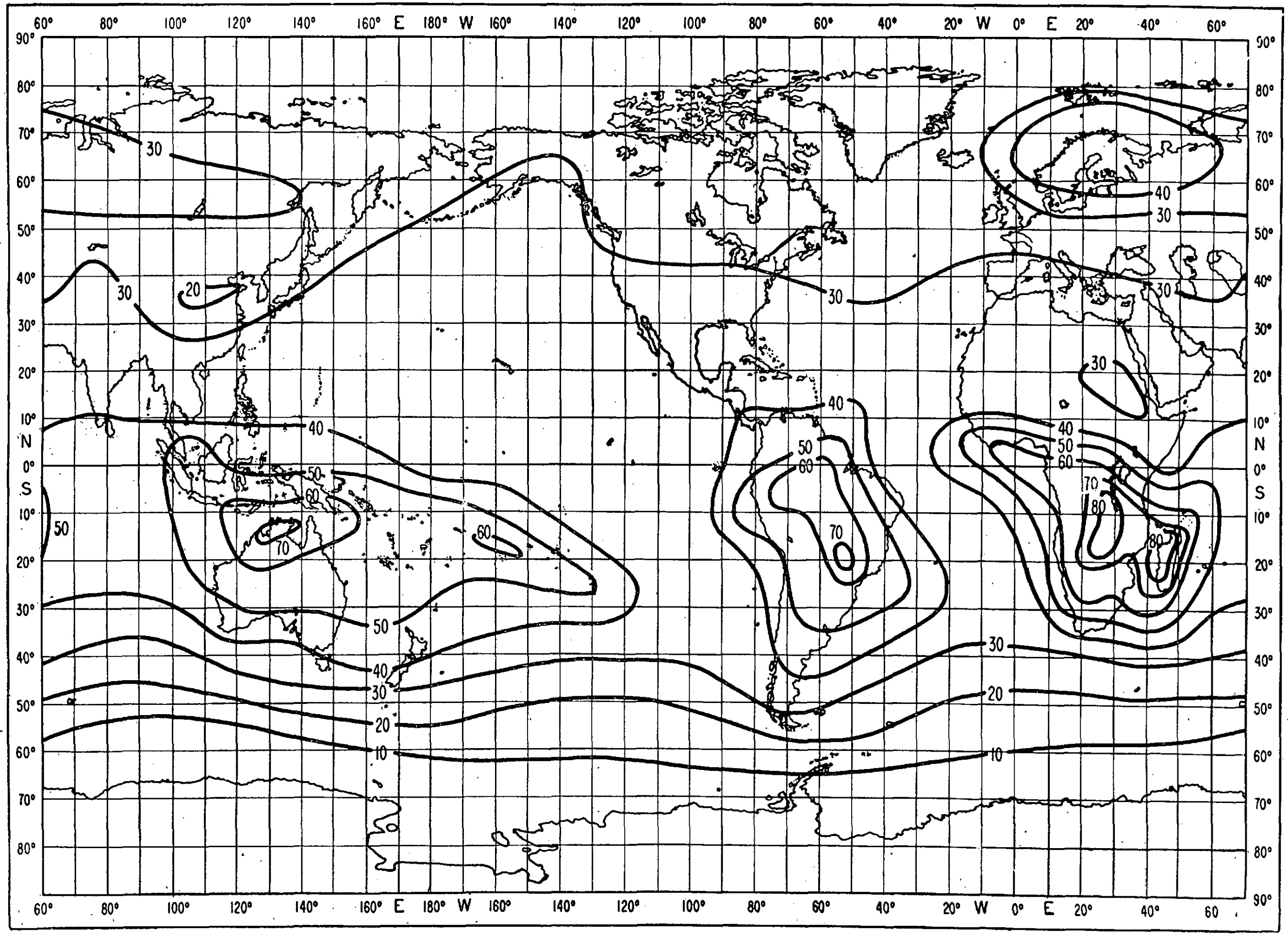


FIGURE 4

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 1200–1600 hrs, for December, January and February

[redacted]

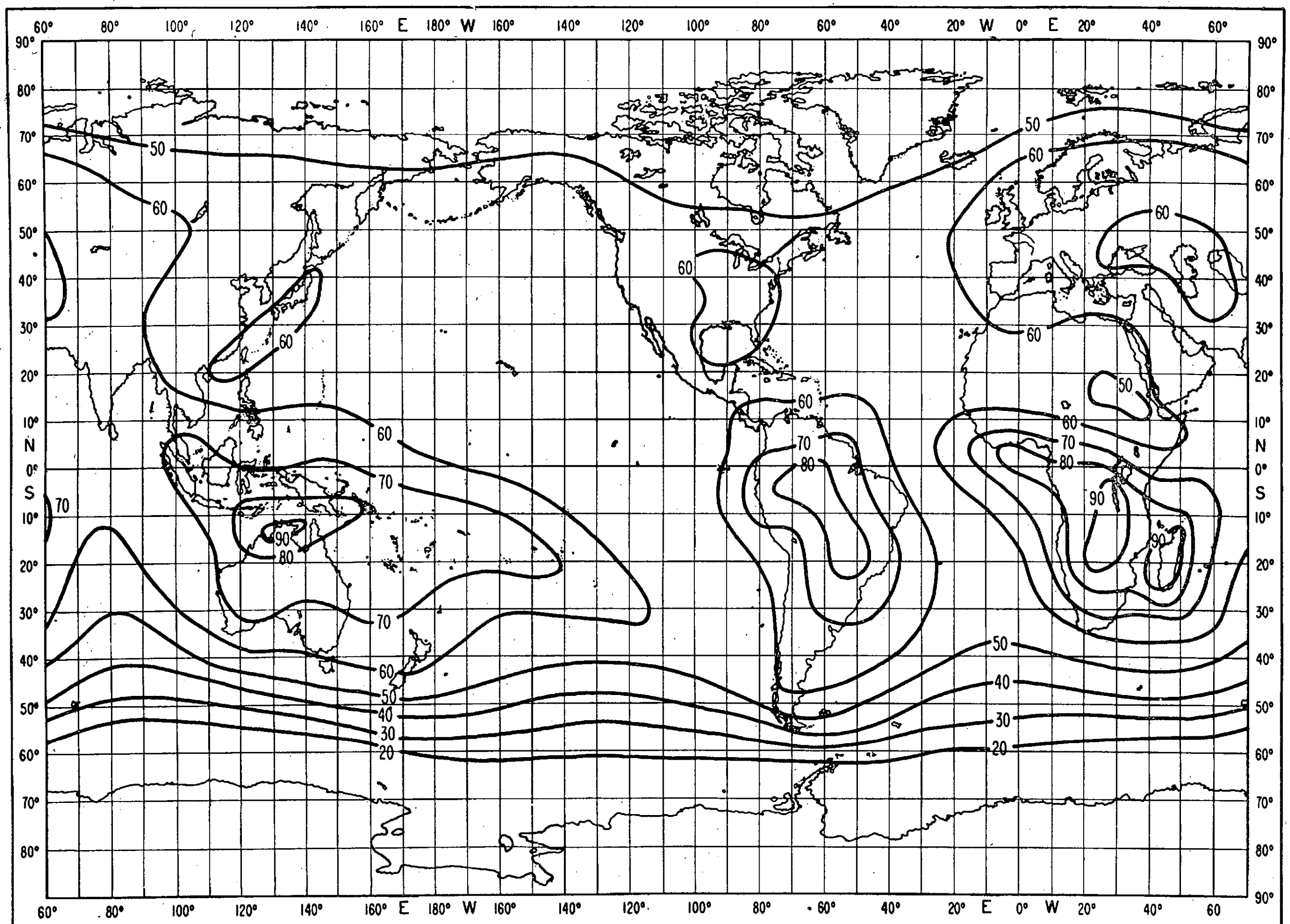


FIGURE 5

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 1600–2000 hrs, for December, January and February

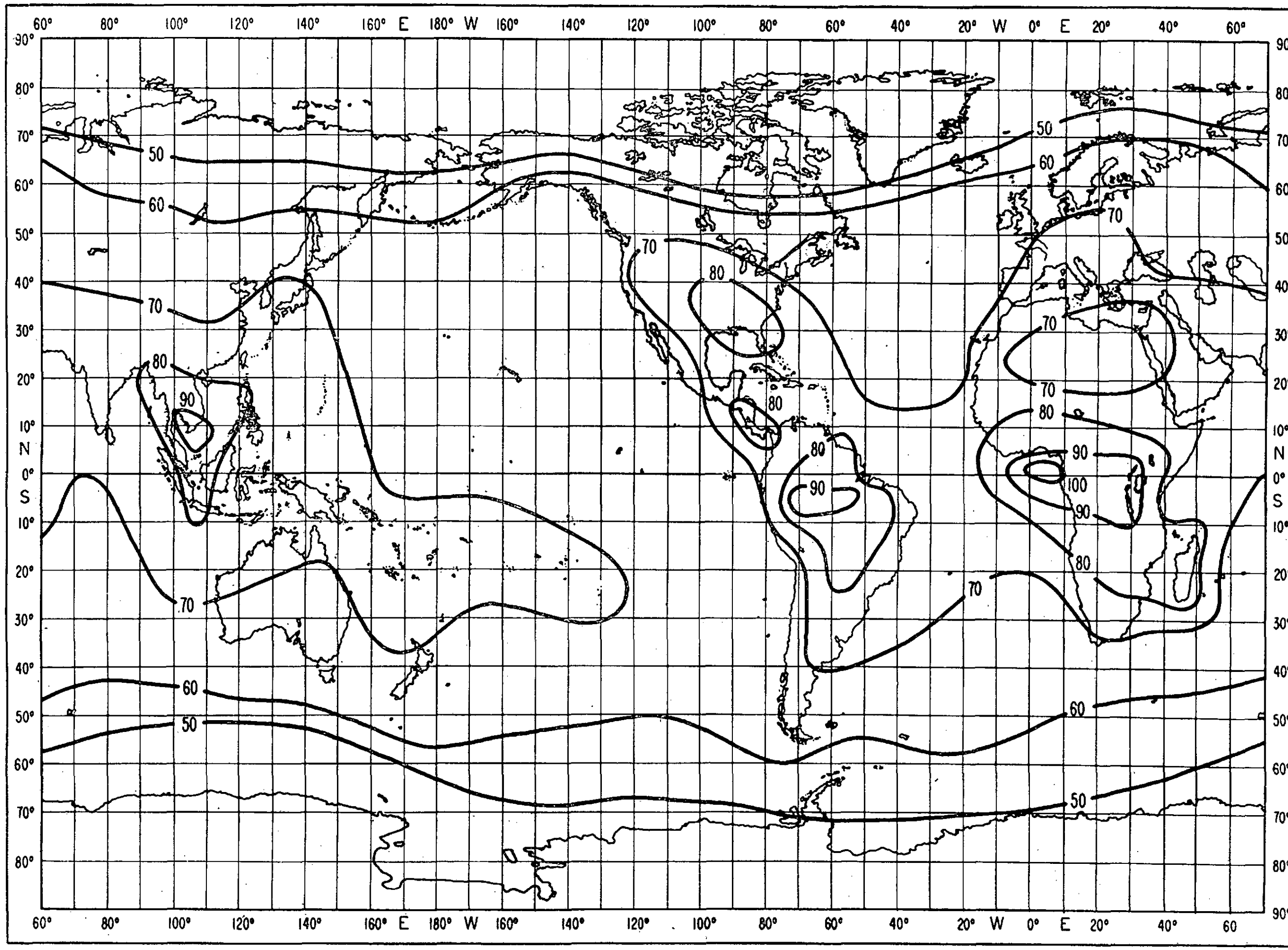


FIGURE 6

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0000–0400 hrs and from 2000–2400 hrs, for March, April and May

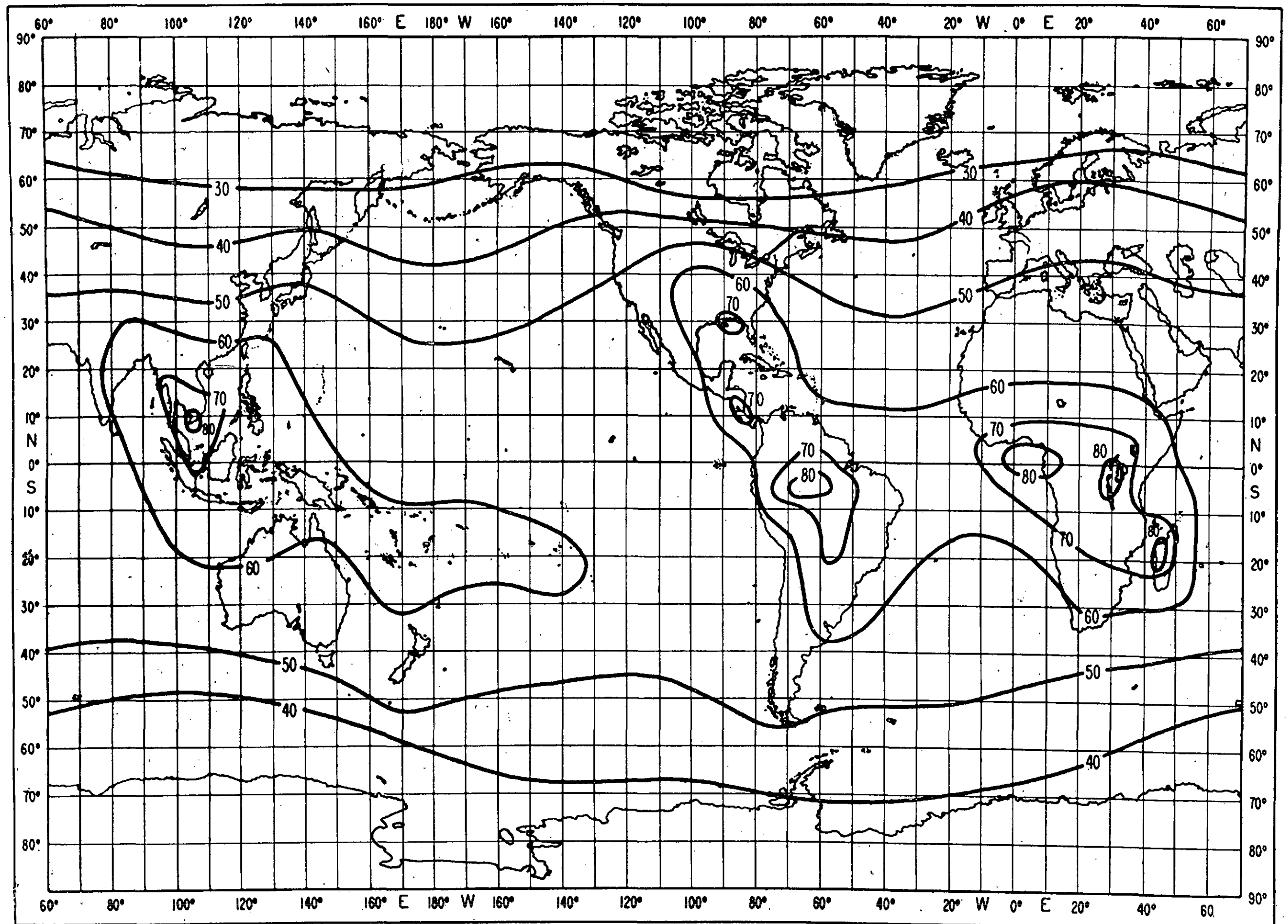


FIGURE 7

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0400—0800 hrs, for March, April and May

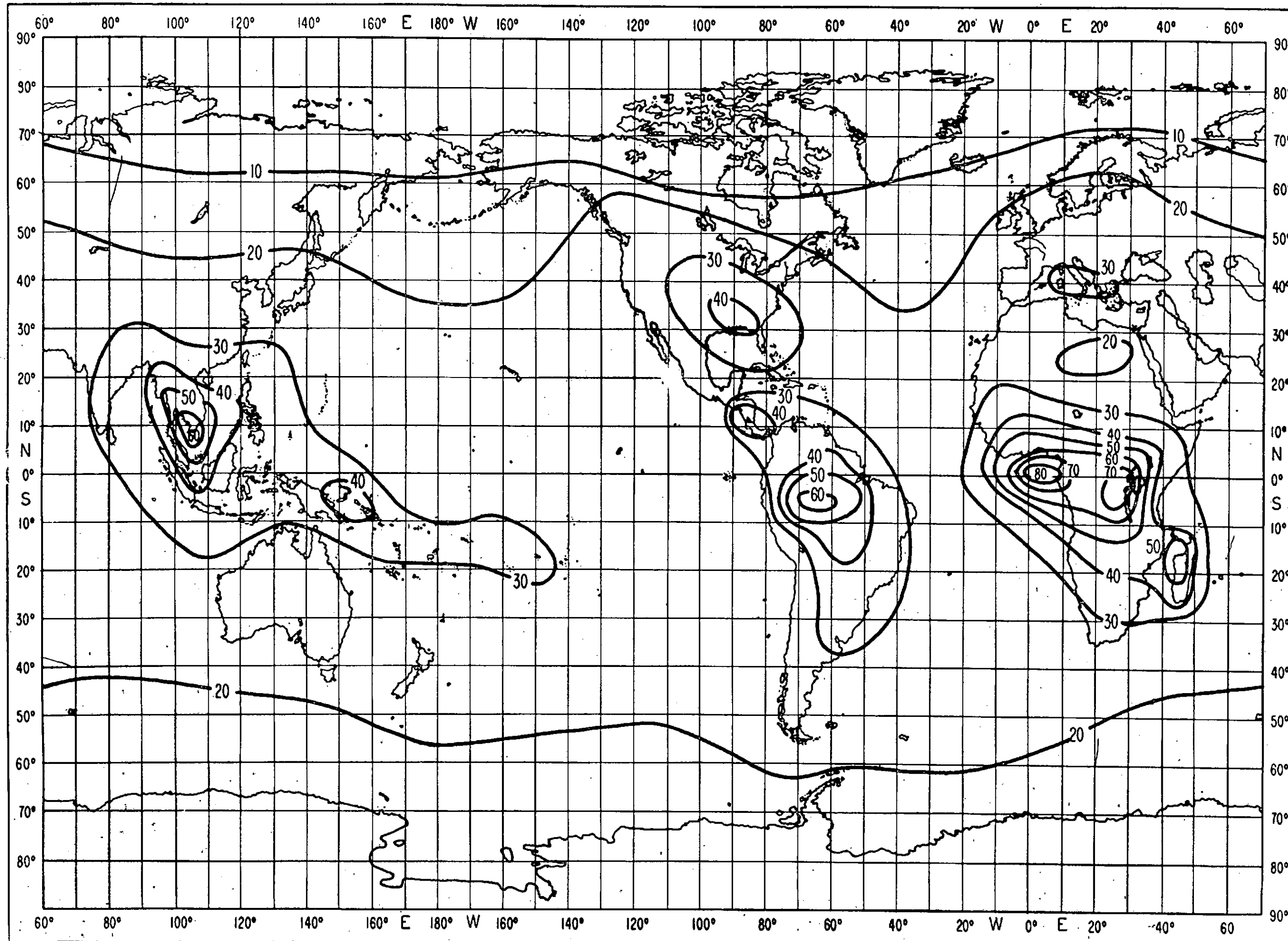


FIGURE 8

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0800—1200 hrs, for March, April and May

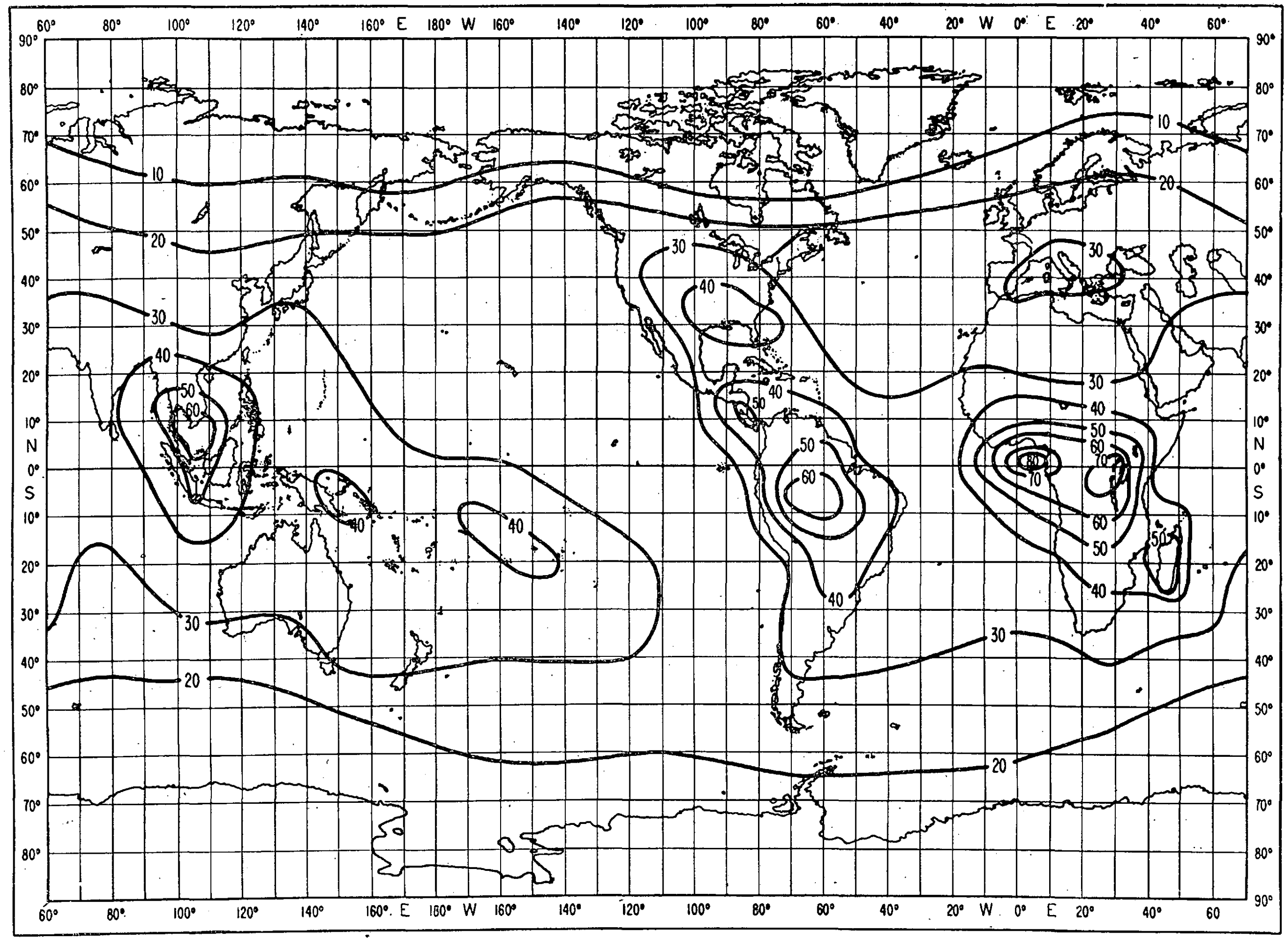


FIGURE 9

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 1200—1600 hrs, for March, April and May

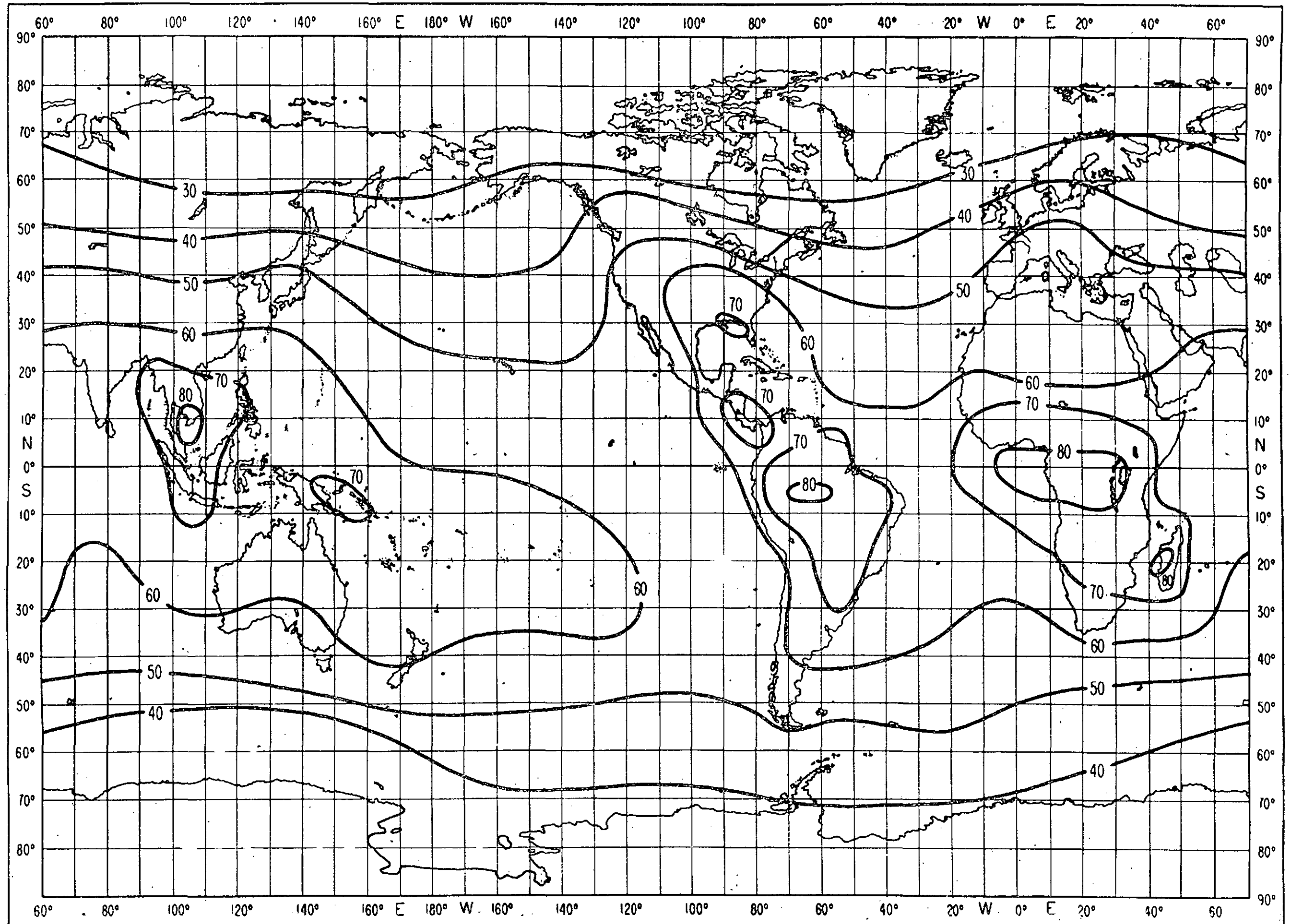


FIGURE 10

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 1600—2000 hrs, for March, April and May

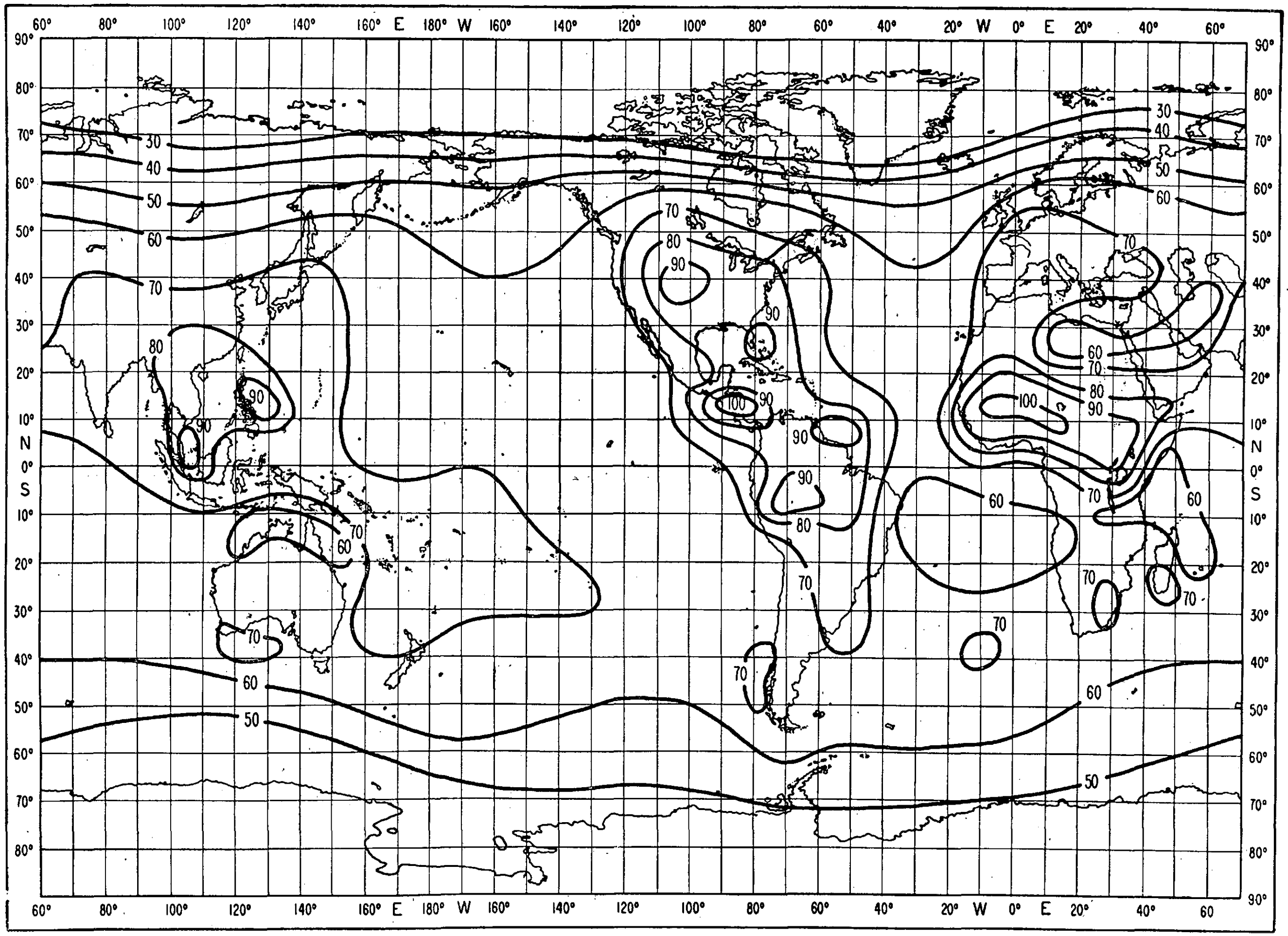


FIGURE 11

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0000—0400 hrs and from 2000—2400 hrs, for June, July and August

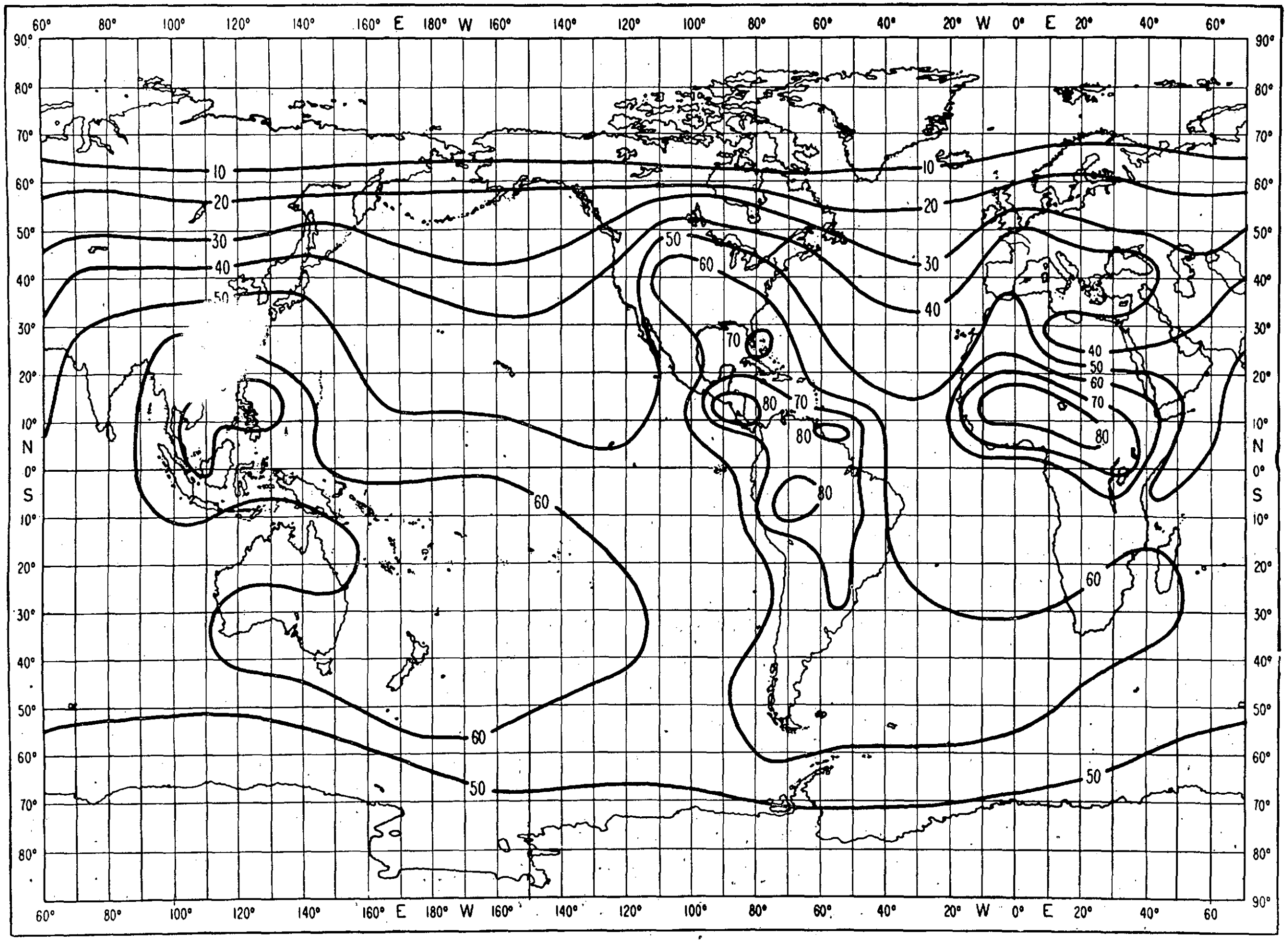


FIGURE 12

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0400—0800 hrs, for June, July and August

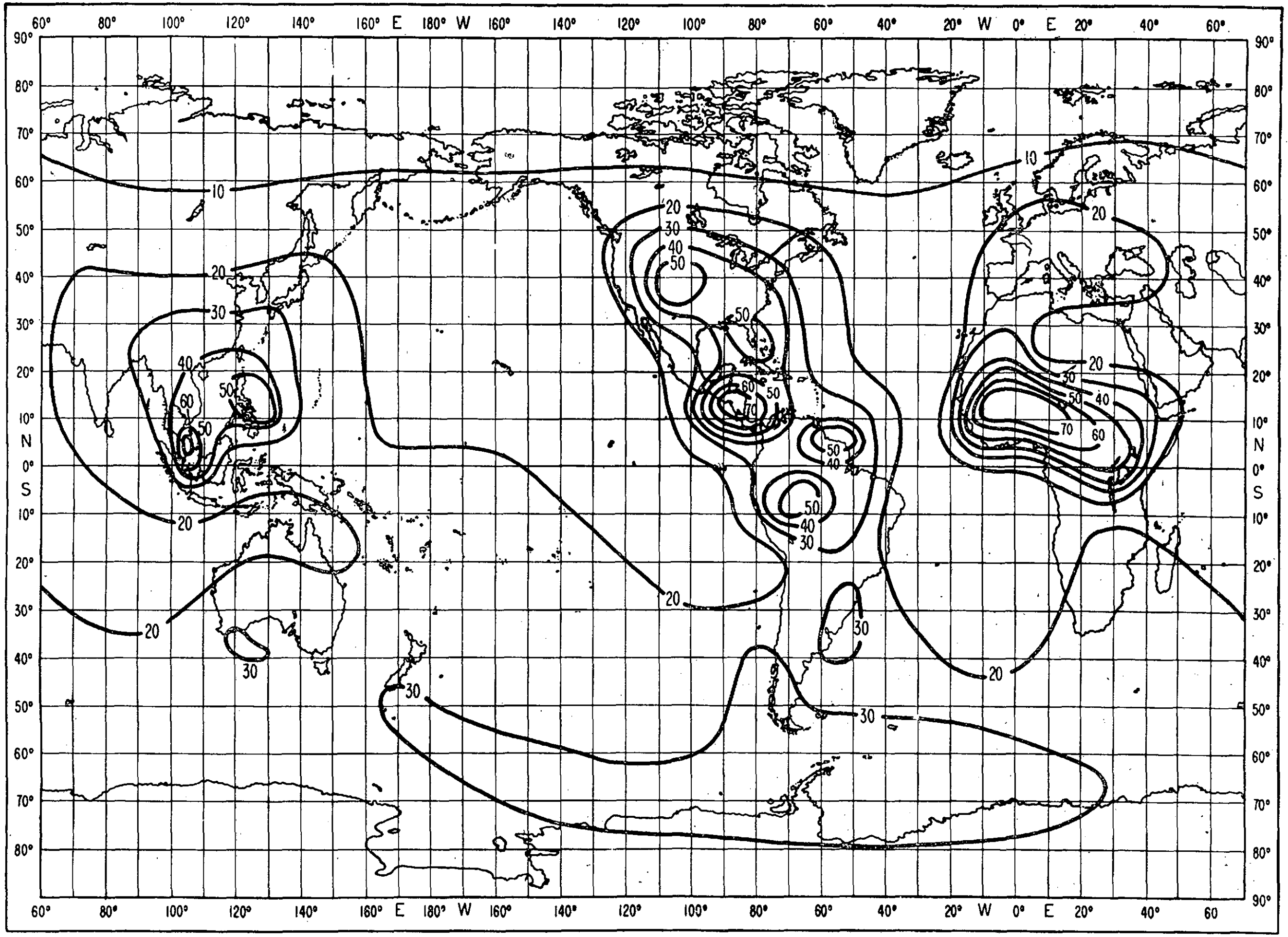


FIGURE 13

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0800–1200 hrs, for June, July and August

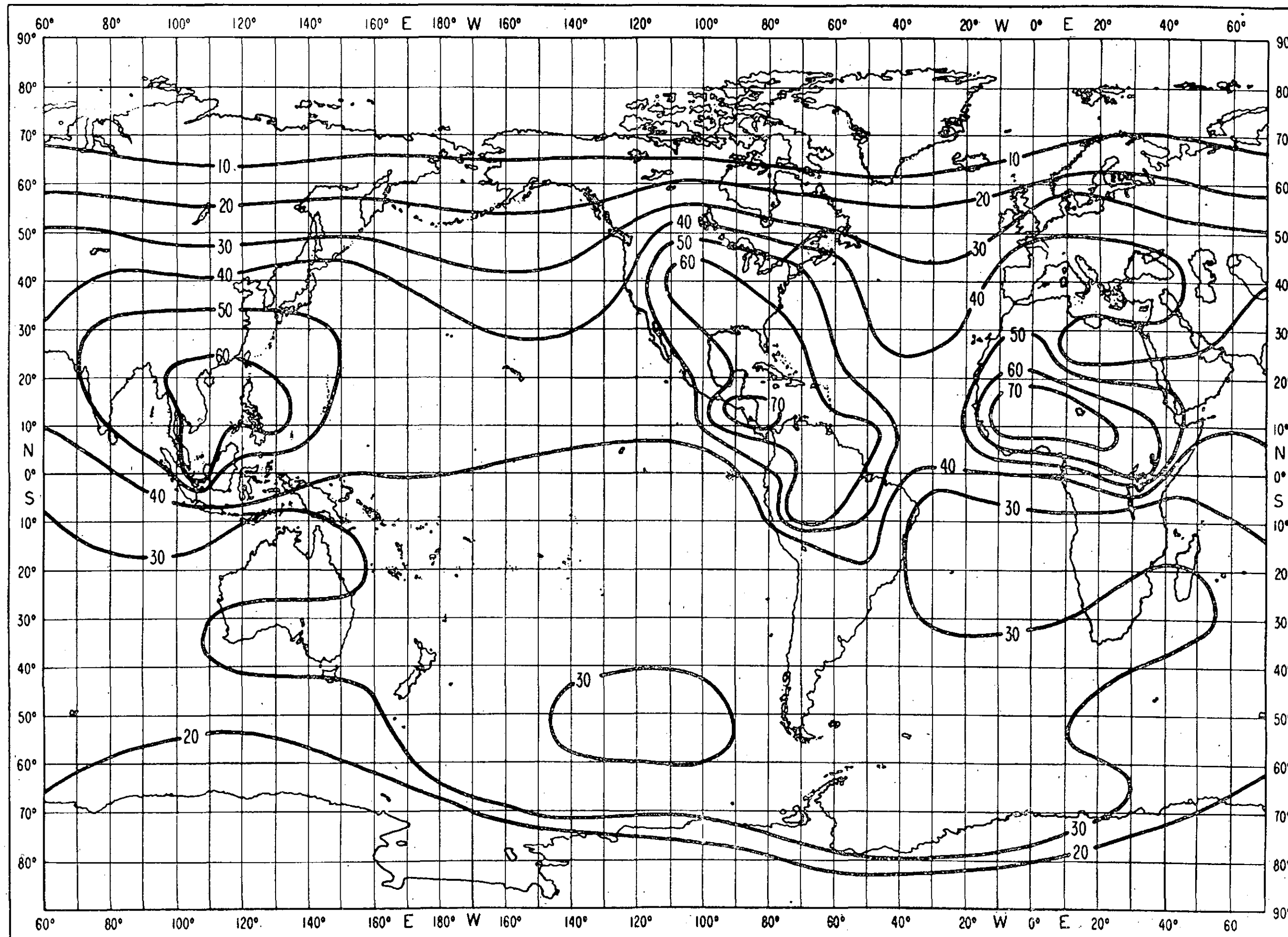


FIGURE 14

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 1200—1600 hrs, for June, July and August

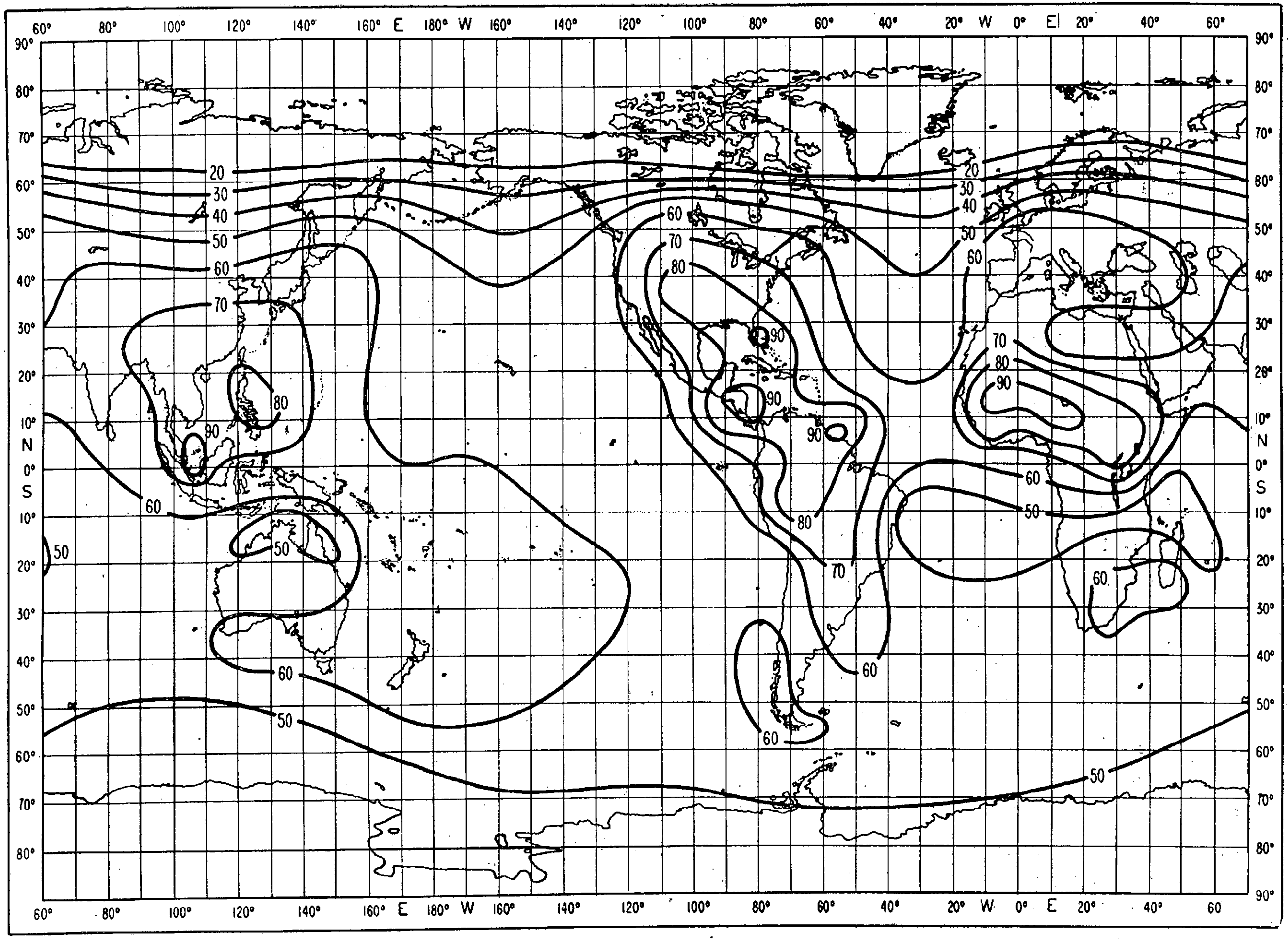


FIGURE 15

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 1600—2000 hrs, for June, July and August

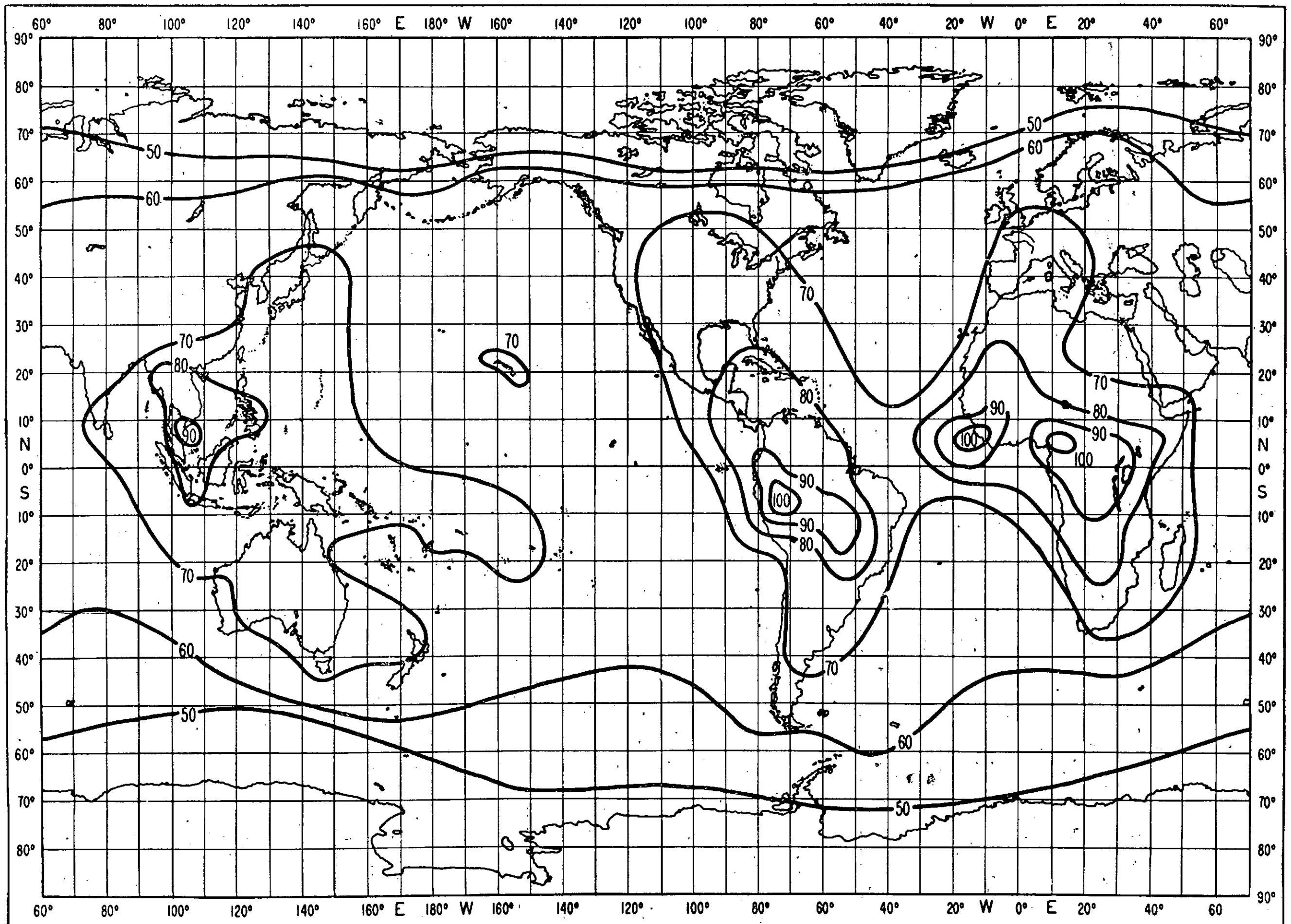


FIGURE 16

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0000—0400 hrs, and from 2000—2400 hrs, for September, October and November

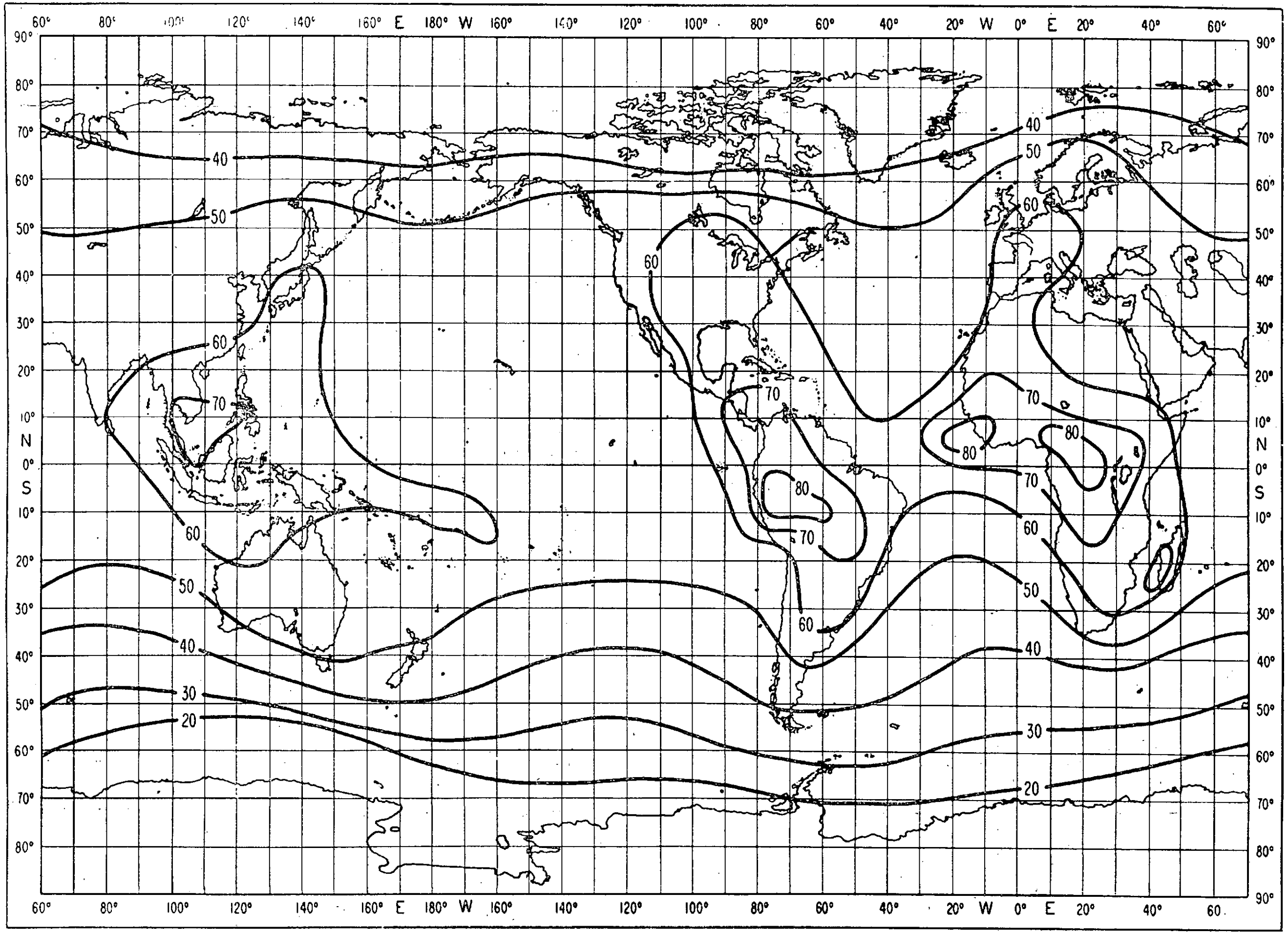


FIGURE 17

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0400—0800 hrs, for September, October and November

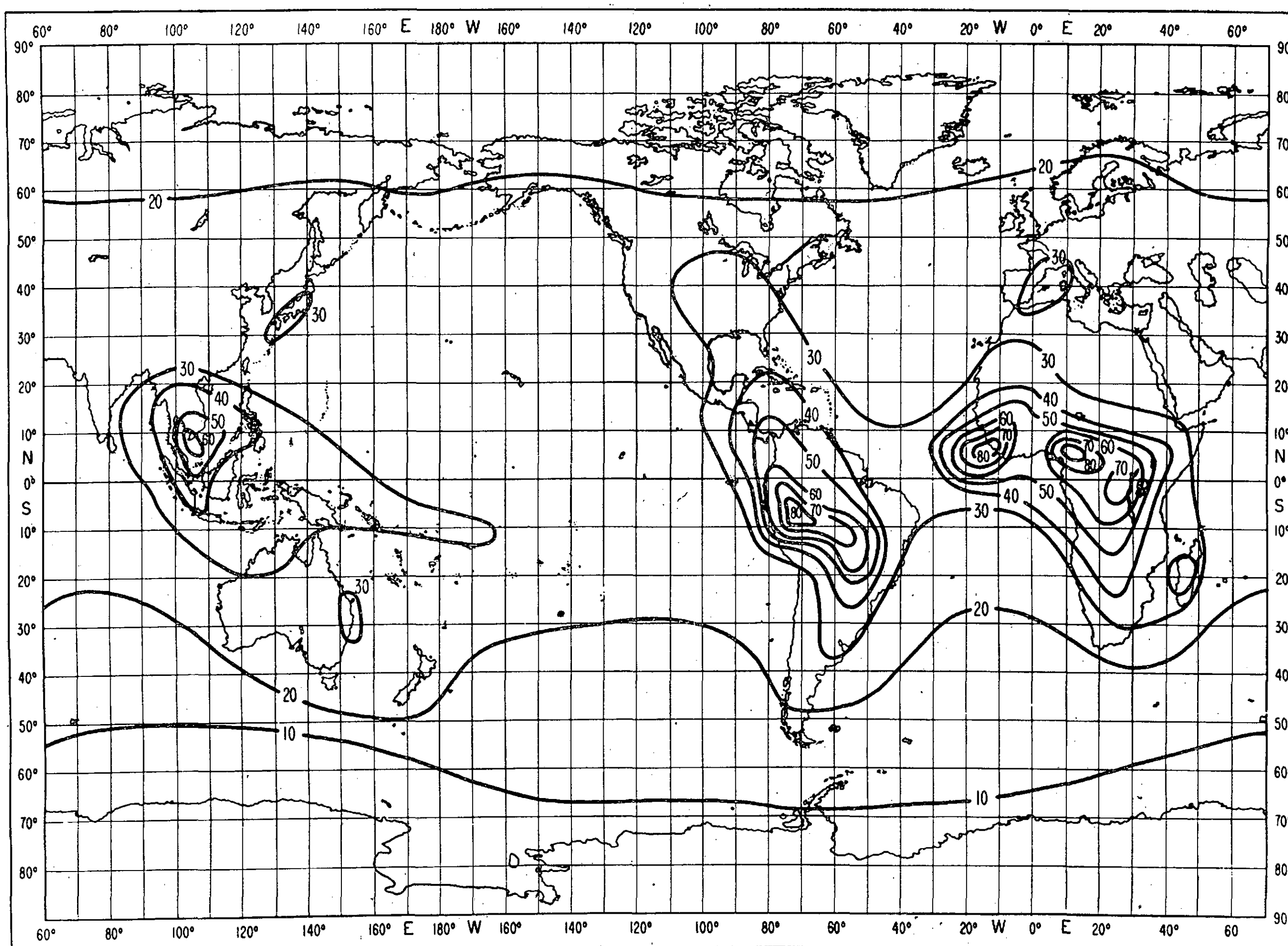


FIGURE 18

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 0800–1200 hrs, for September, October and November

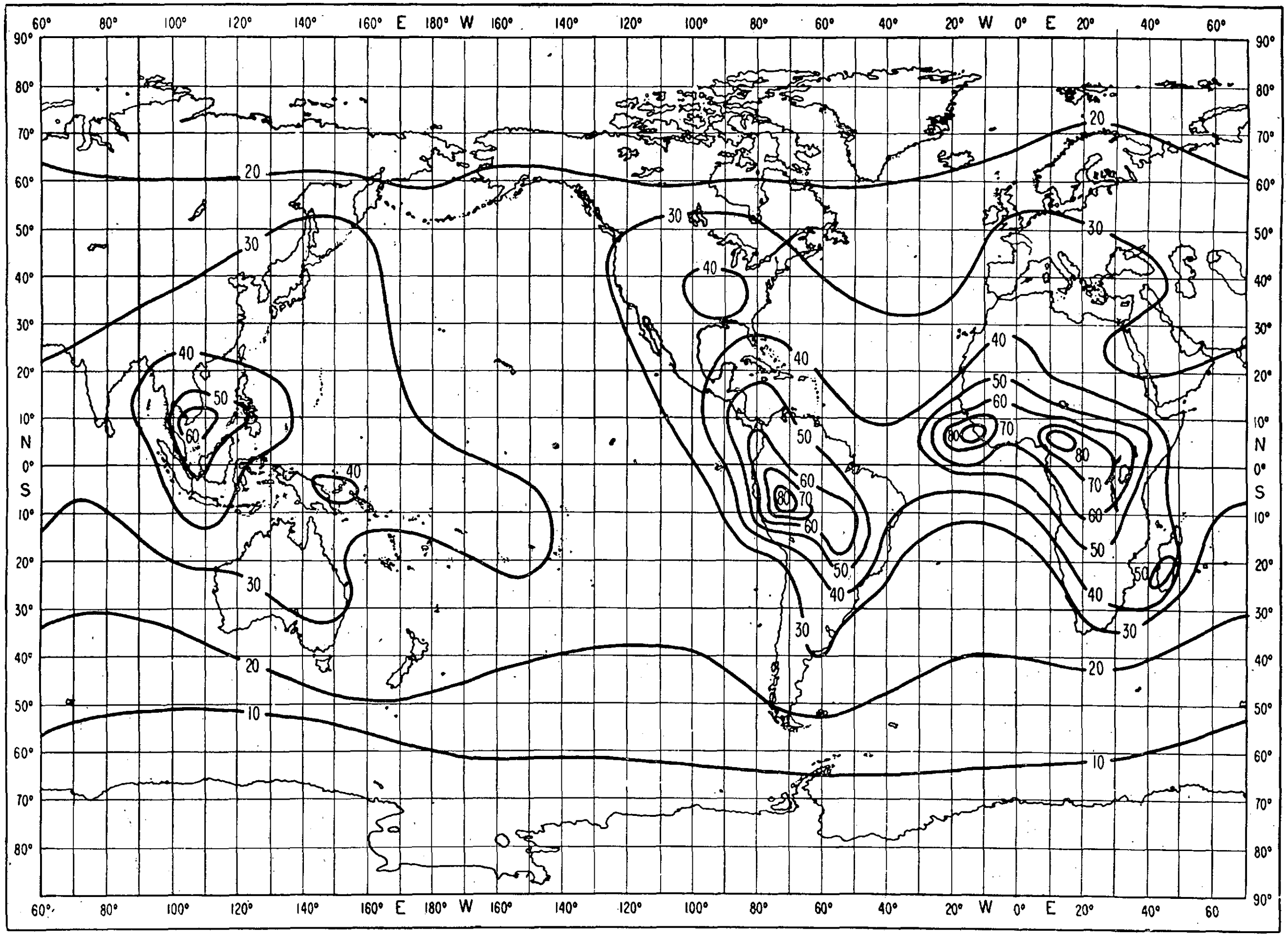


FIGURE 19

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 1200—1600 hrs, for September, October and November

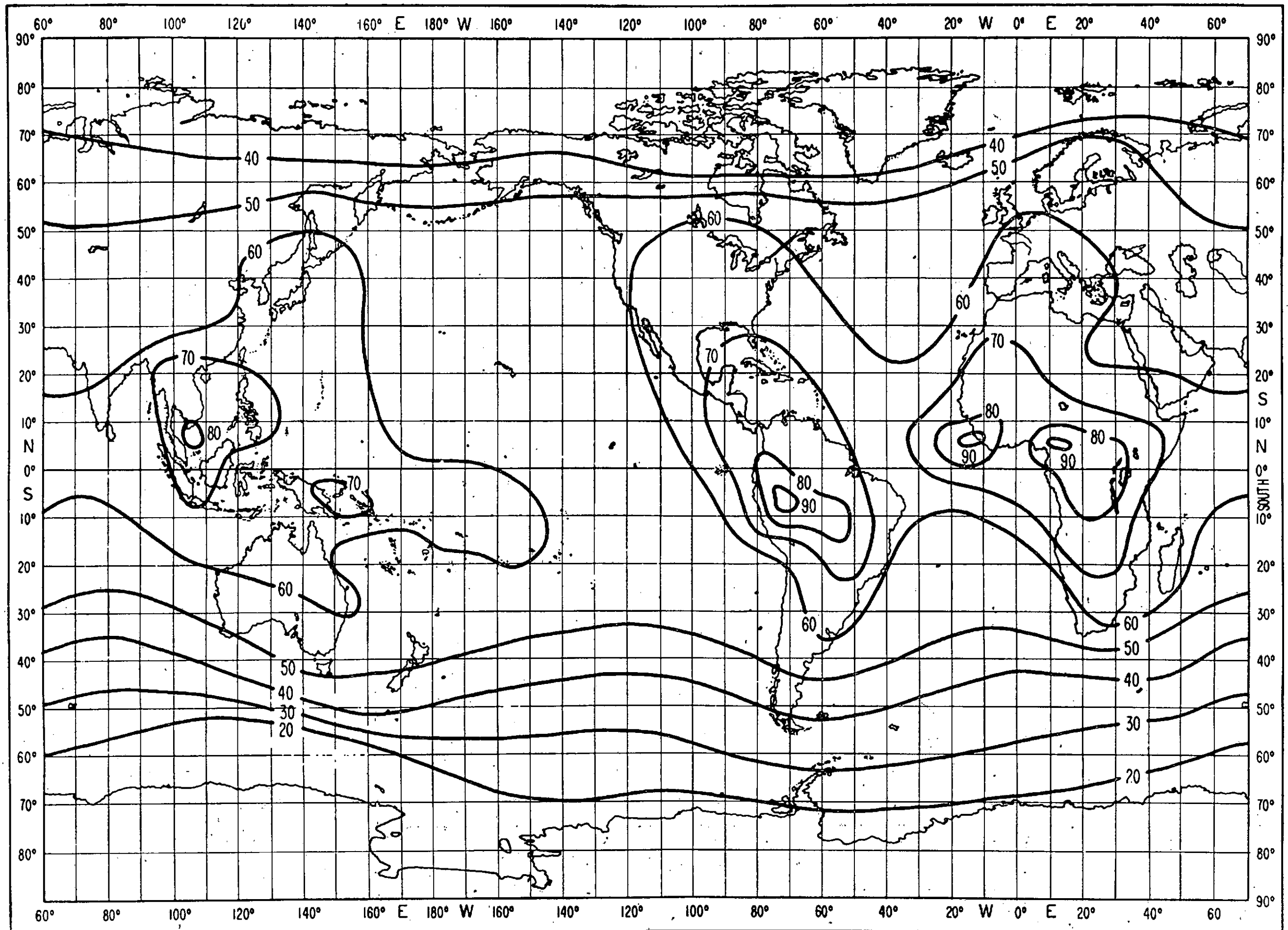
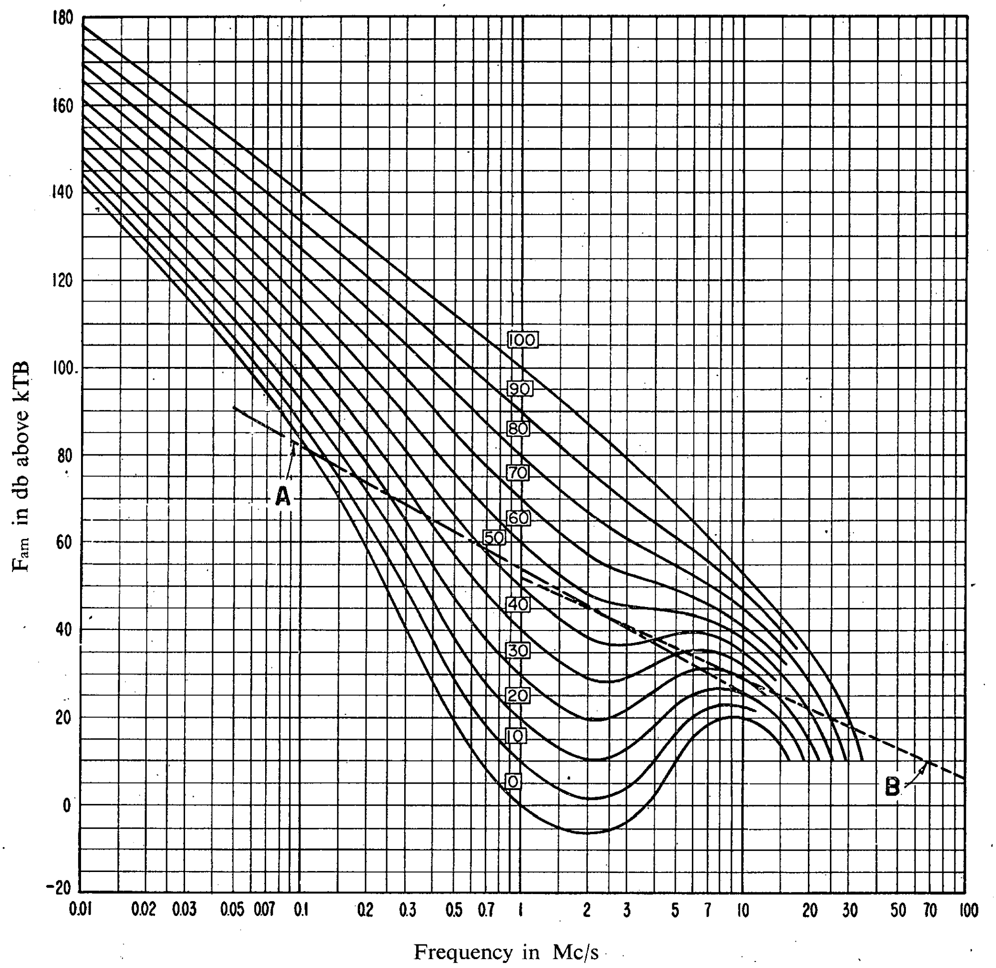


Figure 20

Expected values of radio noise F_a (in db above kTB) at 1 Mc/s, from 1600—2000 hrs, for September, October and November

[redacted]

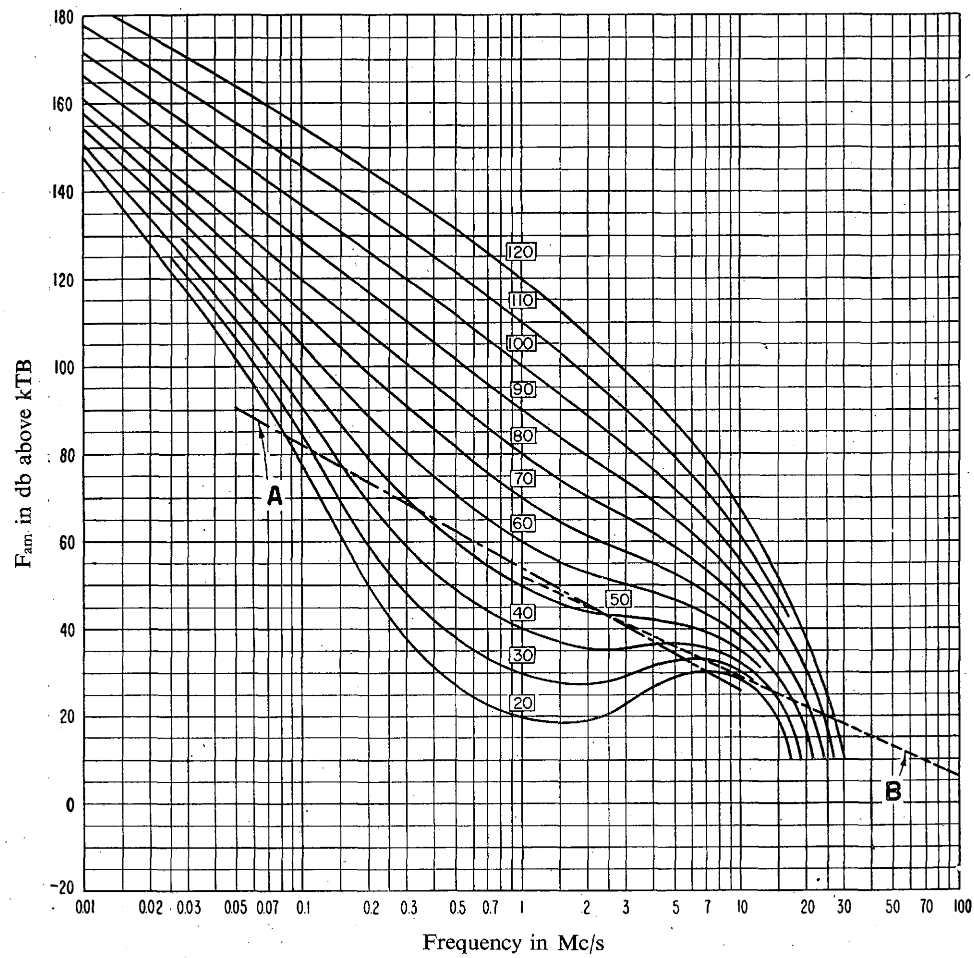


A — Expected values of man-made noise at a quiet receiving location.
B — Expected values of galactic radio noise.
The figures in rectangles indicate the noise grades at 1 Mc/s.

FIGURE 21

Median values of radio noise expected for a short vertical antenna for the time blocks :

0800—1200 hrs and 1200—1600 hrs for all seasons
0400—0800 hrs and 1600—2000 hrs for spring and summer



A — Expected values of man-made noise at a quiet receiving location

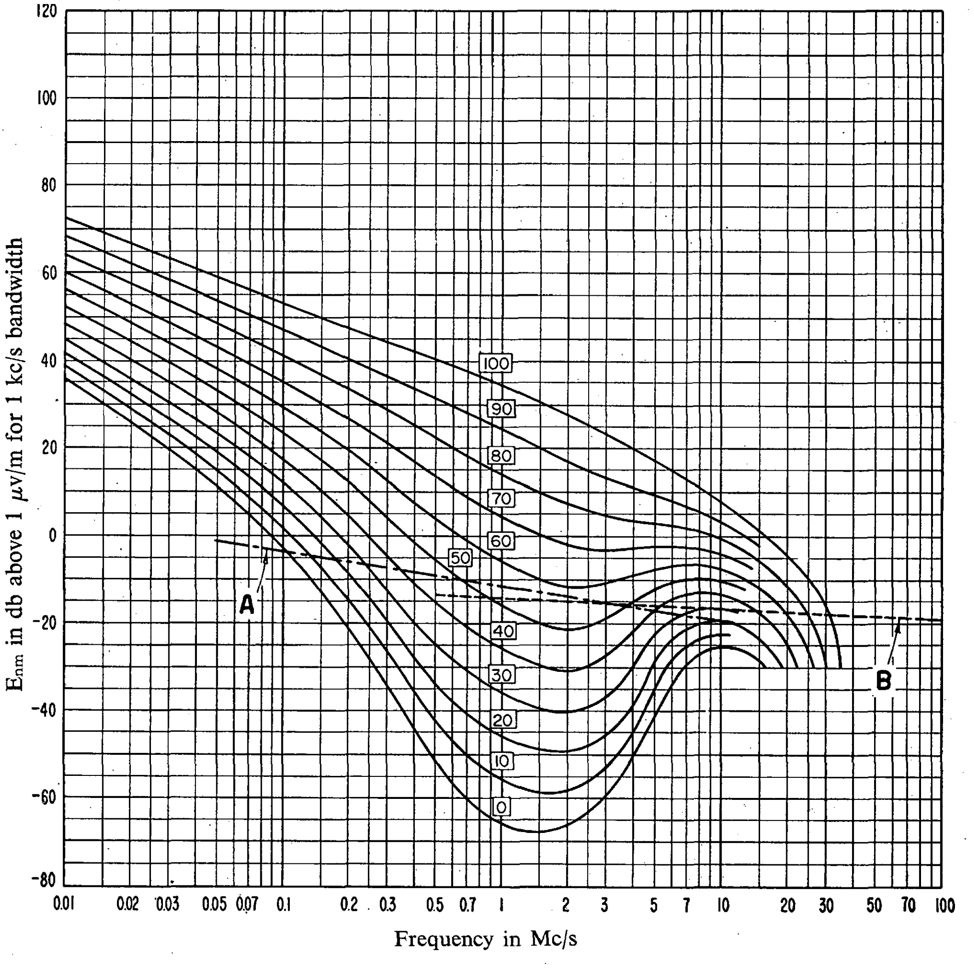
B — Expected values of galactic radio noise

The figures in rectangles indicate the noise grades at 1 Mc/s

FIGURE 22

Median values of radio noise expected for a short vertical antenna for the time blocks :

0000—0400 hrs and 2000—2400 hrs for all seasons
0400—0800 hrs and 1600—2000 hrs for autumn and winter



A — Expected values of man-made noise at a quiet receiving location

B — Expected values of galactic radio noise

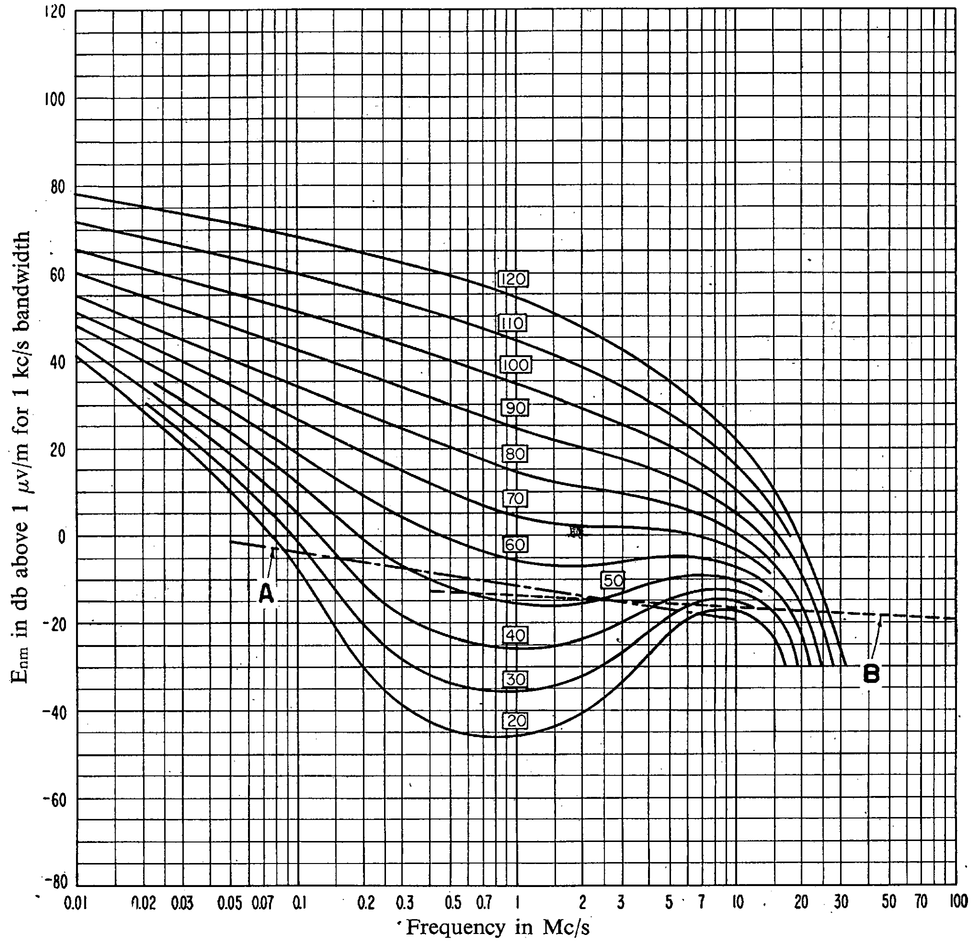
The figures in rectangles indicate the noise grades at 1 Mc/s

FIGURE 23

Median values of radio noise expected for a short vertical antenna for the time blocks :

0800—1200 hrs and 1200—1600 hrs for all seasons

0400—0800 hrs and 1600—2000 hrs for spring and summer



A — Expected values of man-made noise at a quiet receiving location

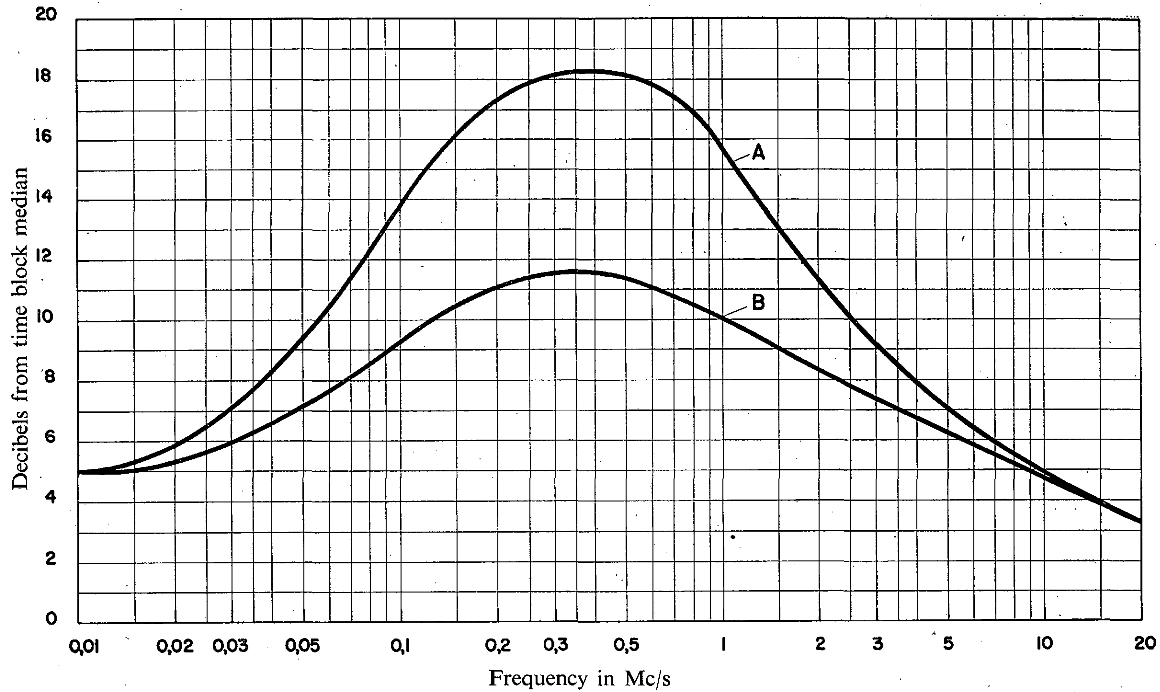
B — Expected values of galactic radio noise

The figures in rectangles indicate the noise grades at 1 Mc/s

FIGURE 24

Median values of radio noise expected for a short vertical antenna for the time blocks :

0000—0400 hrs and 2000—2400 hrs for all seasons
0400—0800 hrs and 1600—2000 hrs for autumn and winter



A — Ratio D_u (in db) of the upper decile to the median for the time blocks :
0400—0800 hrs 0800—1200 hrs
1200—1600 hrs 1600—2000 hrs

B — Ratio D_u (in db) of the upper decile to the median for the time blocks:
0000—0400 hrs
2000—2400 hrs

and ratio D_e (in db) of the median to the lower decile for all time blocks

FIGURE 25

Variations from the time block median radio noise levels

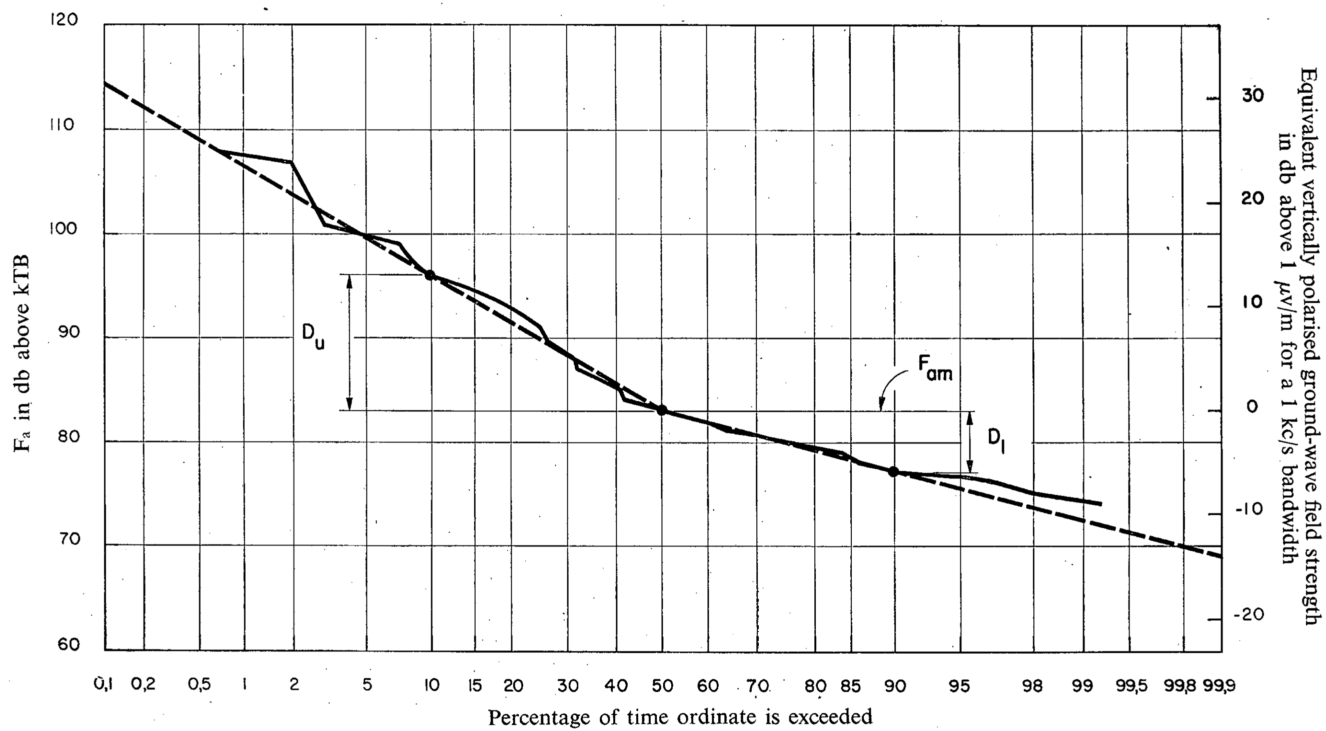
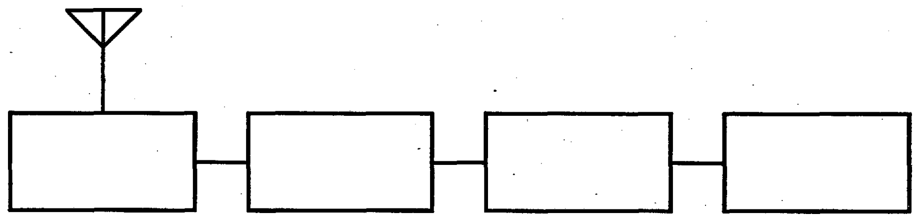


FIGURE 26

Typical distribution of hourly medians
Front Royal, Virginia, 135 kc/s, for the time block 1200—1600 hrs
September, October and November 1952

[redacted]



$$F = F_{actr.} = F_a - 1 + F_c F_t F_r$$

FIGURE 27

Network for the definition of F, the effective receiver noise figure

REPORT No. 66 *

STANDARD-FREQUENCY TRANSMISSIONS AND TIME SIGNALS

(Question No. 140 VII)

(Warsaw, 1956)

By the time of the VIIIth Plenary Assembly, some parts of the question on the establishment and operation of a world-wide standard-frequency and time-signal service in the allocated bands had been resolved. Some of the principal remaining problems are:

(1) large areas of the world do not yet have an adequate service;

(2) the signal-to-noise ratio is too low in some industrial areas;

(3) higher accuracy is needed by many users; however, the services in the allocated bands are frequently deteriorated in the process of propagation and sufficiently accurate measurement in a few minutes does not appear to be practicable;

(4) the best design for time pulses and for receiving equipment to obtain the highest accuracy is not yet available;

(5) the standard-frequency service continues to experience interference from stations which are not standard-frequency stations but which operate in the bands allocated to this service;

(6) the problem of mutual interference between standard-frequency stations, operating simultaneously on the same carrier frequency, remains unsolved and serious difficulty is experienced by specialised users in some locations.

Since the VIIth Plenary Assembly studies and changes in the services may indicate ways of alleviating some of the difficulties mentioned above. For example, each station now has a complete interruption, at regular intervals, in its emission; also, the experimental use of an independent-sideband technique for the tone modulation has been continued by one station.

Several types of time pulses have been studied; the preparatory documents show that the type generally in use can be improved, e.g., by the interruption of the continuous wave and the insertion of the pulse during the interruption. The pulse form recommended by the VIth Plenary Assembly, which remained unchanged by the VIIth Plenary Assembly, is retained in Recommendation No. 179 " Standard-frequency transmissions and time signals "; however, it is hoped that more information may be obtained which will lead to its improvement. It is believed that some improvement would result from increasing the power in the pulse. It appears highly desirable, for identification purposes, that each station choose and put into operation a different modulation frequency for formation of the time pulse.

It is hoped to publish promptly in the I.T.U. Journal all new information pertinent to standard-frequency transmissions and time signals. This is recommended because many experiments or changes have in the past been commenced by different administrations without adequate prior notice to others. Under these conditions it is not possible for many related and mutually beneficial measurements and experiments to be performed. Also, it is considered important that each administration should prepare and distribute an up-to-date leaflet describing their technical radio broadcast services. Information on the exact waveform of the radiated time pulse would be particularly useful.

* This Report replaces Report No. 29. It was adopted unanimously.

The errors introduced by the radio propagation of standard frequencies and time signals and the need for high measurement accuracy in a short measurement time led to proposals for future work by Study Group VII. The importance of Doppler effect in the reception of standard frequencies was mentioned in several of the Warsaw Documents; in one document the theory and measurement results were reviewed in considerable detail. Two new questions have been prepared: No. 142 (VII) " Standard-frequencies and time signals in new bands "; and No. 141 (VII) " Stability of standard-frequency transmissions and time signals as received ".

The trend toward higher accuracy was evident throughout most of the preparatory documents; it is thought preferable to have a 10 to 1 improvement in accuracy before decreasing the recommended tolerance. Frequency comparison methods, suitable for high precision measurements, were reported in greater detail than at previous Plenary Meetings; for example, the following documents were related to this subject:

" Comparison of frequency and time standards by carrier phase recording " (Doc. No. 151);

" Use of very low frequencies for radio frequency standard transmissions " (Doc. No. 557);

" Determination of relative deviations of standard frequencies " (Doc. No. 367);

" Reception of standard frequencies at the Instituto Superiore Delle Poste e Telecommunicazioni " (Doc. No. 479);

" A measurement method for precision comparison of quasi-harmonically related frequencies " (Doc. No. 439).

A possible new standard of frequency was mentioned in some of the preparatory documents, for example, in the document " MSF standard frequencies expressed in terms of caesium resonance " (Doc. No. 509). The use of atomic or molecular resonances can be expected to be of considerable assistance in:

(a) maintaining a more nearly constant frequency at each station,

(b) maintaining the same frequency at each station, and

(c) reporting deviations and adjustments with reference to a basic frequency standard which for the first time can be immediately available.

It is interesting to note in Annex I of this report entitled " Main characteristics of standard-frequency and time-signal stations in use ", that each station is now making adjustments in small steps, 10, 20 or 50 milliseconds, as required, to compensate for time deviations.

With reference to new stations in the allotted bands, four came into use subsequent to the VIIth Plenary Assembly and four are expected to commence in 1956 or 1957. Details on these stations are given in Annexes I and II, and Annex IV gives the geographical locations of the stations. It is encouraging to note that there are now three stations in the southern hemisphere. It should be pointed out again that too many stations in a given area may degrade instead of improve the service. The new Study Programme (No. 101 (VII) " Standard-frequency transmissions and time signals ") requests that investigations be commenced into methods of avoiding harmful interference between stations. Useful proposals were included in several of the preparatory documents, for example:

(1) the grouping of several stations transmitting on the same frequency and arranging their operation on a time-sharing basis,

(2) the trial of double-sideband modulation with suppressed carrier.

A number of standard-frequency and time-signal stations are operated on frequencies outside those allotted for standard-frequency and time-signal use. In addition a transmitter at Rugby, England (GBR) operating a world-wide telegraphic service on 16 kc/s now has its carrier controlled from the same source as the MSF standard-frequency transmissions. Those transmissions known at the time of the VIIIth Plenary Assembly are listed in Annex III. Those on

16 and 60 kc/s are of particular interest because results therefrom can help in answering Question No. 142 (VII) already mentioned. With further reference to the latter, it is important that careful consideration be given to the possibility of including the distribution of standard frequencies in long-range continuous-wave navigation systems. Close coordination should be established with the International Civil Aviation Organisation (I.C.A.O.) which has already set down the basic requirements from the navigational-aid standpoint.

The C.C.I.R. wishes to thank the I.F.R.B. for emphasising to administrations the need to undertake a clearance of the frequency bands exclusively allocated to the standard-frequency service. At present all administrations have agreed in principle to do everything possible to complete the clearance of the bands as requested in the I.F.R.B. Circular Letter No. 2003/56/R dated 14th May, 1956.

Radio propagation forecasts, which tell the present and expected condition of the ionosphere, for particular areas of the earth, were added to WWVH and continued on WWV and JJY. In addition to giving valuable information for radio communication and research, these forecasts may be used to advantage in high accuracy work in determining the reliability of the standard-frequency transmissions and time signals at a particular time.

The use of special broadcasts such as single-sideband or double-sideband modulation within the standard-frequency bands, as proposed by Study Group VI, for radio propagation research and services, was discussed jointly by representatives of Study Groups VI and VII. It is hoped that the work proposed in Study Programme No. 94 (VI) " Use of special modulation on the standard-frequency transmissions for assessing the reliability of propagation forecasts " can be accomplished at an early date.

The users of standard-frequency transmissions and time signals may obtain additional details pertaining to the work of Study Group VII by writing to the Chairman: M. B. Decaux, Laboratoire National de Radioélectricité, 196 rue de Paris, Bagneux (Seine), France.

ANNEX I

Main characteristics of standard-frequency and time-signal stations in use

	Station		Buenos Aires Argentine	Hawaiian Islands USA	Johannesburg South Africa	Lower Hutt N. Zealand	Moskva U.S.S.R.	Rugby England	Tokyo Japan	Torino Italy	Uccle Belgium	Washington U.S.A.
2	*Latitude and longitude*		34° 37′ S 58° 21′ W	20° 46′ N 156° 28′ W	26° 11′ S 28° 94′ E	41° 14′ S 174° 55′ E	— —	52° 22′ N 1° 11′ W	35° 42′ N 139° 31′ E	45° 03′ N 7° 40′ E	50° 48′ N 4° 21′ E	39° 00′ N 76° 51′ W
3	*Call sign*		LOL	WWVH	ZUO	ZLFS	—	MSF	JJY	IBF	—	WWV
4	*Carrier power to antenna* (kW)		2	2	0.1	0.03	20	0.5	1	0.3	0.02	0.1-10
5	*Type of antenna*		—	Vert. dip.	Hor. dip.(9)	—	Hor. dip.(9)	Vert. dip.	Vert. (24)	Hor. dip.(31)	Vert.	Vert. dip.
6	*Number of simult. transmis.*		6	3	1	1	1	3	2-3	1	1	6
7	*Number of carrier frequencies used*		6	3	1	1	2	3	4	1	1	6
8	*Trans-missions*	*Days per week*	6 (1)	7	7	1 (13)	6 (1)	7	7-1 (25)	6 (1)	7	7
9		*Hours per day*	5 (2)	23 (5)	24 (10)	3 (14)	1/2 (15)	24 (20)	24 (25)	1 (32)	22 (34)	24 (35)
10	*Standard frequencies used*	*Carriers* (Mc/s)	2.5; 5; 10; 15; 20; 25	5; 10; 15	5	2.5	10 (16) 15 (17)	2.5; 5; 10	2.5(26); 5(27) 10(28); 15(29)	5	2.5	2.5; 5; 10; 15; 20; 25
11		*Modulation* (c/s)	1 (3); 440; 1000	1 (6); 440; 600	1 (11)	None	1 (18)	1 (21); 1000	1 (30); 1000	1 (33); 440; 1000	None	1 (36); 440; 600
12	*Duration of audio modulation (minutes)*		4 in each 5 (4)	3 in each 5 (7)	Nil	Nil	Nil	5 in each 15	4 in each 5	5 in each 10 (4)	Nil	3 in each 5 (7)
13	*Frequency accuracy* ($\times 10^{-9}$)		± 20	± 10	± 20	± 100	± 20	± 5 (22)	± 20	± 20	± 10	± 10
14	*Max. val. of steps of freq. adjust. in parts in* 10^{-9}		—	5	10	—	20	10	20	20	—	1
15	*Duration of time signal transmissions (minutes)*		4 in each 60	continuous	continuous	Nil	5 in each 30 (19)	5 in each 15	continuous	5 in each 10	Nil	continuous
16	*Accuracy of time intervals*		$\pm 20 \times 10^{-9}$ $\pm 1\ \mu s$	$\pm 10 \times 10^{-9}$ $\pm 1\ \mu s$	$\pm 20 \times 10^{-9}$ $\pm 1\ \mu s$	None	—	$\pm 5 \times 10^{-9}$ $\pm 1\ \mu s$	$\pm 20 \times 10^{-9}$ $\pm 1\ \mu s$	$\pm 20 \times 10^{-9}$ $\pm 1\ \mu s$	None	$\pm 10 \times 10^{-9}$ $\pm 1\ \mu s$
17	*Method of time signal adjust.*		20 ms approx.	By steps of 20 ms (8)	By steps of 20 ms (12)	None	—	By steps of 50 ms (23)	By steps of 10 ms	By steps	None	By steps of 20 ms (8)

NOTES ON THE TABLE IN ANNEX I

(1) Weekdays.
(2) From 11.00 to 12.00, from 14.00 to 15.00, from 17.00 to 18.00, from 20.00 to 21.00, and from 23.00 to 24.00 U.T.
(3) Pulses of 5 cycles of 1000 c/s tone; no 59th pulse of each minute.
(4) Alternately 440 or 1000 c/s.
(5) Interruptions from minute 0 to minute 4, and from minute 30 to minute 34 of each hour, as well as from 19.00 to 19.34 U.T.
(6) Pulse of 6 cycles of 1200 c/s tone; no 59th pulse of each minute.
(7) Alternately 440 and 600 c/s.
(8) Adjustments are made on Wednesdays at 19.00 U.T. when necessary.
(9) Maximum radiation N-S.
(10) Interruption from 06.30 to 07.00 U.T.
(11) Pulses of 10 cycles of 1000 c/s tone; the first pulse of each minute is prolonged (500 ms).
(12) If required, the first Monday of each month.
(13) Tuesdays.
(14) From 01.00 to 04.00 U.T.
(15) From 07.15 to 07.45 U.T.
(16) Even days.
(17) Odd days.
(18) Signals Al keyed. Duration of each signal 100 ms; the first signal of each minute is prolonged.
(19) From 07.15 to 07.18, and from 07.43 to 07.45 U.T.
(20) Interruption from minute 15 to minute 20 of each hour.
(21) Pulses of 5 cycles of 1000 c/s tone; the first pulse of each minute is prolonged (100 ms).
(22) Relative to an atomic standard.
(23) Adjustments are made the first day of the month, when necessary.
(24) Two half-wave dipoles on 15 Mc/s; one half-wave dipole on 2.5 and 5 Mc/s.
(25) See (26) to (29).
(26) From 07.00 to 23.00 U.T.; interruption from minute 29 to minute 39 of each hour.
(27) Mondays. Interruption from minute 9 to minute 19, from minute 29 to minute 39, and from minute 49 to minute 59 of each hour.
(28) Wednesdays. Interruptions as for (27).
(29) From 21.00 to 11.00 U.T. Interruptions as for (26).
(30) Transmission suspended for 20 ms; the suppression before second 0 lasts 200 ms.
(31) Maximum radiation NW-SE.
(32) From 07.00 to 07.30 and from 11.00 to 11.30 U.T.
(33) Pulses of 5 cycles of 1000 c/s tone; the first pulse of each minute is repeated 7 times at intervals of 10 ms.
(34) Interruptions from 11.30 to 12.30, and from 20.30 to 21.30 U.T.
(35) Interruption from minute 45 to minute 49 of each hour.
(36) Pulses of 5 cycles of 1000 c/s tone; no 59th pulse of each minute. The first pulse of each minute is repeated 100 ms later.

NOTES ON THE TABLE IN ANNEX II

(1) Possibly 3.
(2) Possibly also 10 Mc/s.
(3) 5 carrier interruptions, each of 1 ms and spaced by 1 ms. The beginning of the first interruption indicates the exact second. The complete minute signal comprises 250 successive interruptions.
(4) Ultimately 2 kW.
(5) Ultimately 3.
(6) Ultimately 22.
(7) Ultimately 5, 10 and 15 Mc/s.
(8) Pulses of 5 cycles of 1000 c/s tone; the first pulse of each minute is repeated 5 times at intervals of 10 ms.
(9) Weekdays.
(10) From 08.00 to 16.25 U.T.; interruption from minute 25 to minute 30 of each hour.
(11) From 07.30 to 08.00 and from 16.30 to 17.00 U.T.; odd days.
(12) From 07.30 to 08.00 and from 16.30 to 17.00 U.T.; even days.
(13) Pulses of 5 cycles of 1000 c/s tone; the first pulse of each minute is prolonged to 100 ms, and followed by 440 c/s tone during 100 ms.
(14) 440 c/s during 1 minute, and 1000 c/s during 9 minutes.
(15) If required, the first Monday of each month.
(16) Interruption from minute 40 to minute 45 of each hour.
(17) Pulses of 5 cycles of 1000 c/s tone; the first pulse of each minute is prolonged to 500 ms.

ANNEX II

Main characteristics of projected standard-frequency and time-signal stations

	STATION		NEUCHATEL Switzerland	NEW DELHI India	PARIS France	PRAHA Czechoslovakia
2	*Latitude and longitude*		46° 58′ N 6° 57′ E	30° 03′ N 78° 00′ E	48° 46′ N 2° 20′ E	— —
3	*Call sign*		H B N	A T A	F F H	—
4	*Carrier power to antenna* (kW)		0.5	0.3 (4)	0.3	2
5	*Type of antenna*		Horizont. dipole	Vertical dipole	Inverted L	Directed to E
6	*Number of simult. transm.*		1	1 (5)	1	1
7	*Number of carrier frequencies used*		2 (1)	1 (5)	3	1
8	*Trans-missions*	*Days per week*	7	7	6 (9)	7
9		*Hours per day*	24	2 (6)	9	24 (16)
10	*Standard frequencies used*	*Carrier* (Mc/s)	2.5; 5 (2)	10 (7)	2.5 (10); 5 (11); 10 (12)	2.5
11		*Modulation* (c/s)	1 (3)	1 (8); 1000	1 (13); 440; 1000	1 (17); 1000
12	*Duration of audio modulation (minutes)*		Nil	5 in each 15	10 in each 20 (14)	14 in each 30
13	*Frequency accuracy (parts in 10^9)*		± 10	—	± 20	± 20
14	*Maximum value of steps of frequency adjustment in parts in 10^9*		—	—	20	—
15	*Duration of time-signal transmissions (minutes)*		5 in each 10	continuous	10 in each 20	14 in each 30
16	*Accuracy of time intervals*		—	—	$\pm 20 \times 10^{-9}$ ± 1 µs	—
17	*Method of time-signal adjust.*		Steering	—	B steps of 50 ms (15)	By steps of 100 ms
18	*Probable date for commencement of service*		Spring 1957	—	End of 1956	End of 1956

ANNEX III

Main characteristics of standard-frequency and time-signal stations operating outside the exclusive bands

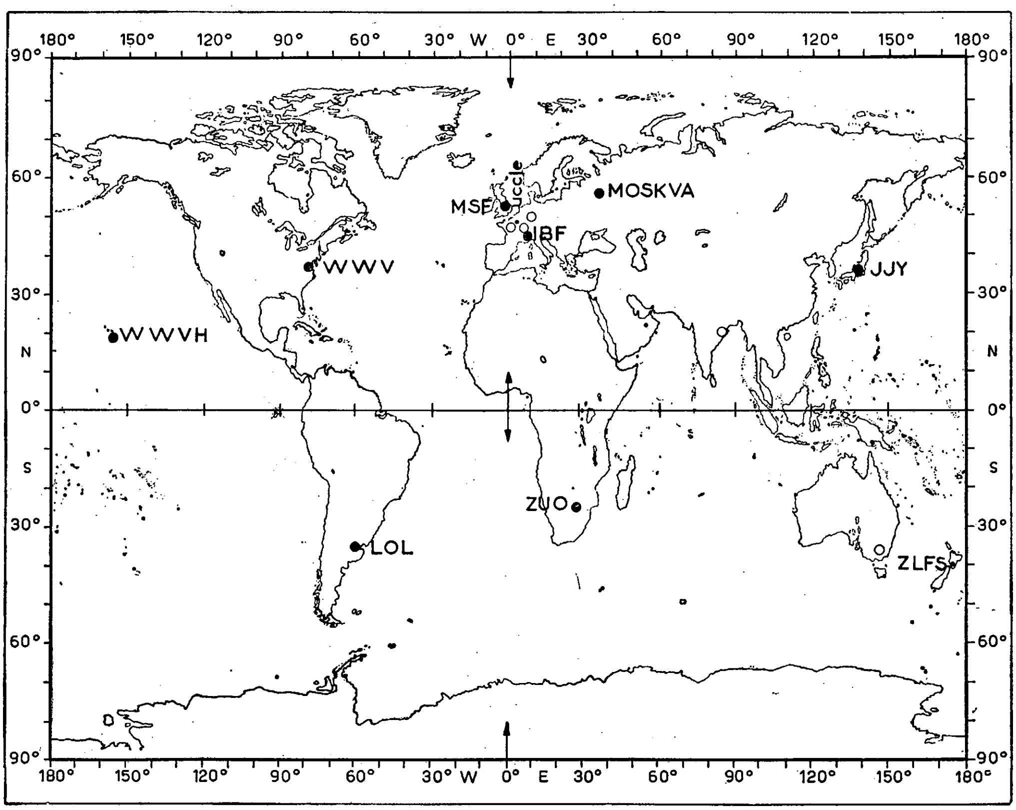
1	STATION	BOULDER U.S.A.	RUGBY United Kingdom		TOKIO Japan	MAINFLINGEN Fed. Germ. Rep.
2	*Latitude and longitude*	40°00′ N 105°15′ W	52° 22′ N 1° 11′ W		45° 03′ N 139° 31′ E	50° 01′ N 09° 00′ E
3	*Call sign*	KK 2 XEY	GBR	MSF	JJY	DCF 77
4	*Carrier power to antenna* (kW)	2	300	10	1	—
5	*Type of antenna*	—	—	—	Vertical	—
6	*Number of simult. transmis.*	1	1	1	1-2	1
7	*Number of carrier freq. used*	1	1	1	2	1
8	*Trans-missions* — *Days per week*	6 (6)	7	7	7	7
9	*Trans-missions* — *Hours per day*	1 (2)	22 (3)	1 (4)	24 (10)	20 (14)
10	*Standard frequencies used* — *Carrier* (kc/s)	60	16	60	4000 (11); 8000 (12)	77.5
11	*Standard frequencies used* — *Modulation* (c/s)	Nil	Nil (5)	1 (6); 1000	1 (13); 1000	1 (15); 200 (16) 440
12	*Duration of audio modulation (minutes)*	Nil	Nil	5 in each 15	4 in each 5	(17)
13	*Frequency accuracy (parts in 10^9)*	±10	±5 (7)		±20	±10
14	*Maximum value of steps of frequency adjustment in parts in 10^9*	1	10		20	—
15	*Duration of time-signal transmission (minutes)*	Nil	(8)	5 in each 15	Continuous	(15)
16	*Accuracy of time intervals*	Nil	—	$\pm 5 \times 10^{-9}$ ± 1 µs	$\pm 20 \times 10^{-9}$ ± 1 µs	—
17	*Method of time-signal adjust.*	Nil	—	By steps of 50 ms (9)	By steps of 10 ms	—

NOTES ON THE TABLE IN ANNEX III

(1) Weekdays.
(2) From 1530 to 1630 UT. Possibly from 2030 to 2130 UT.
(3) Depending on telegraphic traffic.
(4) From 1430 to 1530 UT. (2000-2100 UT until about the end of 1958).
(5) Al telegraphy.
(6) Pulses of 5 cycles of 1000 c/s tone; the first pulse of each minute is prolonged (100 ms).
(7) Referred to an atomic caesium resonance standard.
(8) Telegraphic international time signals from 0955 to 1006 and from 1755 to 1806 UT.
(9) If required, the first day of each month.
(10) See 11) and 12).
(11) No interruption.
(12) From 2100 to 1100 UT.
(13) Transmission suspended for 20 ms; the suppression before second 0 lasts 200 ms.
(14) From 0700 to 0310 UT.
(15) Al telegraphic time signals from the Physikalisch-Technische Bundesanstalt from 0728 to 0735 and from 1028 to 1035 UT. Al telegraphic international time signals from Osterloog DHI from 0800 to 0810, from 1100 to 1110, from minute 0 to minute 10 and from minute 30 to minute 40 of each hour from 1730 to 2000, from minute 0 to minute 10 of each hour, from 2000 to 0310 UT.
(16) A2, keyed by traffic.
(17) Depending on traffic.

ANNEX IV

World-wide distribution of standard-frequency and time-signal stations



● Station in service.

• Low-power station operating on 2.5 Mc/s.

○ Projected station.

REPORT No. 67 *

FREQUENCY MEASUREMENTS ABOVE 50 Mc/s AT MONITORING STATIONS

(Question No. 89)
(Study Group No. VIII)

(Warsaw, 1956)

Question No. 89 asked in general terms in sub-paragraphs 2 and 3 for the preferred equipment and methods for frequency measurements above 50 Mc/s.

Information on the equipment and methods is contained in Docs. Nos. 35, 37, 41, 117 and 427 of Warsaw.

The frequency-measuring equipments of the individual countries differ so much that it is only possible to comment generally upon them. Administrations all prefer to make measurements with nearly the same equipment which they use for frequency measurements below 50 Mc/s. The extension to a higher frequency range is effected by the use of harmonics of either a secondary standard or a stable transfer oscillator or a frequency synthesis method providing a single tunable frequency. All equipments use direct reading dials in conjunction either with electronic counters or with visual indicators such as pointer instruments or oscilloscopes.

The mobile frequency-measuring equipments do not differ very much from those used at fixed monitoring stations. The main differences are that the mobile equipment is made lighter and is suitably designed to avoid physical damage or reduced electrical performance due to vibration or shock. The accuracy of the secondary standards of mobile frequency-measuring equipment is, however, generally somewhat lower than at fixed monitoring stations.

The methods of measurement used differ with the various equipments.

The necessary accuracy of frequency measurements both at fixed and at mobile monitoring stations for frequencies above 50 Mc/s has been added to the table of Recommendation No. 20.** Further studies, however, are needed to enable a recommendation to be made regarding the accuracy of frequency measurements of frequency-modulated emissions and to improve the accuracy of frequency measurements of amplitude-modulated emissions. A new question has therefore been prepared. (Question No. 145 (VIII) " Frequency measurements at monitoring stations ").

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* This Report was adopted unanimously.

** This Recommendation has been replaced by Recommendation No. 180.

REPORT No. 68 *

SPECTRUM MEASUREMENT AT MONITORING STATIONS

(Study Programme No. 70) **

(Study Group No. VIII)

(Warsaw, 1956)

Study Programme No. 70, " Spectrum measurement at monitoring stations ", was assigned to Study Group No. VIII at the VIIth Plenary Assembly, London, 1953. While it is not yet possible to prepare a Recommendation on the subject under study, it is desirable to make this Report on the progress that has been made to date.

The subject has been given consideration in several countries (Docs. Nos. 34, 38, 42, 572) and ft is possible to present some provisional ideas on the type and characteristics of equipment suitable ior spectrum measurement at monitoring stations, at least for emissions using radio frequencies below 30 Mc/s. Some countries have had experience of spectrum measurement at monitoring stations at these frequencies using equipment of the type detailed in Annex II of Recommendation No. 88. These equipments, generally known as radio-frequency spectrum analysers, may have inadequate sensitivity and selectivity for operation at low signal levels and in the presence of interference, but when preceded by a communications receiver of good performance in respect of these characteristics they operate satisfactorily from the intermediate-frequency output signal of such a receiver.

The results that have been obtained show that very satisfactory measurement of the spectra and bandwidths of emissions on frequencies below 30 Mc/s can be obtained except under adverse conditions of fading, noise or interference. These measurements can be of considerable value in detecting emissions using excessive bandwidth and thus liable to increase the risk of interference.

While errors of measurement can occur under adverse fading conditions, these can be reduced, and perhaps largely removed, either by making measurements when fading is absent or by averaging the results of a number of successive measurements. Similarly, a number of measurements are required to determine the variation of the spectrum and bandwidth with the variation of the modulation of the emission under normal traffic conditions.

It is considered that in general a spectrum analyser of the type described in paragraph 1.1 of Recommendation No. 88 is the most suitable for use at monitoring stations. With this equipment the emission spectrum is analysed by passing each component successively through a narrow-band filter of fixed frequency by heterodyning the signal with an external frequency varied either automatically or manually. It is considered that the spectrum analyser should be capable of simple and rapid operation and that for monitoring work this feature is more desirable than high accuracy. For use in the frequency range below about 30 Mc/s the swept frequency range should be variable from about 1 kc/s to about 100 kc/s but it is recognised that for use above 30 Mc/s this range may need to be extended to the order of 10 Mc/s. The duration of the sweep may be required to be adjustable over a range of about 1/10 sec. to 60 sec. The amplitude range should be at least 40 db and preferably 60 db or more and a logarithmic scale is desirable. A resolution of about 50 c/s

* This Report was adopted unanimously.

** This Study Programme has been replaced by Study Programme No. 103 (VIII).

at 60db is considered desirable for analysers operating at frequencies below 30 Mc/s. The resolution should be adjustable to permit optimum selection of sweep speeds to meet amplitude accuracy requirements.

The characteristics referred to above are of course put forward only tentatively and are largely based on experience with equipments of the type referred to in Recommendation No. 88. Much more experience in the operation and use of spectrum analysers at monitoring stations is needed before any recommendations can be made on this aspect of the subject.

In the light of the consideration given to the Study Programme and the experience so far gained in spectrum measurements at monitoring stations, it has been decided to amend and enlarge the scope of Study Programme No. 70 as agreed at London and a revised Study Programme has been prepared, (Study Programme No. 103 (VIII) " Spectrum measurement at monitoring stations ").

REPORT No. 69 *

INTERNATIONAL WIDE-BAND RADIO RELAY SYSTEMS OPERATING ON FREQUENCIES ABOVE ABOUT 30 Mc/s

Transmission of telephony and television on the same system

(Question No. 91) **
(Study Group No. IX)

(Warsaw, 1956)

1. *Introduction.*

In Question No. 91 ** bearing the same title as this Report, the following phrase appears: " . . . the transmission of telephony and television simultaneously or alternatively on the same system; . . . ". It is the view of the C.C.I.R. that this phrase is intended to refer to " transmission simultaneously or alternatively *on the same radio-frequency carrier* ", and the question is so regarded in this Report.

2. *Alternative transmission of telephony and television.*

It is considered that substantial economic and operational advantages may be realised in certain cases by using the same radio relay system for the *alternative* transmission of multichannel telephony and television on the same radio-frequency carrier. These advantages are likely to accrue under the following conditions:

— where the " busy-hours " for telephony and the need for television transmission occur at different times of the day;

— where several radio-frequency channels are provided on a route and it is desired to provide a spare channel which can be used for either telephony or television as required; the spare channel may also be used for " special event " television broadcasts not justifying the provision of a regular channel;

— where it is desired to provide a flexible network offering the possibility of alternative routes in the event of a major breakdown.

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* This Report was adopted unanimously.

** This Question has been replaced by Question No. 146 (IX).

It is considered practicable at the present time to visualise the use of frequency-modulation radio relay systems for the alternative transmission of television signals or frequency-division multiplex telephony with some 240 or 600 telephone channels, since the transmission requirements are similar in many respects. However, it should be noted that:

— the transmission characteristics of the common equipment (aerials, feeders, radio-frequency and intermediate-frequency filters and amplifiers) must meet the more stringent of the requirements for television on the one hand, or for telephony on the other hand;

— provision may need to be made for stabilising the mean frequency of the carrier in the case of multi-channel telephony whereas for television it may be necessary to stabilise the carrier frequency corresponding to a certain part of the television waveform, e.g. the tips of the synchronising pulses;

— in any case, the essential technical characteristics for the relaying of multi-channel telephony and television signals should, wherever practicable, be chosen in such a manner that the use of the greatest number of similar or common units is made possible, the costs being thereby reduced.

3. *Simultaneous transmission of telephony and television.*

It is considered that it may be possible to realise advantages as compared with two separate radio-frequency channels transmitting television and multi-channel telephony separately, by using the same radio-frequency channels for the *simultaneous* transmission of multi-channel telephony and television on the same radio-frequency carrier. However, no such system of simultaneous transmission is as yet in commercial service, although development work is in hand and the characteristics of such systems will require study when further experience has been gained. It is pointed out that the advantages of such a system depend in any case on the type of television signal to be transmitted, since, if the bandwidth of the latter is wide, it may be practicable to transmit simultaneously only a small number of telephone channels.

REPORT No. 70 *

PREFERRED CHARACTERISTICS OF MULTI-CHANNEL RADIOTELEPHONE SYSTEMS USING TIME-DIVISION MULTIPLEX AND OPERATING ON FREQUENCIES ABOVE ABOUT 30 Mc/s

Technical characteristics which should be specified in order to be able to interconnect any two time-division multiplex (TDM) systems

(Question No. 92 (IX))
(Study Group No. IX)

(Warsaw, 1956)

1. *General.*

There are a number of different forms of TDM system in use or under consideration. Of those in service the majority use pulse position modulation, combined with amplitude modulation of the radio carrier (PPM-AM). However PPM systems with frequency modulation of

* This Report was adopted unanimously.

the radio carrier (PPM-FM) are also used, as are systems with pulse amplitude modulation combined with frequency modulation of the radio carrier (PAM-FM).

Different numbers of speech channels are provided by various systems; other systems again provide for telegraph channels, high quality music channels or other forms of traffic, either specifically or as alternatives to speech channels. Still further systems transmit by time division groups of speech channels which are themselves assembled by frequency-division multiplex.

Systems using pulse code modulation are not covered by this report.

From the point of view of international interconnection, TDM systems can, in this report, be divided conveniently into those using pulse position modulation and those using pulse amplitude modulation. Systems of one type can be interconnected with the other, or with FDM radio relay links or landlines, at audio frequency, and recommendations regarding this are given in Recommendations Nos. 40 and 186.

Interconnection at baseband (by which is meant here the sequence of modulated pulses before application to the radio carrier), at intermediate frequency or at radio frequency requires the two systems concerned to be of the same type (both PPM or both PAM) and that the specifications of certain parameters should be coordinated.

Part 2 of this report lists those parameters requiring specification for baseband interconnection, while Part 3 gives the *additional* parameters for intermediate-frequency interconnection. Intermediate-frequency interconnection is not normally used for PPM-AM systems, but could be appropriate for systems using frequency modulation of the radio carrier.

Where international interconnection at radio frequency is more appropriate, it is considered that at present the coordination of the necessary technical parameters should be the subject of direct agreement between the administrations concerned.

To render unnecessary any specific agreement regarding the characteristics of the supervisory system, it is suggested that in an international connection between a TDM radio relay system and a second telecommunication system (either similar or different), both supervisory systems should terminate at or near the international boundary, or that the method of interconnection should be the subject of agreement between the administrations concerned.

A service channel is considered necessary as part of a TDM radio relay system and this service channel should be accessible at all repeater stations.

2. *Technical characteristics to be specified for baseband interconnection of any two TDM systems using pulse position modulation or of any two TDM systems using pulse amplitude modulation.*

A. *Characteristics applicable to both PPM and PAM systems*

2.1 Audio channel characteristics.

2.2 *(a)* Maximum number of telephone traffic channels;

(b) Maximum number and type of traffic channels for other types of service, e.g., music, telegraphy, facsimile, groups of telephone channels assembled in FDM.

2.3 Number of equal time intervals in a sequence.

2.4 Channel sampling rate:

(a) for telephone traffic;

(b) for other types of service.

2.5 Pulse polarity at the point of interconnection.

2.6 Impedance characteristics and resulting reflection effects at the point of interconnection.

2.7 Characteristics of synchronising signal at the point of interconnection.

2.8 Characteristics and position of service channel, if included in the baseband.

2.9 Characteristics of any special signals sent over the system.

2.10 Type and characteristics of compander, if used.

2.11 Special requirements, if any, for the insertion and dropping of channels and blocks of channels.

B. *Characteristics applicable to PPM systems only.*

2.12 Width and shape of channel pulses at point of interconnection.

2.13 Significant characteristics of pulse.

2.14 Peak to peak excursion of the channel pulse, without companders, for standard modulation.*

2.15 Input and output pulse amplitudes at the point of interconnection.

C. *Characteristics applicable to PAM systems only.*

2.16 Width and shape of channel pulses at point of interconnection:

(a) with zero modulation;

(b) with standard modulation.*

2.17 Input and output amplitudes of the channel pulse at the point of interconnection, with zero modulation.

2.18 Maximum and minimum amplitude of the channel pulse (without companders) at the point of interconnection, for standard modulation.*

Coordination of all the above parameters is necessary at stations where channels are demodulated. At those repeater stations where channels are not demodulated it is only necessary for the following characteristics to be coordinated:

for PPM, the characteristics given in 2.5, 2.6, 2.12, and 2.15;

for PAM, the characteristics given in 2.5, 2.6, 2.16, 2.17, and 2.18.

3. *Technical characteristics, additional to those listed in Section 2 above, to be specified for interconnection at intermediate frequency of any two TDM systems using pulse position modulation or of any two TDM systems using pulse amplitude modulation.*

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* Note: By " standard modulation " is meant modulation by an 800 c/s signal of 1 mW at a point of zero relative level, or the equivalent signal for music or for other types of service.

3.1 Centre value of the intermediate frequency.

3.2 The frequency deviation of the carrier and, if necessary, the sense of deviation (if frequency modulation is used), for standard modulation as defined in Section 2 of this report.

3.3 Input and output levels of the intermediate-frequency signal at the point of interconnection.

3.4 Impedance characteristics and resulting reflection effects at the point of interconnection.

4. *Present position regarding the recommendation of specific values for the parameters listed in Section 2.*

At present it has not been found possible to reach such agreement on these parameters as to make interconnection possible between any two different PPM or any two different PAM systems other than at audio frequency, and where such cases arise they should be dealt with in the manner indicated in Recommendation No. 204.

There has however been a general agreement on certain points particularly concerning PPM systems. These agreed points may form a suitable basis for the future study of Part 2 of Question No. 92 (IX) and are therefore listed below under the paragraph numbers used in Section 2.

2.1 *Audio channel characteristics*

For telephone circuits reference is made to Recommendation No. 186.

2.2 *(a) Maximum number of telephone traffic channels*

To achieve maximum economy in interconnection with other systems, particularly FDM radio relay systems and line systems, it is very desirable to provide telephone traffic channels in groups of 12.

2.4 *(a) Channel sampling rate for telephone traffic*

The preferred value of channel sampling rate is 8 kc/s with a tolerance of ± 8 c/s or better.

Unless otherwise agreed between the administrations concerned, the pulse trains may be separately generated for the two directions of transmission.

2.5 *Pulse polarity at point of interconnection*

For PPM systems positive polarity is preferred.

2.6 *Impedance characteristics and resulting reflection effects at the point of interconnection*

The preferred nominal value of the impedance at the point of interconnection is 75 ohms.

2.12 }
2.16 } *Width and shape of channel pulses at point of interconnection*

Attention is drawn to the need to use pulse shapes requiring the minimum bandwidth consistent with the facilities given by the system.

2.15 *Input and output pulse amplitudes at the point of interconnection in PPM systems*

The preferred value of the pulse amplitude at a point of international interconnection is 1.4 V at the output from the receiving equipment and 0.7 V at the input to the transmitting equipment. The difference in level allows for loss in the interconnecting means.

REPORT No. 71 *

PREFERRED CHARACTERISTICS FOR MULTI-CHANNEL RADIO RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

Characteristics to be specified

(Question No. 93 (IX))

(Warsaw, 1956)

1. *Introduction.*

This Report is concerned with Part I of Question No. 93, that is, the preferred characteristics of radio relay systems using frequency-division multiplex (FDM) which it is proposed to specify and the reasons why such specification is considered necessary.

The systems under consideration are those in which the input and output signals, i.e., the " baseband " signals, consist of an assembly of suppressed-carrier single-sideband telephone signals in channels spaced 4 kc/s apart, using arrangements of channels recommended by the C.C.I.F.

It is assumed that the FDM signals themselves modulate the frequency or the phase of a radio-frequency carrier; other possible methods exist, e.g., the modulation of a sub-carrier by the FDM signal which in turn modulates the radio-frequency carrier, but such methods will not be considered further in this Report.

The specification of certain preferred characteristics of FDM radio relay systems forming part of an international circuit is necessary in order to permit the ready interconnection of different radio relay systems; the specification of some of these characteristics is also necessary to permit the ready interconnection of FDM radio relay systems with FDM line systems.

2. *Stages at which the interconnection of radio relay systems among themselves or with line systems may be required.*

The interconnection of different radio relay systems at national boundaries may be required at:

(a) baseband frequencies,

(b) intermediate frequencies,

(c) radio frequencies.

The interconnection of radio relay systems at baseband frequencies may be essential in some cases in order to permit the extraction or insertion of individual channels, groups or super-groups of channels, and it may also be necessary for level regulating, monitoring, supervisory or control purposes. The interconnection of radio relay and line systems will normally be carried out at baseband frequencies, since the possibility of interconnection at the intermediate or radio frequencies does not exist in such cases.

The interconnection of radio relay systems at intermediate frequency enables the additional noise and distortion due to demodulation and remodulation to be avoided; it also reduces

* This Report was adopted unanimously.

the amount of equipment required as compared with interconnection at baseband frequencies. It should be noted that interconnection at the intermediate frequency requires the specification of the baseband signal, as well as the modulation characteristics, i.e., the deviation of the intermediate-frequency carrier. Interconnection of two radio relay systems at intermediate frequency is, of course, more readily carried out if the two intermediate frequencies are the same; nevertheless, the possibility exists of translating from one intermediate frequency to another if need be, but it should be borne in mind that difficulties may arise if the two intermediate-frequency bands overlap.

However, the need for a preferred spacing between the radio-frequency channels (discussed below) makes it necessary to adopt a value for the intermediate frequency, such that interference in the working channels from the frequency-change oscillators of receivers and repeaters is avoided. This requirement, together with the need to facilitate interconnection at intermediate frequency, makes it desirable to adopt a preferred value for the intermediate frequency.

The interconnection of two radio-relay systems at radio-frequencies may be needed when crossing a boundary between two countries where the topography is such that a common frontier station is impracticable or undesirable, as for example, when the boundary is located in a wide river estuary or a sea channel between the two countries. In such cases there must be agreement on the radio frequencies themselves, as well as on the modulation characteristics of the radio-frequency carriers and on the baseband signal. This in turn necessitates agreement on the spacings between, and the arrangement of, the radio-frequency channels. The adoption of preferred values for the spacing and arrangement of the radio-frequency channels has the advantages of economising in the use of the frequency spectrum and of minimising interference between radio relay systems whose routes intersect or are in close proximity.

3. *Characteristics to be specified for international connections.*

It is assumed that overall performance of the telephone channels should, as far as possible, be in accordance with the relevant C.C.I.F. recommendations for modern types of telephone circuit (C.C.I.F. Recommendations Nos. 40 and 188).

Where international connections are involved, agreement on the characteristics listed below and marked by the sign †, is considered essential; the agreement on the remaining characteristics, although not essential, is considered highly desirable in order to make interconnection possible in the most economical and effective manner.

As standardisation is not yet possible, it is suggested that preferred values should be indicated for the guidance of those concerned with the specification and design of radio relay systems.

The characteristics for which preferred values should be given are listed below according to whether they relate to interconnection at the baseband, intermediate or radio frequencies.

(a) For interconnection at baseband frequencies :

i) maximum number of telephone traffic channels †;

ii) highest and lowest frequencies of telephone traffic channels, i.e., the frequency limits of the baseband †; it is assumed that the arrangement of the telephone channels is in accordance with C.C.I.F. recommendations;

iii) nominal impedance of baseband circuits at the point of interconnection;

iv) relative input and output power levels at the point of interconnection *.

In addition to the above, consideration will need to be given to the monitoring, control or supervisory signals transmitted with the traffic channels.

* The choice and precise definition of a point of international interconnection is a subject for agreement between the administrations concerned.

(b) For interconnection at intermediate frequencies :

For interconnection at intermediate frequencies it will be necessary to give preferred values for the baseband characteristics *(a)* (i) and *(a)* (ii), in addition to the following characteristics:

i) centre value of the intermediate frequency † * ; because of the wide range of radio frequencies and numbers of channels that may be employed, it may be necessary to give more than one preferred value for the intermediate frequency; the number of intermediate frequencies should, however, be no more than is essential to meet the various requirements;

ii) the frequency deviation of the carrier due to a tone of 1 mW applied to a channel at a point of zero relative level in the system †; in systems with large number of telephone channels, e.g., 600, it may be found desirable to use pre-emphasis producing a larger deviation for the higher frequency channels in order to improve the signal-to-noise ratio; if this is the case it will be necessary to specify the amount of pre-emphasis to be employed at the various channel frequencies;

iii) input and output levels of the intermediate-frequency signal at the point of interconnection;

iv) impedance of the intermediate-frequency circuit at the point of interconnection.

(c) For interconnection at radio frequencies :

For interconnection at radio frequencies it will be necessary to give preferred values for the baseband characteristics *(a)* (i) and *(a)* (ii), and the frequency deviation *(b)* (ii), in addition to the following characteristics:

i) number and arrangement of the radio-frequency channels †;

ii) wave polarisation.

Interconnection at radio-frequencies also requires that the frequency stability of the transmissions employed shall be within certain tolerances. Since the International Radio Regulations, Atlantic City, 1947, Appendix 3, p. 227, give insufficient guidance on this point, reference is made to Recommendation No. 148.

REPORT No. 72 **

MAINTENANCE PROCEDURE FOR WIDE-BAND RADIO RELAY SYSTEMS

Service Channels

(Question No. 96 (IX))

(Warsaw, 1956)

The C.C.I.R. considers that the question of service channels is a particularly important point which should be examined together with the problems of maintenance of wide-band radio relay systems, since the service channels are necessary for the exchange of the information required for maintenance. The name " wide-band radio relay systems " is essentially applicable to radio links for the transmission of at least 60 telephone channels or of television signals.

* In the case of multi-channel telephony systems, the centre value of the intermediate frequency corresponds to the unmodulated carrier frequency.

** This Report was adopted unanimously.

This question is also of interest to the C.C.I.F. which has already put it on its study programme. However, the C.C.I.R. feels it desirable to express its views on this matter.

The stations of a wide-band radio relay system are usually of two types:

— Attended stations;

— Remotely controlled stations, unattended, except when maintenance operations require the presence of staff.

Like the C.C.I.F.*, the C.C.I.R. considers that the attended stations of a wide-band radio relay system should be linked to the general telephone network. The C.C.I.R. realises also that provision must be made for other service channel possibilities. In particular, it considers that a service channel interconnecting attended and unattended stations is necessary, but that, for the present, it is for the administrations concerned to decide whether this service channel should be prolonged and interconnected on both sides of the frontier.

If the service channel interconnecting all the stations cannot, for some reason or another, cross the frontier, the C.C.I.R. then considers it necessary for a service channel to provide a direct connection between the two attended stations on either side of the frontier from which the maintenance operations will be controlled.

If the service channel linking all the stations can actually be interconnected at the frontier, a direct service channel between two attended stations on either side of the frontier is not absolutely indispensable, but it would be highly desirable, since it facilitates maintenance operations.

Service channels can be obtained in different ways:

(a) by metallic lines;

(b) by a separate radio link over the same path as the main link;

(c) by the main radio link itself.

The C.C.I.R. does not consider it possible at the present time to achieve standardisation of the characteristics of service channels over a radio link and advises administrations, for the moment, to make their own mutual arrangements. However, the C.C.I.R. proposes that the study of service channels and their interconnection should be continued and has posed a new question on this subject. (Question No. 147 (IX)).

REPORT No. 73 **

TRANSMISSION OF PILOT FREQUENCIES OVER CIRCUITS CONSISTING OF CABLE PATHS AND RADIO RELAY SYSTEMS

(Question No. 96 (IX))
(Study Group No. IX)

(Warsaw, 1956)

The C.C.I.F. has recommended the use of group and super group pilot frequencies for carrier transmissions on metallic lines. These pilot frequencies should be regarded as intimately bound up with the channel groups and should be transmitted over radio relay links in the same way as the channel signals proper ***.

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* See in particular: Reply of the 5th Study Group of the C.C.I.F. to C.C.I.F. Question No. 9 (Doc. No. 10 of the C.C.I.F 5th Study Group, Geneva, March 1956).

** This Report was adopted unanimously.

*** See Doc. 339/C.C.I.F. (Geneva, March 1956) pp. 41-52.

The C.C.I.F. has also defined other types of pilot frequencies and, in particular, line regulating pilot frequencies *. The C.C.I.R. after examining the question of transmission of such pilot frequencies over radio relay links issued a Recommendation in 1953 (Recommendation No. 128).

The C.C.I.R. considers that the question cannot be divorced from the problem of the maintenance of wide-band radio circuits (Question No. 96 (IX)) and that it should be re-examined as a whole. It might, in certain cases, be useful to transmit over a radio relay link the line-regulating pilot frequencies of the coaxial cables with which it is interconnected, particularly when the cable sections are relatively short.

Consequently, the C.C.I.R. considers that the Question should be retained for study and that Recommendation No. 128 might, if necessary, be reconsidered when sufficient experience in this sphere has been obtained. For the present, should cases of such interconnection arise, it is recommended that the administrations concerned decide directly among themselves whether or not it would be advisable to transmit the line-regulating pilot frequencies envisaged by the C.C.I.F. over the overall circuit consisting of a radio relay link and its connecting cables.

In addition, the C.C.I.R. would like to draw the attention of the C.C.I.F. to the useful purpose which would be served by defining the line-regulating pilot frequencies to be used for circuits with 240 channels and 600 channels respectively, the C.C.I.R. being at present unable to take into consideration radio relay links with more than 600 telephone channels. The C.C.I.R. would wish to see the upper line regulating pilot placed as near as possible to the upper limit of the frequency band occupied by the telephone channels: e.g. pilot frequencies of 1116 kc/s for circuits with 240 channels and 2604 kc/s for circuits with 600 channels could be transmitted without difficulty over radio relay links whenever required.

REPORT No. 74 **

METHODS FOR THE COMPUTATION OF INTERMODULATION NOISE DUE TO NON-LINEARITY IN RADIO RELAY SYSTEMS

(Question No. 115 (IX))

(Warsaw, 1956)

The subject of intermodulation distortion in frequency-modulated radio relay systems carrying multi-channel telephone signals has been studied and attention is called to the following documents which contain valuable reference material:

1. Geneva, 1954, Doc. No. 29 (U.S.S.R.). The calculation of non-linear distortion in FDM radio relay systems with frequency modulation.

2. Warsaw, 1956, Doc. No. 193 (France). Methods for the computation of intermodulation noise due to non-linearity in radio relay systems.

3. Warsaw, 1956, Doc. No. 268 (Netherlands). Methods for the computation of intermodulation noise due to non-linearity in radio relay systems.

4. Warsaw, 1956, Doc. No. 388 (Federal German Republic). Methods for the calculation of distortion noise due to non-linearity in radio relay systems.

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* C.C.I.F. XVIIth Plenary Assembly (Geneva 1954) Volume III (Transmission by line), page 87.

** This Report was adopted unanimously.

5. Warsaw, 1956, Doc. No. 407 (U.S.S.R.). Non-linear distortion due to multi-path propagation and mismatching of antenna wave-guides in FM multi-channel systems.

6. Warsaw, 1956, Doc. No. 444 (Federal German Republic). Demands on the linearity of multichannel radio link systems with frequency modulation.

7. Warsaw, 1956, Doc. No. 464 (U.S.A.). Methods for the computation of intermodulation noise due to non-linearity in radio relay systems.

8. Warsaw, 1956, Doc. No. 743 (U.S.S.R.). Intermodulation noise in radio relay links.

These documents indicate a very large measure of agreement in the final results, whether the computation is made directly from analysis of the spectrum or indirectly from the correlation function, since the latter is Fourier transformed from the former.

The methods given for computing the intermodulation noise due to the circuit elements at each station are approximations. Nevertheless, the results of experiments are in good agreement with these calculations and the latter may be useful.

With regard to paragraph (1) of Question No. 115 (IX), it does not appear feasible at this time to formulate precise methods for computing the intermodulation noise due to the circuit elements at each station. Reliance is placed instead on experience with particular types of radio relay systems and their circuit elements to estimate performance from the intermodulation noise standpoint. Apart from such estimates, intermodulation noise on complete systems and certain portions of systems can be determined by measurement techniques.

Concerning paragraph (2) of Question No. 115 (IX), random noise adds on a " power " basis. Intermodulation noise in practice usually adds in a manner somewhat between " power " and " voltage " addition, as may be seen from the documents listed above.

It is considered that the study of this Question is terminated.

REPORT No. 75 *

HIGH-FREQUENCY BROADCASTING

Directional antennae with reduced subsidiary lobes

(Question No. 23 (X))

(Warsaw, 1956)

This report summarises the information received by the C.C.I.R. in answer to Question No. 23 (X).

1. *General remarks.*

The reduction of subsidiary lobes in the radiation patterns of directional antennae made up of radiating dipoles has been theoretically solved by the distribution of currents in the radiating elements using Tchebycheff polynomials. However, this method has serious practical drawbacks (great difficulty in adjusting the antenna, decrease in the radiation resistance of the antenna with a consequent decrease in efficiency). That is why attempts have been made in certain countries to find other more practical solutions without such drawbacks.

As an example, the characteristics of an antenna used in Poland are given below.**

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* This Report was adopted unanimously.

** *Reference :* Warsaw Doc. No. 208.

2. *Polish antenna with longitudinal (end fire) radiation and reduced subsidiary lobes.*

A block schematic of this antenna is given in Figs. 1 and 2. The current distribution is quite simple: the current has the same value in each of the half-wave elements and the phase difference between two neighbouring elements one quarter-wave apart is 90°.

Fig. 1 shows the connection with the feeder which supplies the two parts of the antenna symmetrically.

Fig. 2 is a diagram of the current distribution equivalent to that in Fig. 1.

This antenna requires no adjustment of current (in amplitude or in phase) for its normal frequency. The input resistance at this frequency is almost entirely ohmic. It is about 600 ohms when the half-wave dipoles are made up of two parallel wires some 25 cm apart.

The radiation diagrams show that the reduction of the subsidiary lobes is quite satisfactory. Fig. 2 is the horizontal radiation diagram.

Figs. 3 and 4 are the vertical radiation diagrams for an antenna height of about one half-wave. The horizontal and vertical directivity formulae are given in Figs. 2, 3 and 4.

In this new antenna, the absorption resistor has been eliminated and the efficiency is thus very near unity.

This antenna also has the great practical advantage of having a radiation diagram that can be slewed by 180°.

This type of antenna has been used in Poland since 1950 for broadcasting the European programme on high frequencies.

Figs. 1, 2, 3 and 4 should be published in the C.C.I.R. collection of antenna diagrams.

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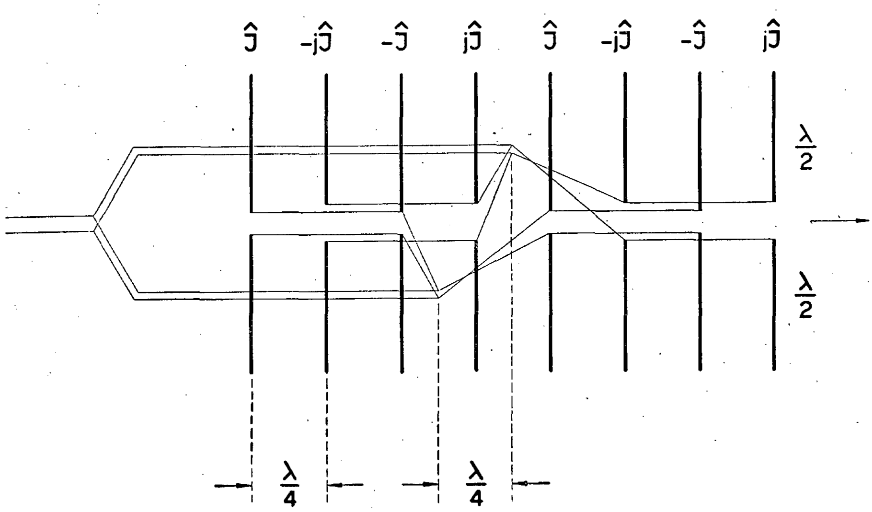
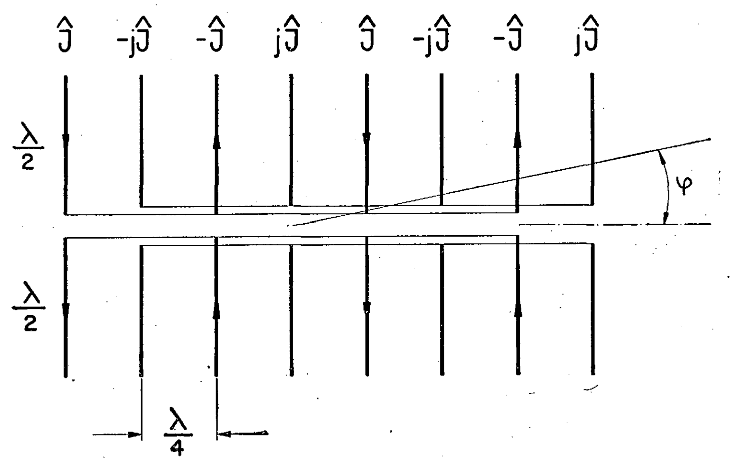
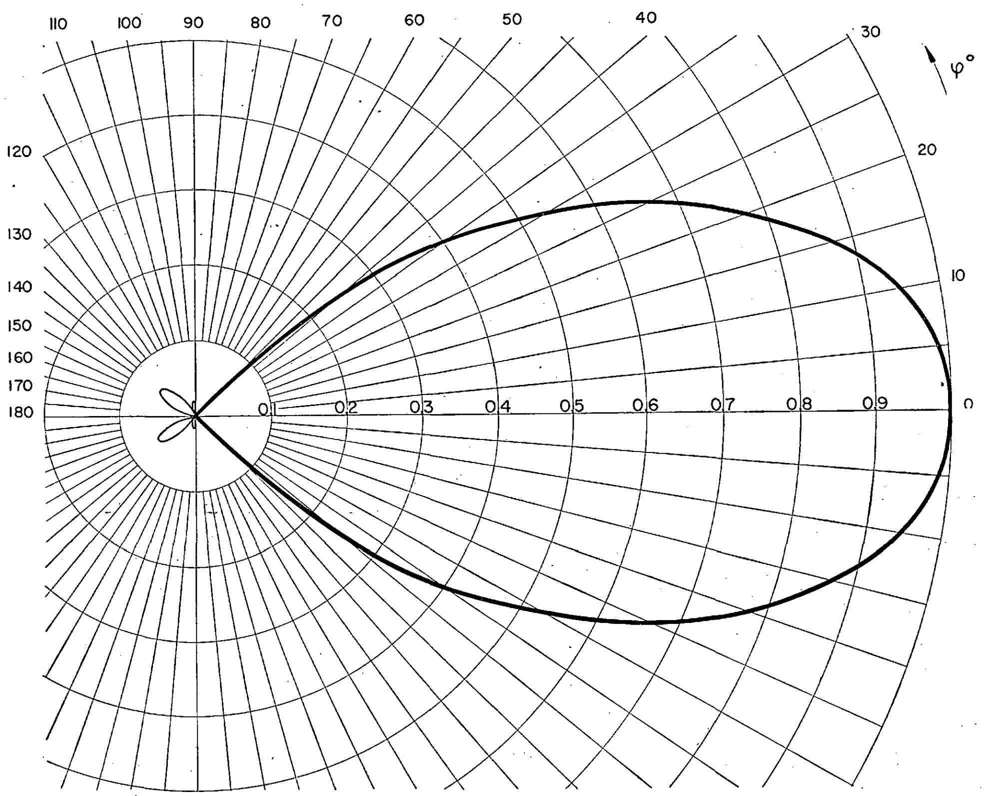


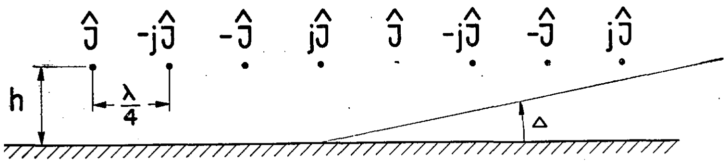
FIGURE 1



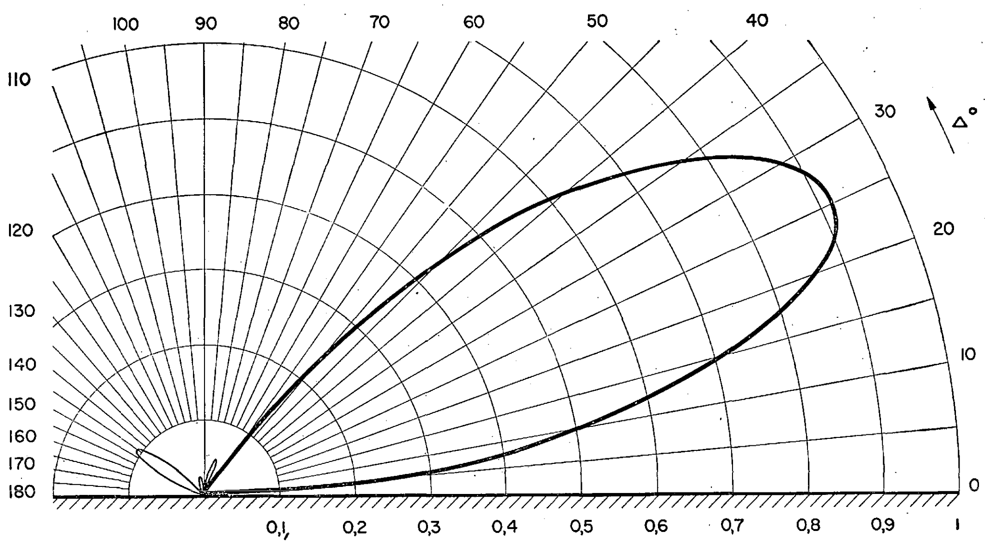


$$\frac{E}{E_{max}} = \left| \frac{\cos\left(\frac{\pi}{2}\sin\varphi\right)}{\cos\varphi} \; \frac{\sin(\pi\sin\varphi)}{2\sin\left(\frac{\pi}{2}\sin\varphi\right)} \; \frac{\sin(2\pi\cos\varphi)}{8\sin\left(\frac{\pi}{4}\cos\varphi - \frac{\pi}{4}\right)} \right|$$

FIGURE 2

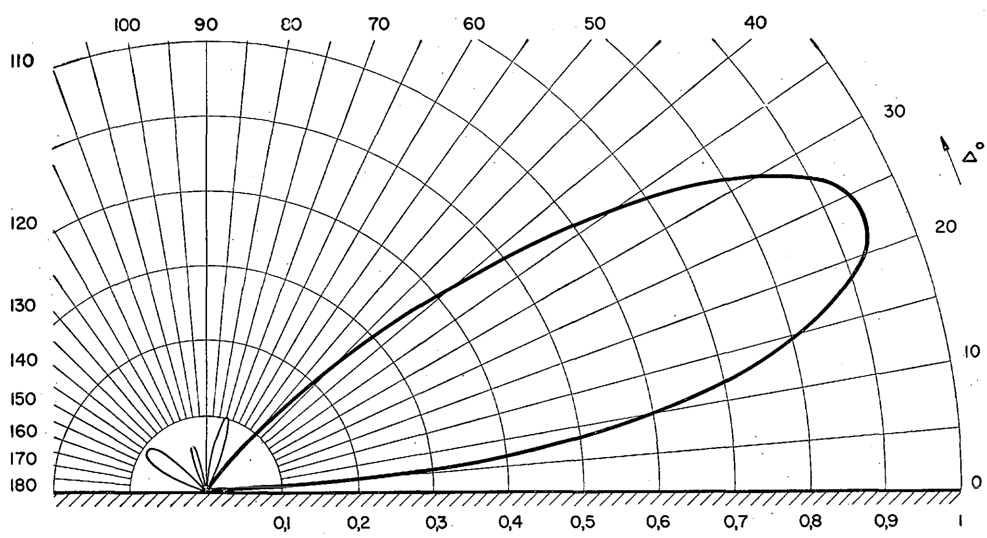


$$E = \left| \sin\left(2\pi \frac{h}{\lambda} \sin \triangle\right) \frac{\sin (2\pi \cos \triangle)}{8 \sin\left(\frac{\pi}{4} \cos \triangle - \frac{\pi}{4}\right)} \right|$$



h=0,5 λ

FIGURE 3



h= 0,6 λ

FIGURE 4

REPORT No. 76 *

MINIMUM NUMBER OF FREQUENCIES NECESSARY FOR THE TRANSMISSION OF A HIGH-FREQUENCY BROADCASTING PROGRAMME

(Question No. 37 (X))

(Geneva, 1951 — Warsaw, 1956)

The C.C.I.R. has studied the technical data contained in Doc. No. 635 of Mexico, and agrees that it is essential to secure the greatest possible economy in the use of radio frequencies and that to this end, as a general rule, only one frequency should be used for the transmission of one programme to one reception area. It is, however, of the opinion that technical conditions do exist which would justify the use of more than one transmission frequency to assure the continuous reception of one programme in one reception area (i.e. the area to which the programme is directed) at certain times and over certain paths.

Wave propagation conditions over certain paths may be difficult to forecast (e.g. very long paths or paths passing through the auroral zones) or the rate of change of FOT may be high (e.g. at sunrise or sunset). Listeners to broadcasting cannot advise the transmitter of an unexpected deterioration in reception conditions as may be the case in radio services other than broadcasting.

The existence of these conditions could justify the simultaneous use of more than one frequency, each in a different band, to cover such periods and paths. In addition there may be cases where the depth of the area extending outward from the transmitter is too great to be served by a single frequency and more than one frequency may be needed.

The use of directional antennae is essential in most cases to ensure a satisfactory signal-to-noise ratio, as recommended by the Mexico City High Frequency Broadcasting Conference, and this limits the geographical area covered by each transmitter and its associated antenna to an extent differing with each particular case. Because of this, it may be necessary to use more than one transmitter and associated antenna to cover a given reception area. By synchronising transmitters, the number of frequencies in the same band may be reduced to two and, under favourable conditions, to one (Recommendation No. 205). Further study should be carried out.

The angle subtended by the reception area at the transmitter, its mean distance from the transmitter and its depth, may differ greatly from one case to another. This limits the value of adopting defined geometric reception areas as it would give rise to insufficient coverage in some cases and a wasteful use of frequencies in others. Thus it would seem that defining the above factors could not produce a useful criterion for the justification on technical grounds of the use of more than one frequency for transmitting one programme to a reception area, but that each case must be considered on its merits taking these factors into account.

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* This Report replaces Report No. 13. It was adopted unanimously.

REPORT No. 77 *

FREQUENCY-MODULATION SOUND BROADCASTING IN THE VHF (METRIC) BAND

(Question No. 150 (X))

(Warsaw, 1956)

In the study of Question No. 99** at the VIIIth Plenary Assembly, it became evident that not enough experience had yet been available to determine the protection ratios required in Item 3 of the Question. The following figures were examined:

	(1)	(2)
For co-channel working	20 db	26 db for 99% of the time
For carriers spaced at 100 kc/s	10 db	10 db " " " "
" " " 200 kc/s	0 db	6 db " " " "
" " " 300 kc/s	−10 db	0 db " " " "
" " " 400 kc/s	−20 db	−12 db " " " "

Figures under (1) resulted from tests with receivers provided with a suitable limiter proceeding the discriminator or ratio detector and with characterics:

kc/s off-tune	0	50	100	200	300
response in db	0	0	−3	−20	−36

Figures under (2) resulted from tests using about 20 different types of receivers and are an average of the results.

A figure of 30 db for co-channel working was also proposed as necessary to give an entirely satisfactory quality and in fact to give a quality superior to the minimum quality required for the sound channel in television (Report No. 82, paragraph 5).

The study of this problem will be continued (Question No. 150 (X)).

REPORT No. 78 *

MEASUREMENT OF WOW AND FLUTTER IN EQUIPMENT FOR SOUND RECORDING AND REPRODUCTION

(Study Programme No. 74 (X); § 1)

(Warsaw, 1956)

Examination of Warsaw Docs. Nos. 364 (Japan), 65 (Federal German Republic), 152 (United Kingdom), and of London Doc. No. 187 (United States of America) indicates that:

1. It is not yet possible to determine what measurements have to be made with regard to wow and flutter (peak, mean or r.m.s.) in order best to express such quantities in relation to the nuisance value of the wow and flutter.

* This Report was adopted unanimously.

** This Question has been replaced by Question No. 150 (X).

2. The various proposed weighting curves (see attached curves) referring to the threshold of perceptibility of wow and flutter show a marked degree of correlation. It seems that in the near future complete agreement may be reached and a standard weighting curve may be adopted.

REPORT No. 79 *

STANDARDS OF SOUND RECORDING FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES

(Study Programme No. 74 (X), § 3)
(Study Group No. X)

(Warsaw, 1956)

In conformity with the recommendation appearing in point 3 of Study Programme No. 74 (X), exchanges of test tapes have taken place during 1954 and 1955 between a number of broadcasting organisations. The results obtained have been reported in the following Warsaw documents:

No. 198 — France,
No. 235 — United Kingdom,
No. 292 — E.B.U.,
No. 374 — Japan (including comments from Denmark, France, Federal German Republic and Switzerland).

The results obtained have made it possible to assess the practical validity of the measuring methods described in Recommendation No. 209 and its Annex. Thus, it is now possible to exchange programmes recorded on magnetic tape at tape speeds of 15 and 7.5 ins/sec. with the assurance that the technical quality will correspond to the standard indicated in paragraph 9 of Recommendation No. 209.

In the course of these exchanges, however, certain discrepancies have been observed for the extreme frequencies. These discrepancies are more systematic at low frequencies and seem to be due to the method of measurement.

A study of these discrepancies has shown that they can all be attributed to a difficulty in applying the definition of the " ideal head " as it appears in paragraph 9 of Recommendation No. 209.

Since an ideal reproducing head is defined as a ferromagnetic reproducing head, the losses of which are negligible, it is important to know precisely the losses of heads normally used in order to construct a reproducing system equivalent to an ideal head.

Recommendation No. 209 mentions explicitly two types of losses:

— those dependent on frequency,
— those due to the gap length,

and in the Annex to Recommendation No. 209 practical methods are given for measuring these.

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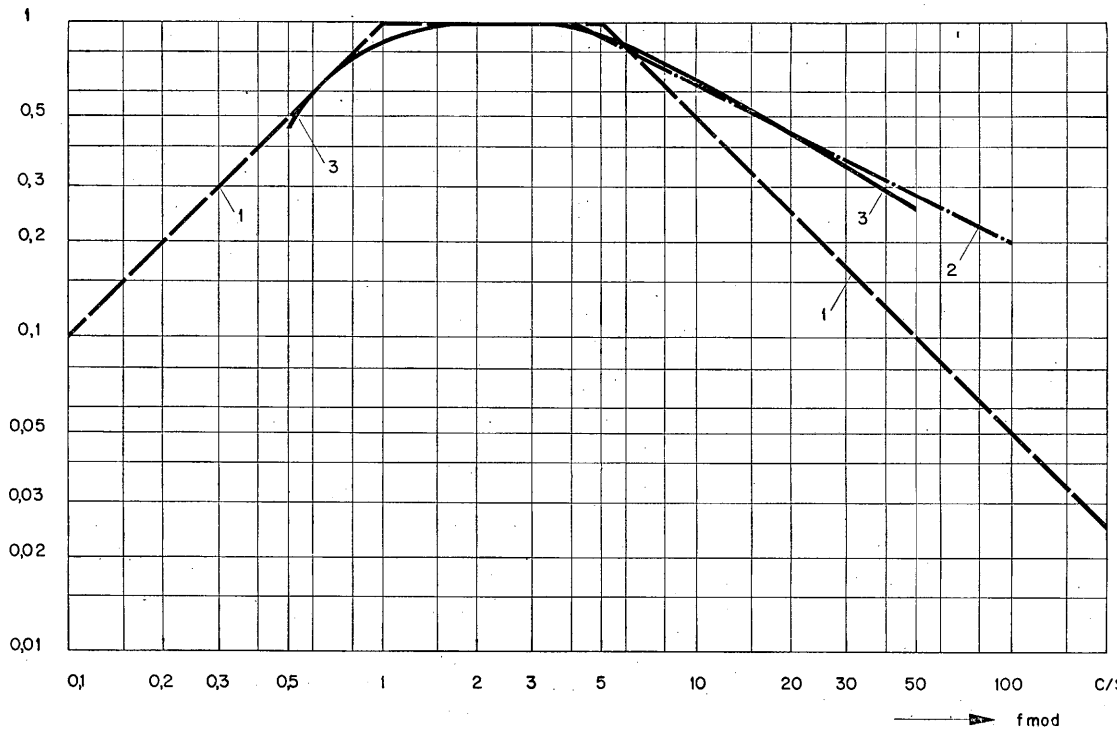
* This Report was adopted unanimously.



1: Doc. No. 187 (London)
2: Doc. No. 65 (Warsaw).
3: Doc. No. 364 (Warsaw).

Proposed weighting curves referring to the threshold of perceptibility of wow and flutter

(See Report No. 78)

During the exchange of test tapes, it was found that in certain cases attention should be given to other losses, for example, those due to the imperfect contact between the tape and the head, and those due to the dimensions of the core of the ferromagnetic head.*

It is not impossible that in the future new causes of losses may be discovered.

For these reasons it will be necessary in the future to decide on a new wording that will eliminate the concept of the ideal head and will define only the state of magnetisation of the tape, and indicate methods for measuring this for all frequencies.

It appears that the study of these problems is not yet sufficiently advanced to permit this change to be made now. It has therefore been considered preferable to leave Recommendation No. 209 in its present form, adding only a note which describes the nature of the errors likely to be encountered at very low frequencies, and the means of avoiding them. The study of the problems should be continued in order to enable the IXth Plenary Assembly of the C.C.I.R. to adopt a revised text for Recommendation No. 209.

REPORT No. 80 **

WIDTH OF MAGNETIC TAPE

(Recommendation No. 209, § 2)
(Study Group No. X)

(Warsaw, 1956)

The possibility of modifying the standard for the width of magnetic tapes was considered during the VIIIth Plenary Assembly of the C.C.I.R.

Doc. No. 187 (Warsaw) submitted by France, suggested that the figures appearing in paragraph 2 of Recommendation No. 209, i.e.

$$0.250 \text{ inches} \begin{cases} +0 \\ -0.006 \end{cases} \text{inches} \left(6.35 \text{ mm} \begin{cases} +0 \\ -0.15 \text{ mm} \end{cases}\right)$$

should be replaced by: 0.246 inches $\pm$ 0.0012 inches (6.25 mm $\pm$ 0.03 mm).

The purpose of this proposal was to reduce the tolerance in order to improve the performance of tape recording equipment operating at a tape speed of 7½ inches/second (19.05 cm/second).

The width of tapes manufactured at present are found to be close to the centre of the relatively large tolerance range specified in Recommendation No. 209. It has therefore proved impossible to reduce the tolerance while retaining the nominal width of 0.250 inches (6.35 mm).

Discussion surrounding the problem have revealed:

1. some delegations supported the opinion expressed in Doc. 187 although certain of them would prefer a somewhat larger tolerance. It was proposed that the tape width should be:

0.246 inches $\pm$0.002 inches (6.25 mm $\pm$0.05 mm)

and that the following note should be inserted:

Note.—It would be desirable to reduce the tolerance to $\pm$0.0012 inches ($\pm$0.03 mm). The measurement should be made at 20° C, 60 % relative humidity and a specified tape tension;

2. many measurements of tape width made in Japan and France have revealed that the mean values adopted by most tape manufacturers throughout the world lie between the limits of 0.245 inches (6.24 mm) and 0.247 inches (6.28 mm);

3. France and the Federal German Republic have already introduced the figures of 0.246 inches $\pm$0.002 inches (6.25 mm $\pm$0.05 mm) into their national standards;

4. the delegations of the United States and the United Kingdom are not able to accept any modification of paragraph 2 (Recommendation No. 209) due to the lack of information regarding manufacturing processes in their countries.

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* These losses, as well as those dependent on frequency, can be negative as well as positive.

** This Report was adopted unanimously.

It has therefore been resolved to retain provisionally the figure appearing in Recommendation No. 209 and to pass a resolution (No. 30) indicating the procedure which will permit the adoption as soon as possible of a new standard acceptable to all.

REPORT No. 81 *

SOUND RECORDING ON FILM FOR THE INTERNATIONAL EXCHANGE OF TELEVISION PROGRAMMES

(Question No. 100)
(Study Group No. X)

(Warsaw, 1956)

In reply to Question No. 100, the VIIIth Plenary Assembly of the C.C.I.R. has adopted Recommendation No. 211 which recommends methods to be used for recording the sound on film for the international exchange of television programmes.

It has been recognised that in certain cases it would be desirable to use a second film, distinct from the picture film, for the recording of one or more additional sound tracks. This second film would be particularly useful in the following cases:

(a) when the sound recorded on the picture film contains elements that cannot be retained (e.g. dialogue in a foreign language). In this case, one of the two films would carry the original sound and the other the " international " sound, by which is meant the sound that has no linguistic content (music and sound effects);

(b) whenever it may be desirable to record several sound tracks simultaneously;

(c) when only one sound track is needed, but the stripe at the edge of the film, for some reason, cannot be used;

Furthermore, apart from the question of programme exchange, the use of a separate film for sound recording is often necessary when carrying out processing operations such as copying, mixing and editing.

It is desirable that the characteristics of this second film should be standardised, particularly in regard to the number, dimension and position of the tracks. For the following reason, it has not been possible, however, to set up standards:

— the techniques are not yet fully developed,
— the characteristics used in different countries are not sufficiently known.

In order to facilitate the exchange of programmes, the C.C.I.R. proposes that when use is made of both picture film and magnetic sound film,

(a) the films should both be 16 mm and the mean speed of both picture and magnetic sound films should be identical;

(b) the recorded sound track should be: a 2.5 mm-wide track at the edge of the film, placed in the same position as the magnetic stripe on the film (Recommendation No. 211), or a 5 mm-wide track placed along the physical centre of the film.

In all cases the recording characteristic should be that defined in para. 9 of Recommendation No. 209 for a tape speed of 7½ inches/second (19.05 cm/s).

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* This Report was adopted unanimously.

Until a definite standard on this question has been set up the choice of the track to be used and whether or not single or double perforated sound film is to be used should be agreed upon by the organisations concerned. Furthermore, in each case where a second film is necessary in the exchange of a programme the track or tracks that are used and, if necessary, the nature of the sounds recorded thereon, should be clearly indicated.

It has been resolved that further studies on this question should be carried out in collaboration with other international organisations (I.E.C. and I.S.O.) so that a definite standard can be achieved as soon as possible.

REPORT No. 82 *

RATIO OF THE WANTED TO THE UNWANTED SIGNAL IN MONOCHROME TELEVISION

(Question No. 67 **)
(Study Group No. XI)

(London, 1953 — Warsaw, 1956)

This report has been prepared using the available results of subjective tests on the tolerable ratios " wanted signal/unwanted signal " in monochrome television.

The protection ratios given in this report are considered acceptable for a short percentage of the time, not precisely defined, but assumed to be between 1% and 10%.

The protection ratios refer to a viewing distance of four times the picture height.

The protection ratios refer to the limit of just tolerable interference: protection ratios for just perceptible interference would be 6 to 10 db higher.

When utilising the protection ratios, suitable allowance will have to be made for fading by adding to these ratios the root-sum-square of the fading of the wanted and unwanted signals. Alternatively, the allowance for fading can be determined using the curves of field strengths exceeded for 1% or 10% of the time when the fading of the wanted signal is small compared with the fading of the unwanted signal.

No account has been taken of the possible effect of using directional receiving antennae or of the advantage which might be gained by using different polarisations for transmission of the wanted and unwanted signals. The protection ratios quoted refer in all cases to the signals at the input of the receiver.

The values to be considered are respectively the r.m.s. value of the carrier at the peak of the modulation envelope for the television signal and the r.m.s. values of the unmodulated carrier for amplitude-modulated and frequency-modulated sound transmissions.

1. *Interference within the same channel — Protection ratio for the picture signal when the wanted and unwanted signals have the same line frequency.*

   (a) *Carriers separated less than 100 c/s but not synchronised:*
   just tolerable interference: 45 db.

   (b) *Carriers separated by 2/3 of the line frequency:*
   just tolerable interference: 30 db.

   (c) *Carriers separated by 1/2 of the line frequency:*
   just tolerable interference: 27 db.

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* This Report replaces Report No. 34. It was adopted unanimously.

** This question has been replaced by Question No. 119 (XI).

2. *Interference within the same channel — Protection ratio for the picture signal when the wanted and unwanted signals have different line frequencies.*

(a) *Carriers separated less than 100 c/s but not synchronised:*
just tolerable interference: 45 db.

(b) *Carriers separated by 1/2 or 2/3 of the line frequency of the wanted signal:*
as in case 1 (b) and 1 (c) the offset brings an improvement in the protection of the picture signal. This improvement, however, is reduced, since the line frequency of the unwanted signal is different from the line frequency of the wanted signal; the amount of the reduction depends on the relation between the line frequencies. More tests are needed before figures can be given for the protection ratios in this case.

3. *Adjacent-channel interference.*

The worst interference on the picture signal results from the sound transmission in the adjacent channel. The figures given below relate to the case when the separation between the vision carrier and the adjacent channel sound carrier is 1.5 Mc/s.

(a) *Frequency-modulated sound carrier:*
just tolerable interference: −6 db.

(b) *Amplitude-modulated sound carrier:*
just tolerable interference: 0 db.

Fairly conservative values have been chosen, to take account of the divergence in performance between different types of television receivers. However, future developments in receiver design will probably enable somewhat higher interfering signals to be tolerated in all cases.

4. *Overlapping-channel interference.*

In the attached figure, curves are given for the protection ratio required when a television signal, using 819, 625, 525 or 405 lines suffers interference from a vision signal of any of the systems or by a frequency-modulated sound signal. The curves cover the case when the carrier of the interfering signal lies within the vision channel of the wanted transmission.

If the interfering signal is an amplitude-modulated sound signal, 5 db should be added to the protection ratios shown by the curves. These curves are tentative and may require modification in the light of further experience.

It is theoretically possible to gain a further advantage by the use of offset methods using a frequency separation between the carriers equal to an odd multiple of half the line frequency. Further tests are needed before it can be said what precise advantage could be derived. Variation of line frequency would render difficult the offsetting at high multiples of half the line frequency.

In the particular case of overlapping sidebands known as the " tête-bêche " arrangement, the protection ratio can be roughly estimated from the curves in the attached figure and from the rejection afforded to the unwanted carrier. More tests are needed before further guidance can be given for the protection ratios required for specific cases.

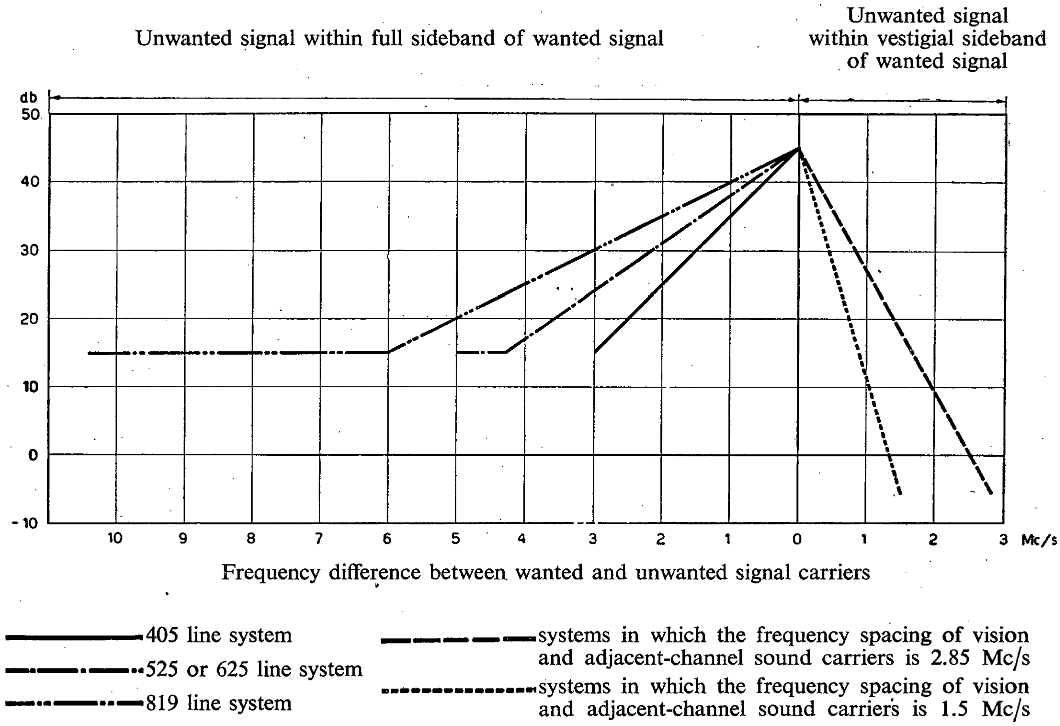
5. *Protection ratio for the sound signal* (for just tolerable interference).

(a) *Wanted and unwanted frequency-modulated signals:* 20 db.

(b) *Wanted and unwanted amplitude-modulated signals:*
for a frequency difference below the audio-frequency range: 30 db.
for a frequency difference within the audio-frequency range: 40 db.
for a frequency difference above the audio-frequency range: 15 db.

(c) *Wanted amplitude-modulated signal, unwanted frequency-modulated signal:*
no frequency difference: 40 db.
25 kc/s frequency difference: 30 db.
50 kc/s frequency difference: 12 db.

PROTECTION RATIOS REQUIRED BY VISION SIGNAL AGAINST UNWANTED VISION OR FREQUENCY-MODULATED SOUND SIGNAL



Note 1. — For an amplitude-modulated sound signal the protection ratios required are about 5 db higher.

Note 2. — The above curves do not take into consideration the actual response of the receiver within the full sideband of the wanted signal; in this range the response is assumed to be 0 db with reference to the vision carrier. Any general departure from this should be noted in computing the effective protection ratio.

Note 3. — It follows, for receivers of the types used for the tests described in Warsaw Docs. Nos. 209 and 224, that in the vestigial sideband, the line marked " systems in which the frequency spacing of vision and adjacent-channel sound carriers is 2.85 Mc/s " would be preferable to the actual dotted line for systems in which the frequency spacing of vision and adjacent-channel sound carrier is 1.5 Mc/s. However, further experimental confirmation including other types of receiver is necessary before a change of the curve could be recommended.

(d) *Wanted frequency-modulated signal, unwanted amplitude-modulated signal :* 20 db.

The above quoted figures, while giving the protection ratios required, will in practice be used to determine the frequency separation which may be needed between the sound carriers.

The C.C.I.R. is of the opinion that Question No. 67 * should remain on the agenda and that further theoretical and experimental work should continue on this question.

REPORT No. 83 **

TELEVISION SYSTEMS

(Recommendation No. 29) ***
(Study Group No. XI)

(Geneva, 1951 — London, 1953 — Warsaw, 1956)

It has not been possible to arrive at unanimous agreement on certain television standards. An extensive study has been made of four systems of black-and-white television, identified by the number of lines per picture as the 405-line system, the 525-line system, the 625-line system, and the 819-line system.

As a result of this study, the attached table has been prepared for the information of those administrations which may wish to establish one of these systems.

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* This Question has been replaced by Question No. 119 (XI).

** This Report replaces Report No. 35. It was adopted unanimously.

*** This Recommendation became Question No. 64, which has been replaced by Question No. 118 (XI).

Table I

Details of television systems

Item	Description of Item	System						
		405	525	625	Belgian 625	O.I.R. 625 [8])	819	Belgian 819
1	Number of lines per picture (frame) . . .	405	525	625	625	625	819	819
2	Video bandwidth	3	4	5	5	6	10.4	5
3	Channel width . . . . Mc/s	5	6	7	7	8	14	7
4	Sound carrier relative to vision carrier Mc/s	−3.5	+4.5	+5.5	+5.5	+6.5	−11.15 [2])	+5.5
5	Sound carrier relative to edge of channel Mc/s	+0.25	−0.25	−0.25	−0.25	−0.25	+0.10 [2])	−0.25
6	Ideal vision transmitter characteristic . .	(See Fig. 1)	(See Fig. 4)	(See Fig. 7)	(See Fig. 10)	(See Fig. 13)	(See Fig. 16)	(See Fig. 10)
7	Interlace [1])	2/1	2/1	2/1	2/1	2/1	2/1	2/1
8	System capable of operating independently of power supply frequency [1])	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	Line frequency . . . . c/s	10 125	15 750	15 625 ±0.1%	15 625 ±0.1%	15 625 ±0.05%	20 475	20 475 ±0.1%
10	Field frequency . . . . c/s	50	60	50	50	50	50	50
11	Picture (frame) frequency . . . . c/s	25	30	25	25	25	25	25
12	Aspect ratio [1]).	4/3	4/3	4/3	4/3	4/3	4/3	4/3
13	Scanning during active periods [1])	L. to R. and Top to B.	L. to R. and Top to B.	L. to R. and Top to B.	L. to R. and Top to B.	L. to R. and Top to B.	L. to R. and Top to B.	L. to R. and Top to B.
14	Type of vision modulation [1])	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
15	Vision emission characteristics [1])	Asymmetric	Asymmetric	Asymmetric	Asymmetric	Asymmetric	Asymmetric	Asymmetric
16	Sense of vision modulation	Positive	Negative	Negative	Positive	Negative	Positive	Positive
17	Black level independent of picture content [1])	Yes	Yes	Yes	Yes	Yes	Yes	Yes
18	Blanking level as % of peak carrier . . .	30	75	75	25	75	25	25
19	Minimum level of carrier as % of peak carrier	0	≤ 15 [3]) [4])	10	0 to 3	10% min.	≤ 3	0 to 3
20	Synchronising waveform	(See Figs. 2 and 3)	(See Figs. 5 and 6)	(See Figs. 8 and 9)	(See Figs. 11 and 12)	(See Figs. 14 and 15)	(See Figs. 17 and 18)	(See Figs. 19 and 20)
21	Sound modulation	A3	F3 ±25 kc/s 75 μs pre-emphasis	F3 ±50 kc/s 50 μs pre-emphasis	A3 50 μs pre-emphasis	F3 ±50 kc/s 50 μs pre-emphasis	A3	A3 50 μs pre-emphasis
22	Ratio of vision to sound effective radiated power	4/1	2/1 to 2/3 [5])	5/1	4/1 [6])	2/1 to 5/1	4/1	4/1 [6])
23	Approximate gamma of radiated signal .	0.4 to 0.5	0.45	0.5	0.5	[7])	0.6	0.5

(1) Items 7, 8, 12, 13, 14, 15, 17 and 23 are in accordance with Recommendation No. 212. See Recommendation No. 212 for further details.

(2) The administrations which desire to adopt this system should conform to the provisions of Recommendation No. 212.

(3) At maximum luminance.

(4) For Japan the figure is 10-15%.

(5) For Japan the ratio is 10/7-20/7.

(6) This figure is provisional.

(7) Information to be given later.

(8) XIIIth Session of the O.I.R. Technical Commission, Sofia, March 1957.

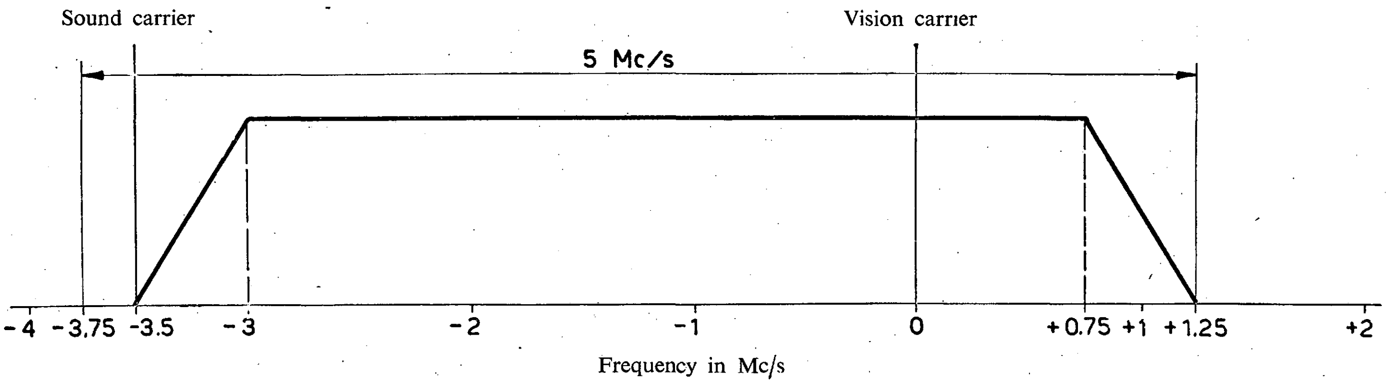
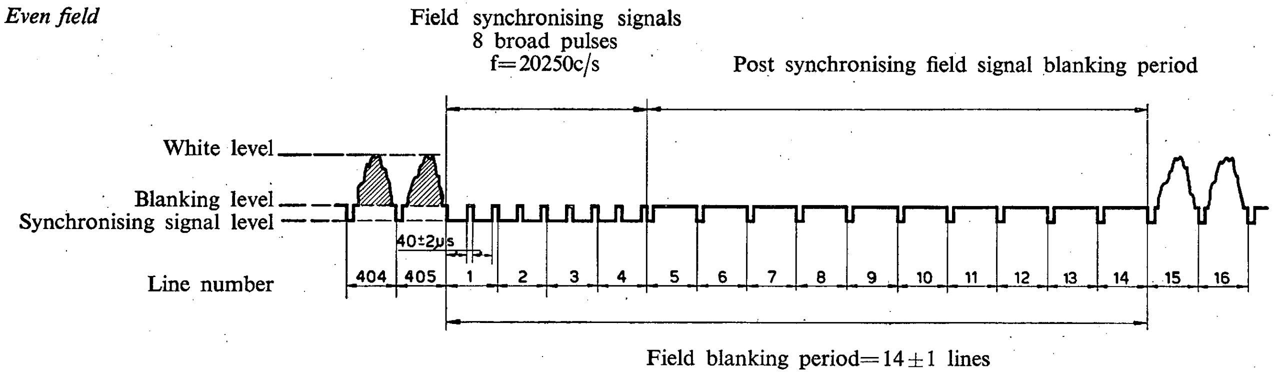


FIGURE 1

Ideal characteristic for vision transmitter, 405-line system

(1) *Even field*



(2) *Odd field*

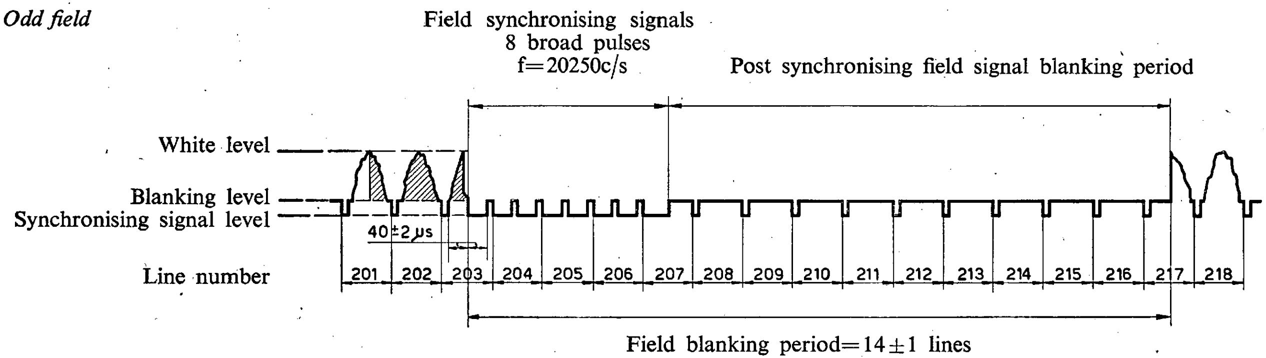


FIGURE 2

Synchronising waveform, 405-line system

The hatched part of the signal can either be occupied by a blanking pulse up to 2 lines in length or by a picture signal as shown.

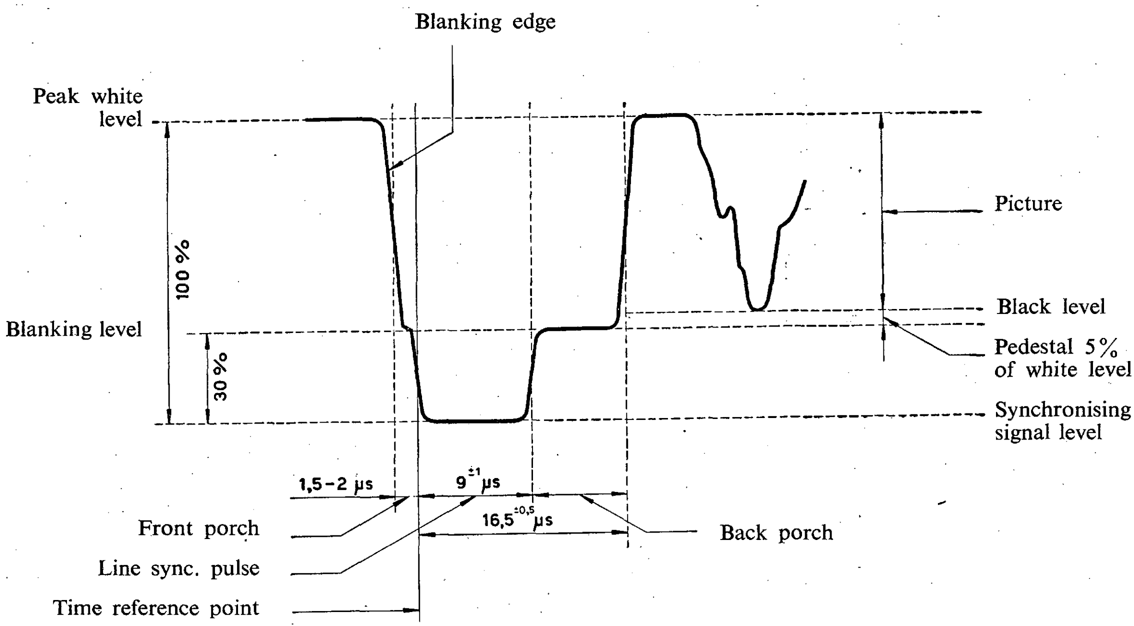


FIGURE 3

Details of synchronising signal, 405-line system

NOTES

(a) The signal is shown in its video form. The corresponding modulated carrier signal (vision signal) has sync. level at 0.3%, blanking level at 30±3%, and white level at 100% of peak carrier amplitude. Time of rise of leading and trailing edges of synchronising pulse (10%–90% amplitude) are not less than 0.25 μs.
Time of rise of leading and trailing edges of blanking pulse (10% to 90% of its amplitude) between 0.25 & 0.5 μs. Field frequency tied to frequency of mains: times shown are based on 50 c/s.

(b) Peak white level and 100% peak white amplitude refer to the vision signal as transmitted (see line waveform).

(c) White level is maximum amplitude of video signal. (See field waveforms).

(d) Pulse durations are measured at half-amplitude points on a white level signal.

TABLE CONVERTING INTERVALS OF TIME TO % OF THE NOMINAL LINE LENGTH

μs	% H
1	1.0125
2	2.0250
3	3.0375
4	4.0500
5	5.0625
6	6.0750
7	7.0875
8	8.1000
9	9.1125
10	10.1250

H = time from the start of one line to the start of the next line (nominal).

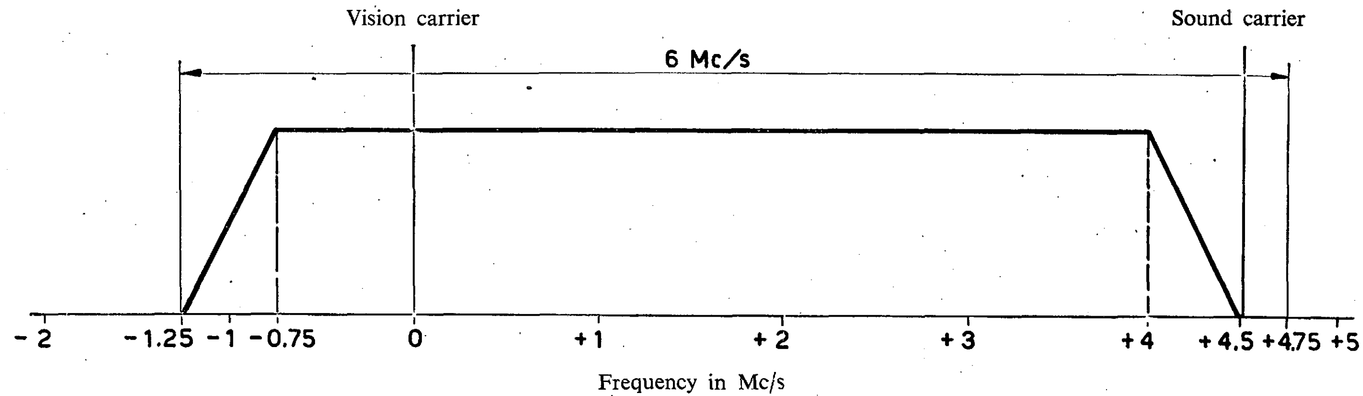
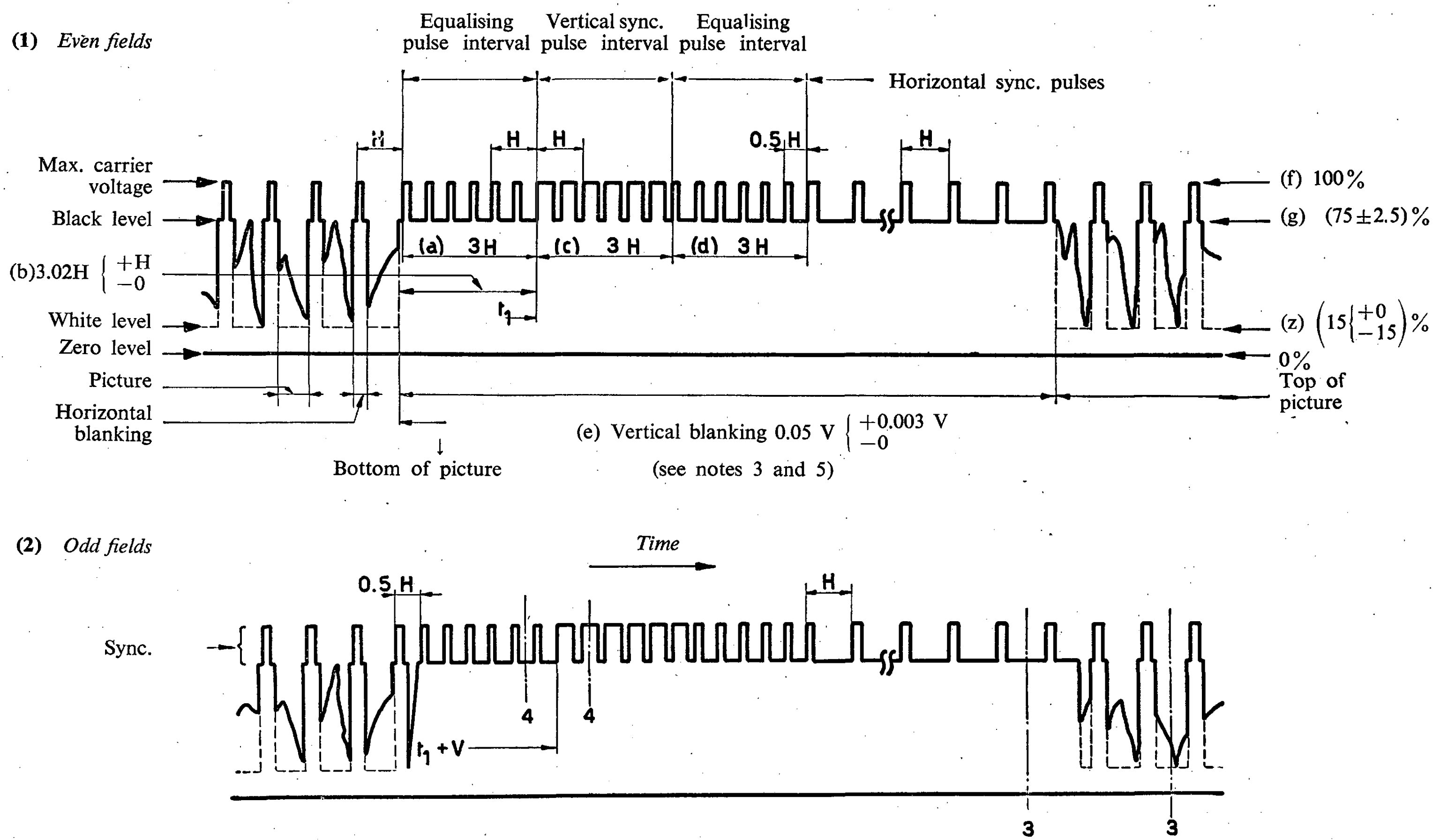


FIGURE 4

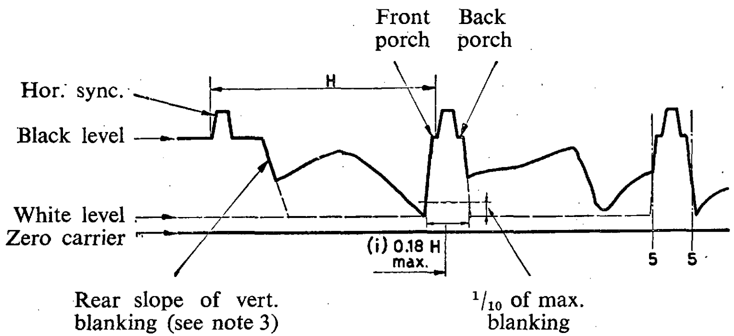
Ideal characteristic for vision transmitter, 525-line system



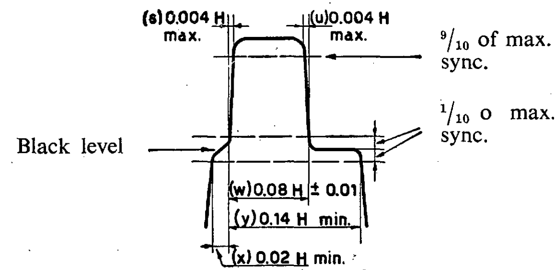
Horizontal dimensions not to scale

FIGURE 5

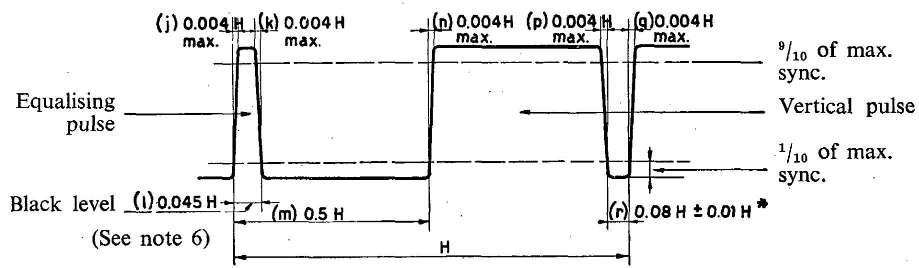
Synchronising waveform, 525-line system



(3) Details between 3-3 in **(2)** of Fig. 5



(5) Details between 5-5 in **(3)**



(4) Details between 4-4 of Fig. 5

Horizontal dimensions not to scale

FIGURE 6

Details of synchronising waveform, 525-line system

TABLE III

Information on Figures 5 and 6
(525 line system)

Notation	Approximate duration	
H		63.5 μs
V	262.5 H	16667 μs
a	3 H	190.5 μs
b	3.02 H to 4.02 H	192 μs to 255 μs
c	3 H	190.5 μs
d	3 H	190.5 μs
e	13 H to 21 H	826 μs to 1334 μs
i	< 0.18 H	< 11.4 μs
j	< 0.004 H	< 0.25 μs
k	< 0.004 H	< 0.25 μs
l	0.04 H	2.5 μs
m	0.5 H	32 μs
n	< 0.004 H	< 0.25 μs
p	< 0.004 H	< 0.25 μs
q	< 0.004 H	< 0.25 μs
r	0.06 H to 0.08 H	3.8 μs to 5.1 μs
s	< 0.004 H	< 0.25 μs
u	< 0.004 H	< 0.25 μs
w	0.07 H to 0.09 H	4.4 μs to 5.7 μs
x	> 0.02 H	> 1.3 μs
y	> 0.14 H	> 8.9 μs

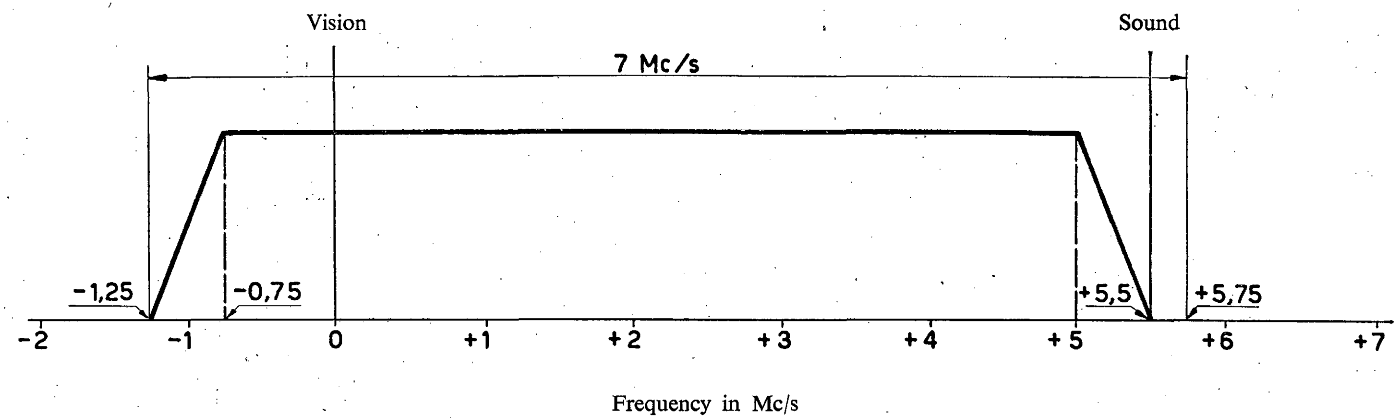
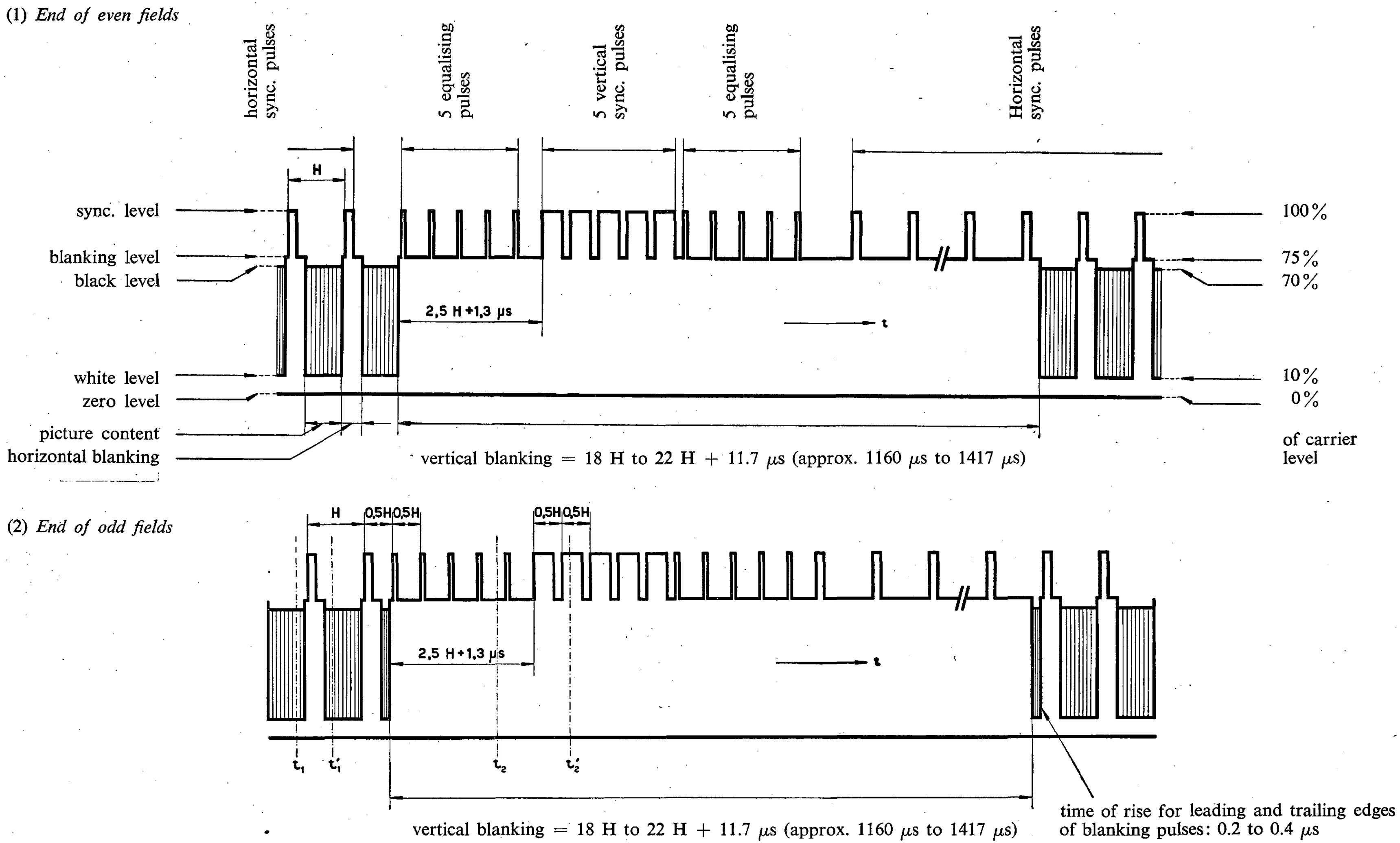


FIGURE 7

Ideal characteristic for vision transmitter, 625-line system for 7 Mc/s channel width

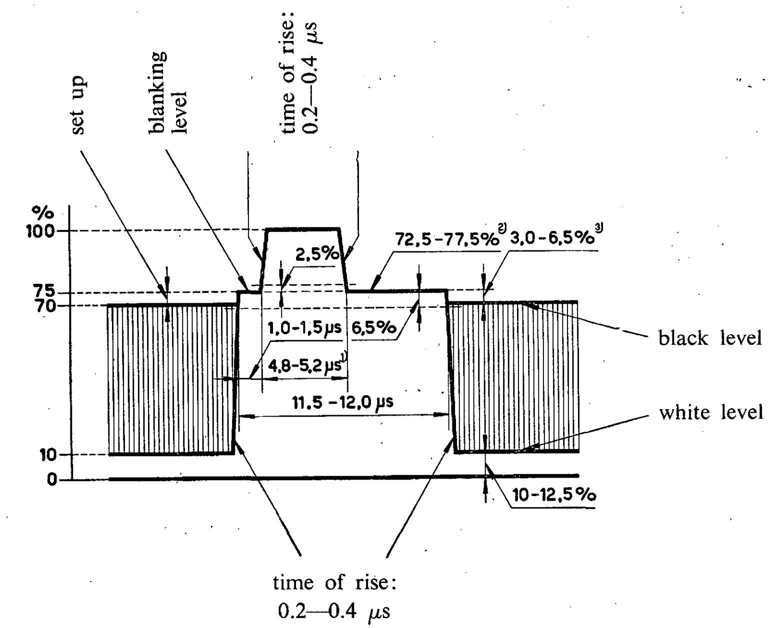


Note: horizontal dimensions not to scale

FIGURE 8

Synchronising waveform, 625-line system for 7 Mc/s channel width

1) *Time interval* t_1 to t'_1 (see 2 of Fig. 8)



(2) *Time interval* t_2 to t'_2 (see 2 of Fig. 8)

All times of rise: 0.2—0.4 µs

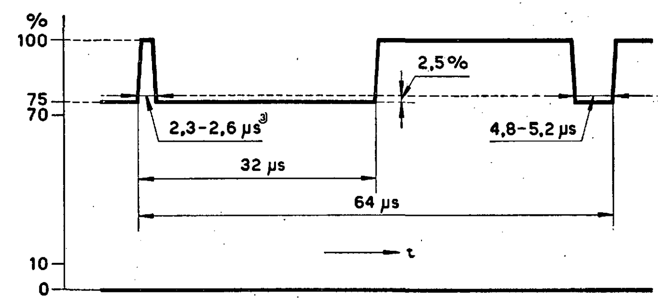


FIGURE 9

Details of synchronising waveform, 625-line system for 7 Mc/s channel width

(1) tentative value

(2) variations of these values with time must be slow enough, not to give undesired information to the receiver

(3) Equalising pulse area = 0.45 — 0.5 × horizontal pulse area

TABLE IV

µs	0.3	0.6	1.3	1.9	2.6	3.2	3.8	4.5	5.1	5.8	6.4
% H	0.5	1	2	3	4	5	6	7	8	9	10

% H	0.5	1	2	3	4	5	6	7	8	9	10
µs	0.8	1.6	3	4.7	6.3	7.8	9.4	11.0	12.4	14.1	15.8

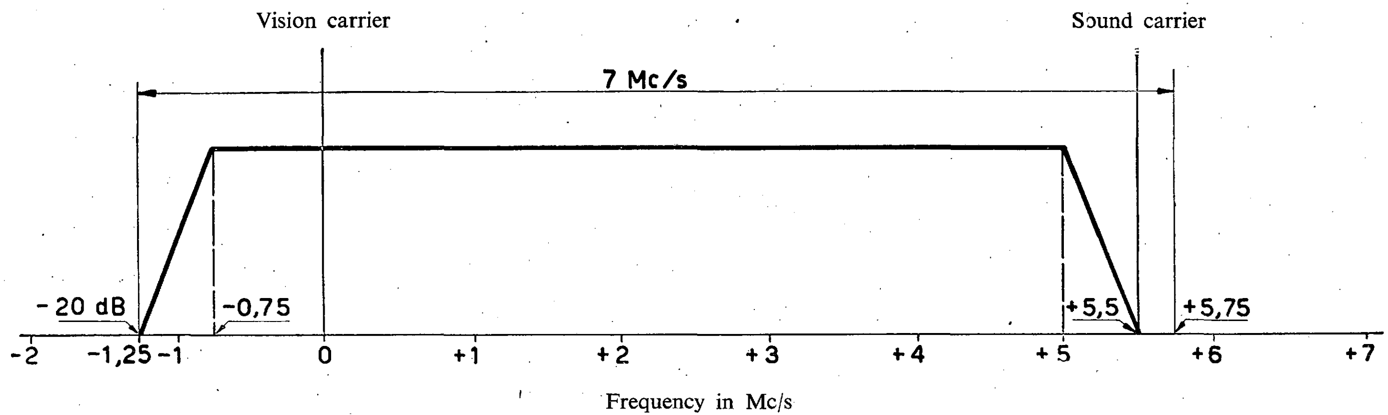
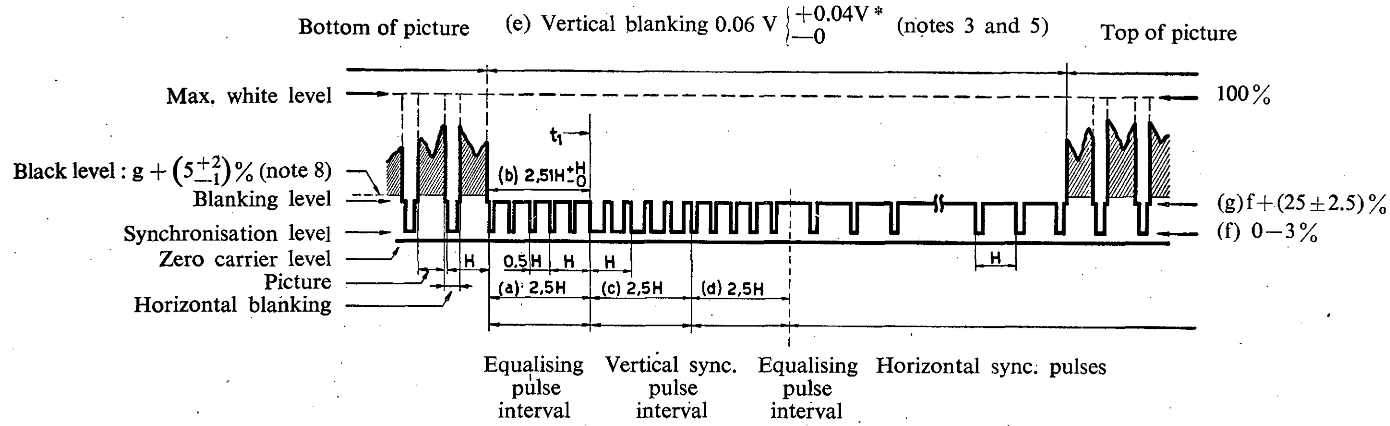


FIGURE 10

Ideal characteristic for a vision transmitter, Belgian 625-line and 819-line systems

Note : For a modulation frequency of 1.25 Mc/s or above, the attenuation of the voltage of the lower sideband is at least 20 db with reference to a modulation frequency of 200 kc/s.
The terms and values shown conform with Doc. RMA: TR 104-A (Oct. 1949).

(1) *Signal at the end of even fields*



(2) *Signal at the end of odd fields*

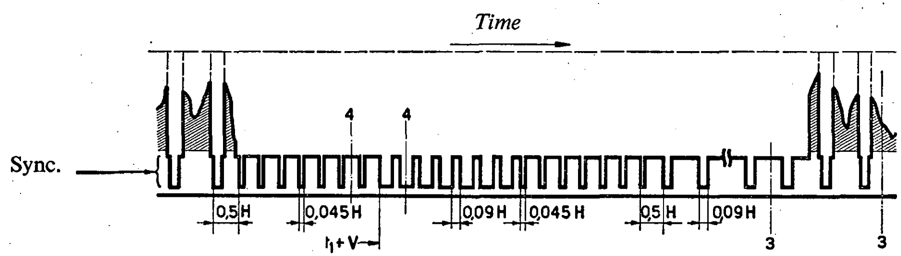
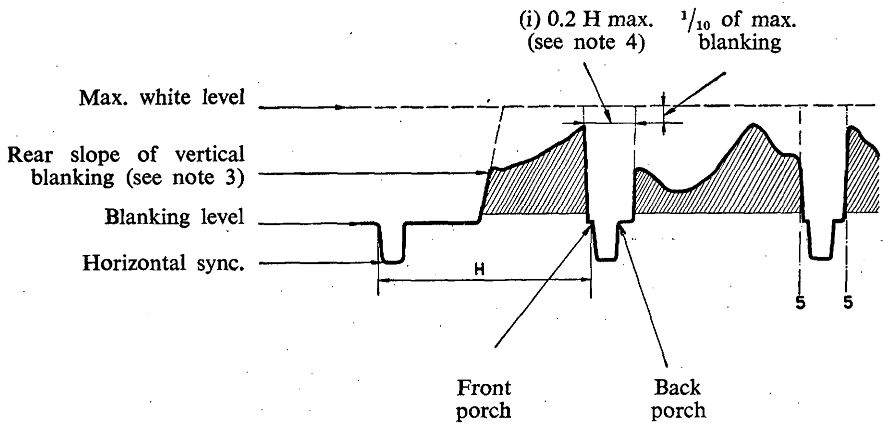
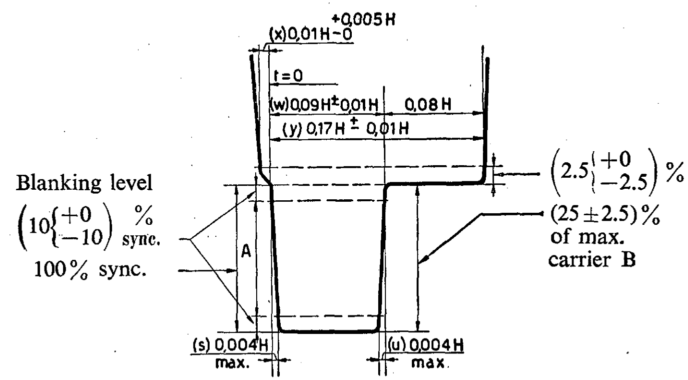


FIGURE 11

Synchronising waveform, Belgian 625-line system

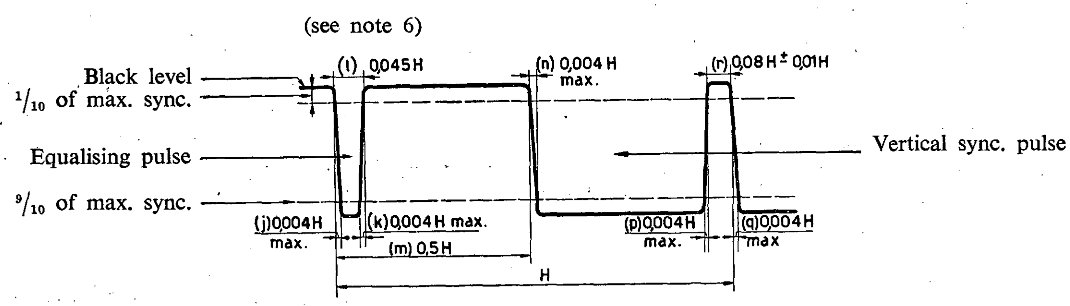


(3) Details between 3-3 in **(2)** of Fig. 11



A. Measured before modulation
B. Measured after ideal detection

(5) Details between 5-5 of **(3)**



(4) Details between 4-4 in **(2)** of Fig. 11

Note. — The dimensions are not to scale

FIGURE 12

Details of synchronising waveform, Belgian 625-line system

Notes

concerning Figures 11 and 12
(Belgian 625-line system)

1. H= time from the start of one line to the start of the next line.
2. V= time from the start of one field to the start of the next field,
3. Leading and trailing edges of vertical blanking should be complete in less than 0.1H.
4. Leading and trailing slopes of horizontal blanking must be steep enough to preserve the max. and min. values of (x+y) and (i) under all conditions of picture content.

*5. Dimensions marked with an asterisk indicate that the tolerances given are permitted only for long time variations and not for successive cycles.

6. Equalising pulse area shall be between 0.45 and 0.5 of the area of a horizontal sync. pulse.
7. The horizontal sweep frequency shall be 15625±0.1% c/s.
8. Provisional data.

Table V

Information on Figures 11 and 12
(Belgian 625-line system)

Notation	Approximate duration	
H		64 μs
V	312.5 H	20 000 μs
a	2.5 H	160 μs
b	2.51 to 3.51 H	161 to 225 μs
c	2.5 H	160 μs
d	2.5 H	160 μs
e	19 to 31 H	1200 to 2000 μs (see notes 3 and 5)
i	<0.2 H	<12.8 μs (s. note 4)
j	<0.004 H	<0.25 μs
k	<0.004 H	<0.25 μs
l	0.045 H	2.9 μs (see note 6)
m	0.5 H	32 μs
n	<0.004 H	<0.25 μs
p	<0.004 H	<0.25 μs
q	<0.004 H	<0.25 μs
r	0.07 H to 0.09 H	4.5 to 5.8 μs
s	<0.004 H	<0.25 μs
u	<0.004 H	<0.25 μs
w	0.08 H to 0.1 H	5.1 to 6.4 μs
x	0.01 H to 0.015 H	0.64 to 0.96 μs
y	0.16 H to 0.18 H	10.2 to 11.5 μs

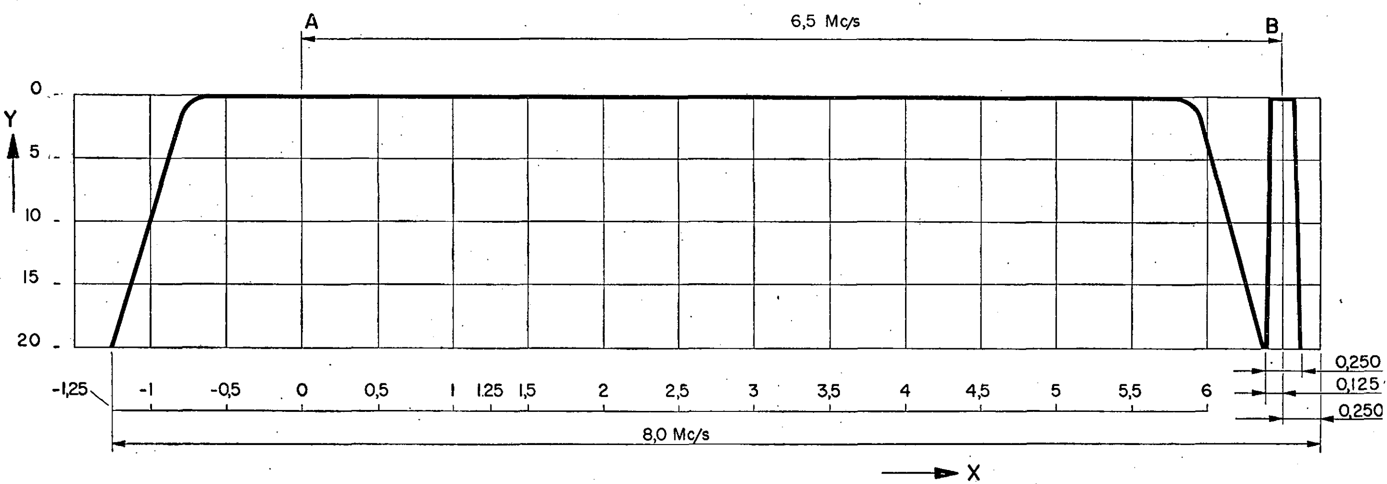
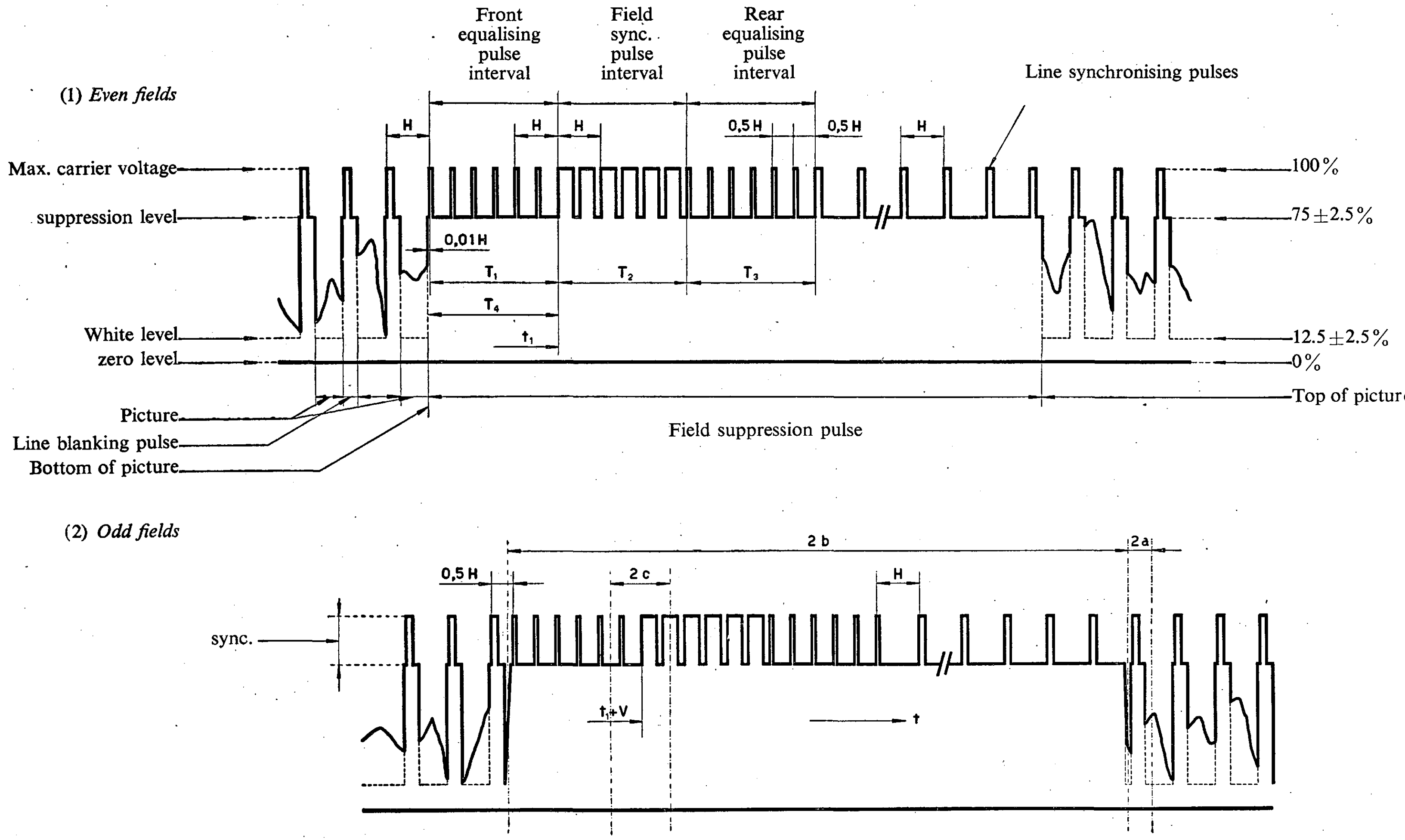


FIGURE 13

Frequency characteristics of video and sound signal transmitters, O.I.R. 625-line system for 8 Mc/s channel width

A video carrier frequency
B sound carrier frequency
X-axis indicates frequency in Mc/s
Y-axis indicates relative attenuation

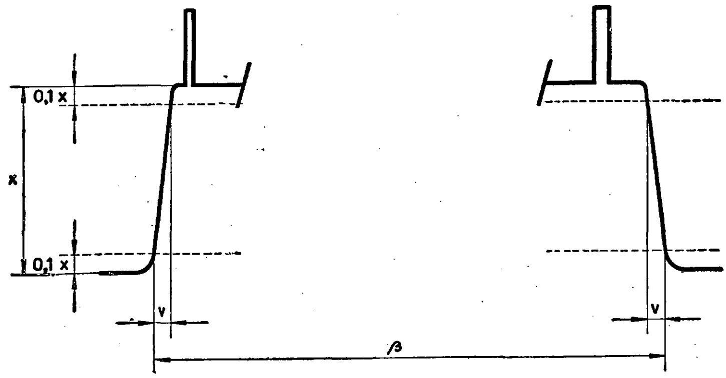


Horizontal dimensions are not to scale

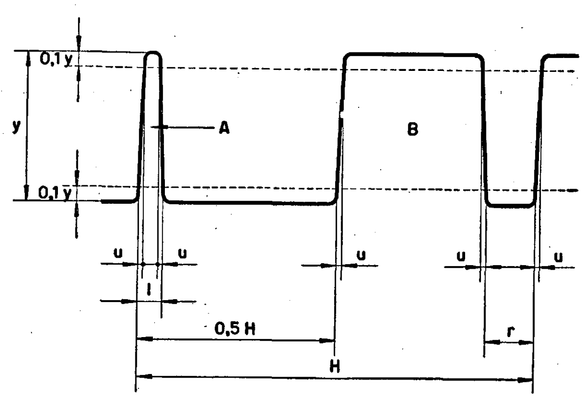
The length of the time intervals T^1, T^2 and T^3 is between 2.5H and 3H. Consequently, there are between 5 and 6 equalisation or synchronisation pulses in each interval.

FIGURE 14

Synchronising waveform, O.I.R. 625-line system for 8 Mc/s channel width



Details of field suppression pulse *(2b)*



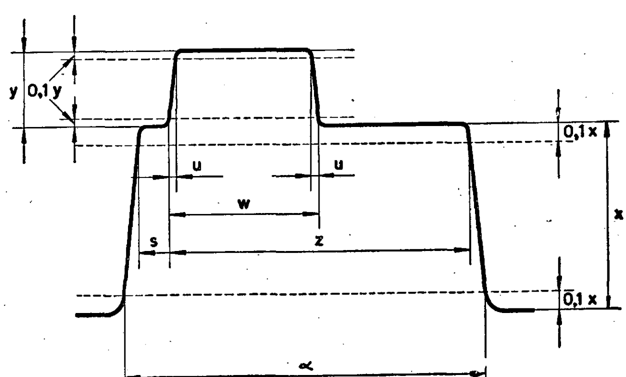
Notation

A. Equalising pulse

B. Field sync. pulse

Note: The numerica values of the tolerances are shown in the table.

Details of equalising and field synchronising pulses *(2c)*



Details of line synchronising pulse *(2a)*

FIGURE 15

Details of synchronising waveform, O.I.R. 625-line system for 8 Mc/s channel width

TABLE VI

Information on Figures 14 and 15

(O.I.R. 625-line system for 8 Mc/s channel width)

Notation	Approximate duration	
H		64 μs
V	312.5 H	20000 μs
l	0.035 H to 0.045 H	2.24 μs to 2.88 μs
r	0.07 H to 0.09 H	4.48μs to 5.76μs
s	0.01 H to 0.02 H	0.64 μs to 1.28 μs *
u	Max. 0.004 H	Max. 0.256 μs
v	Max. 0.1 H	Max. 6.4 μs
w	0.07 H to 0.09 H	4.48 μs to 5.76 μs
z	0.15 H to 0.17 H	9.6 μs to 10.88 μs
α	0.18 H to 0.2 H	11.52 μs to 12.8 μs
β	23 H to 31 H	1470 μs to 2000 μs
T_1	2.5 H or 3 H	160 μs or 192 μs
T_2	2.5 H or 3 H	160 μs or 192 μs
T_3	2.5 H or 3 H	160 μs or 192 μs
T_4	2.51 H to 2.52 H ** or 3.01 H to 3.02 H	— —

* Preferably 0.015 H to 0.020 H (0.96 μs to 1.28 μs)

** Preferably { 2.515 H to 2.52 H or 3.015 H to 3.02 H

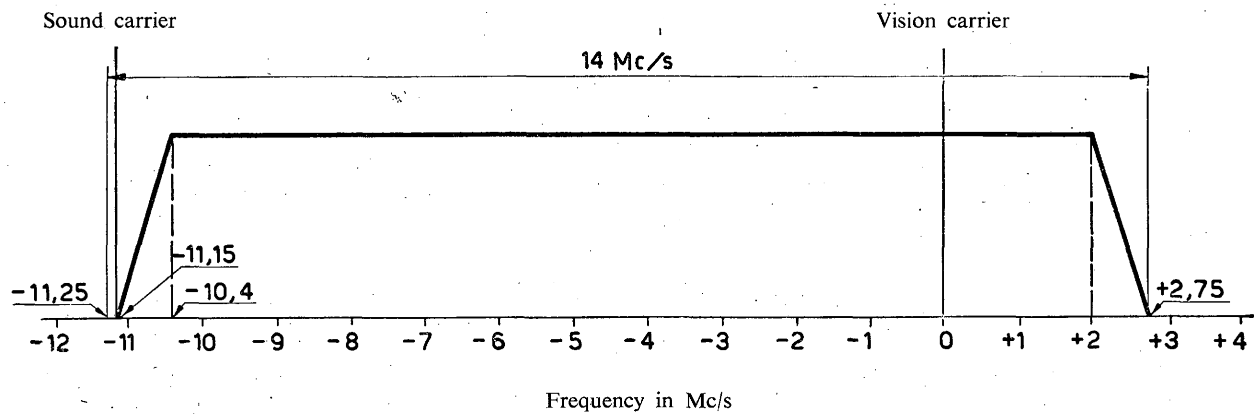
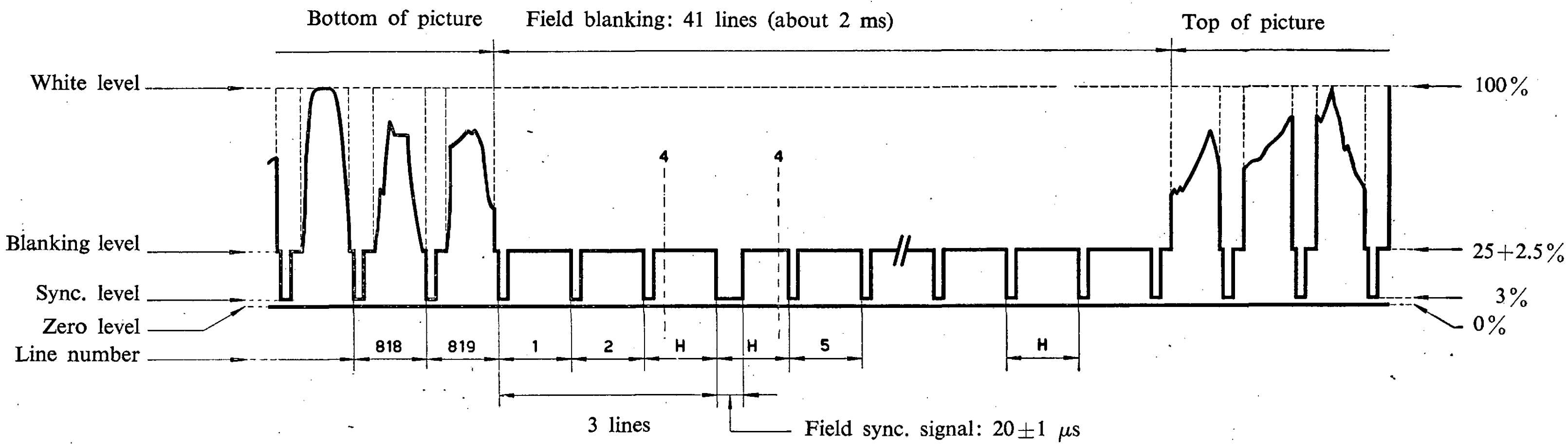


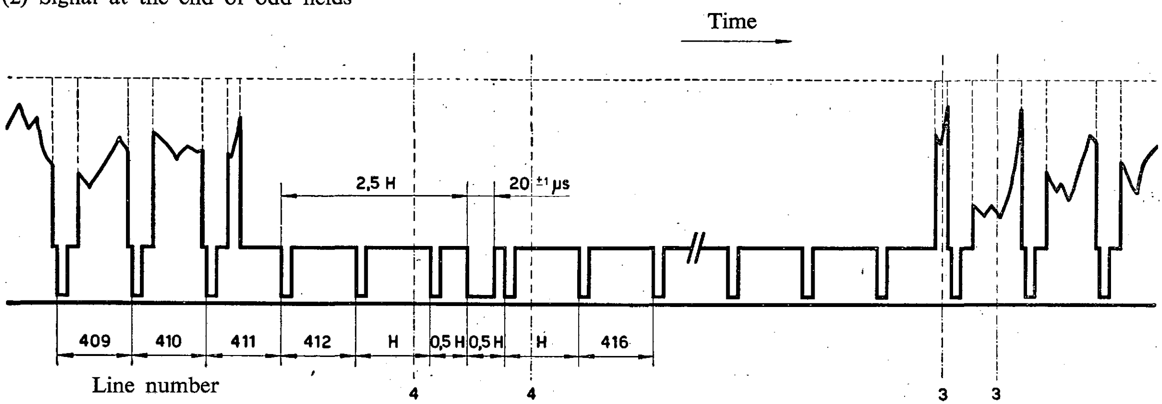
FIGURE 16

Ideal characteristic for vision transmitter, 819-line system

(1) Signal at the end of even fields



(2) Signal at the end of odd fields



The horizontal dimensions are not to scale

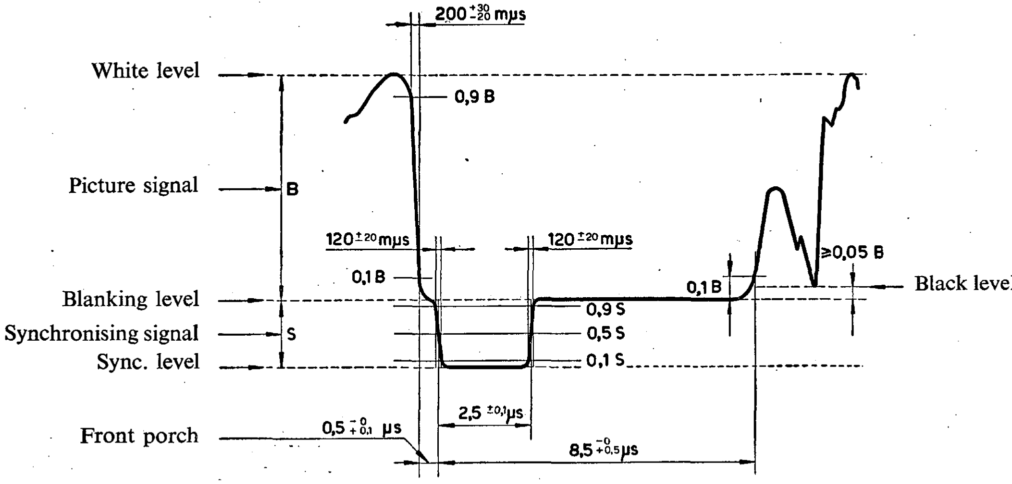
FIGURE 17

Synchronising waveform, 819-line system

TABLE VII

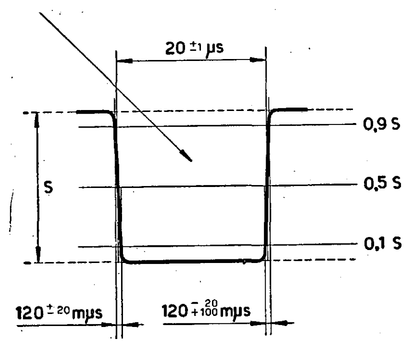
Interval in μs	Fraction of period H
1	0.02
2	0.04
3	0.06
4	0.08
5	0.10
6	0.12
7	0.14
8	0.16
9	0.18
10	0.20

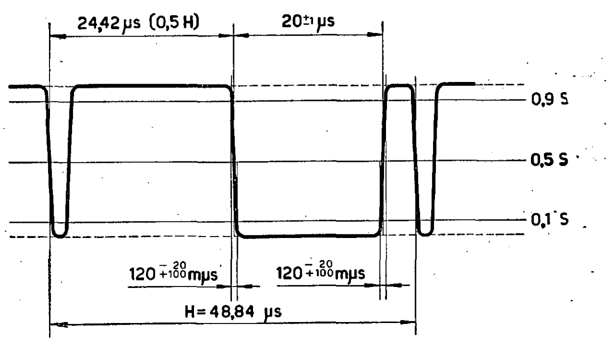
Note : This table has been calculated for the value H=50 μs, whereas the exact duration of a line is 48.84 μs.



Details of interval 3-3 in **(2)** of Figure 17.
Line synchronising signal

Field synchronising signal



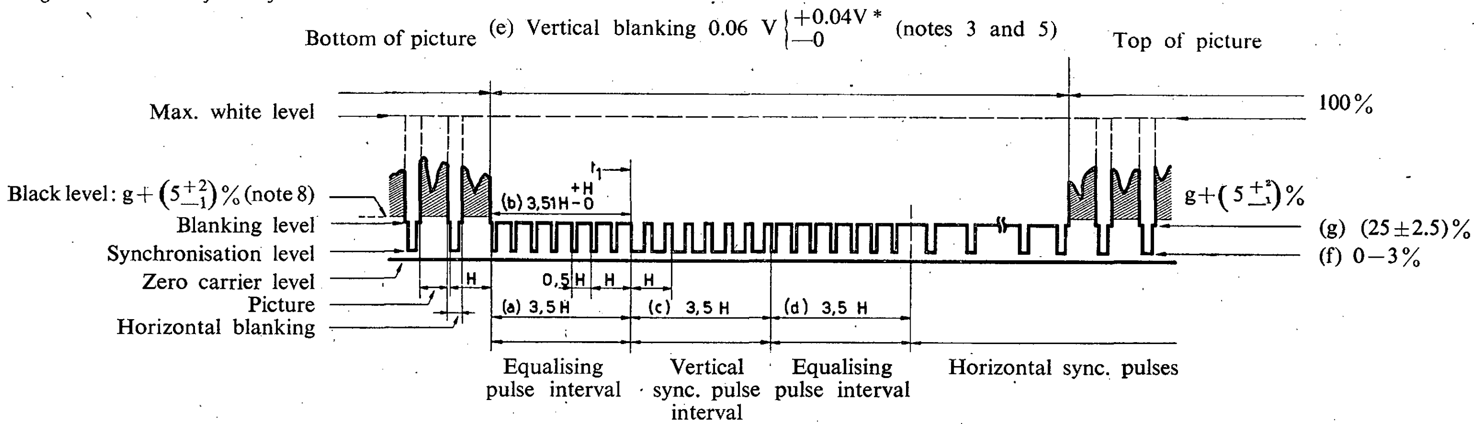


Details of interval 4-4 in **(1)** and **(2)** of Figure 17.
Field synchronising signal

FIGURE 18

Details and duration of synchronising waveform, 819-line system

(1) *Signal at the end of even fields*



(2) *Signal at the end of odd fields*

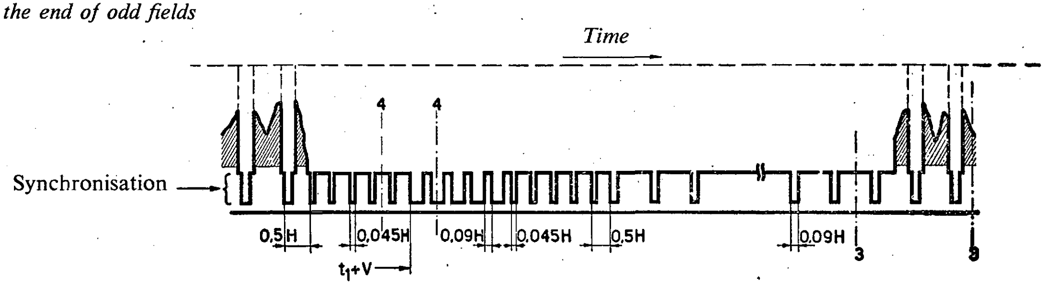
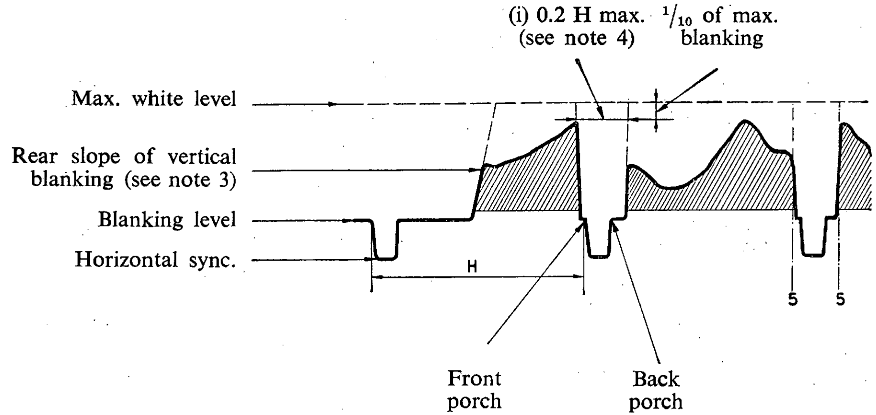
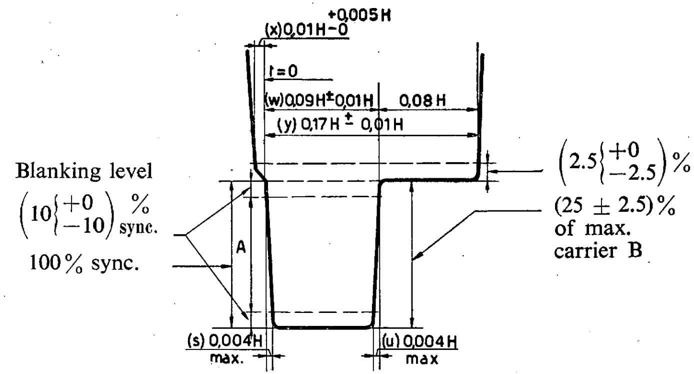


FIGURE 19

Synchronising waveform, Belgian 819-line system

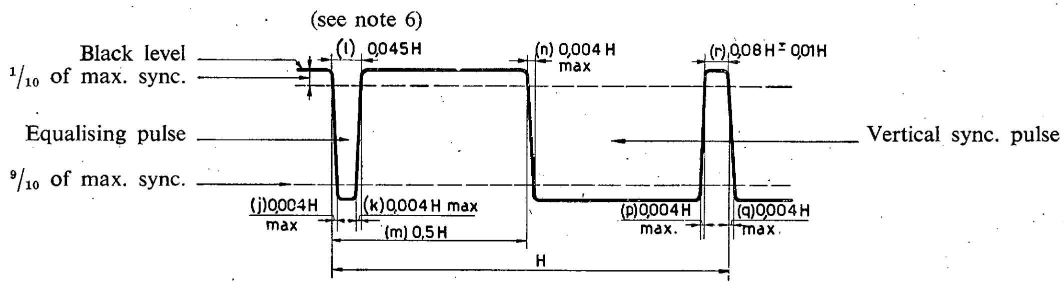


(3) Details between 3-3 in (2) of fig. 19



A. Measured before modulation
B. Measured after ideal detection

(5) Details between 5-5 of (3)



(4) Details between 4-4 in (2) of fig. 19

Note. — The dimensions are not to scale

FIGURE 20

Details of synchronising waveform, Belgian 819-line system

Notes

concerning Figures 19 and 20
(Belgian 819-line system)

1. H=Time from start of one line to start of next line.
2. V=Time from start of one field to start of next field.
3. Leading and trailing edges of vertical blanking should be complete in less than 0.1 H.
4. Leading and trailing slopes of horizontal blanking must be steep enough to preserve the min. and max. values of (x+y) and (i) under all conditions of picture content.

*5. Dimensions marked with an asterisk indicate that tolerances given are permitted only for longt ime variations, and not for successive cycles.

6. Equalising pulse area shall be between 0.45 and 0.5 of the area of a horizontal sync. pulse.
7. The horizontal sweep frequency shall be 20475 c/s ±0.1 %.
8. Provisional data.

Table VIII

Information on Figures 19 and 20
(Belgian 819-line system)

Notation	Approximate Duration	
H		49 μs
V	409.5 H	20 000 μs
a	3.5 H	171 μs
b	3.51 to 4.51 H	172 to 221 μs
c	3.5 H	171 μs
d	3.5 H	171 μs
c	24.5 H to 41 H	1200 to 2000 μs (see notes 3 and 5)
i	<0.2 H	<9.8 μs (see note 4)
j	<0.004 H	<0.19 μs
k	<0.004 H	<0.19 μs
l	0.045 H	2.2 μs (see note 6)
m	0.5 H	24.5 μs
n	<0.004 H	<0.19 μs
p	<0.004 H	<0.19 μs
q	<0.004 H	<0.19 μs
r	0.07 H to 0.09 H	3.6 to 4.4 μs
s	<0.004 H	<0.19 μs
u	<0.004 H	<0.19 μs
w	0.08 H to 0.1 H	3.9 to 4.9 μs
x	0.01 H to 0.015 H	0.49 to 0.74 μs
y	0.16 H to 0.18 H	7.8 to 8.8 μs

REPORT No. 84 *

REQUIREMENTS FOR THE TRANSMISSION OF TELEVISION OVER LONG DISTANCES

(Study Programme No. 32 (XI))

(Warsaw, 1956)

I. General

1. *Definition of a long-distance television link.*

The C.C.I.F. has established the following definitions for a television circuit AD for international television transmission by cable (see Figure 1 below):

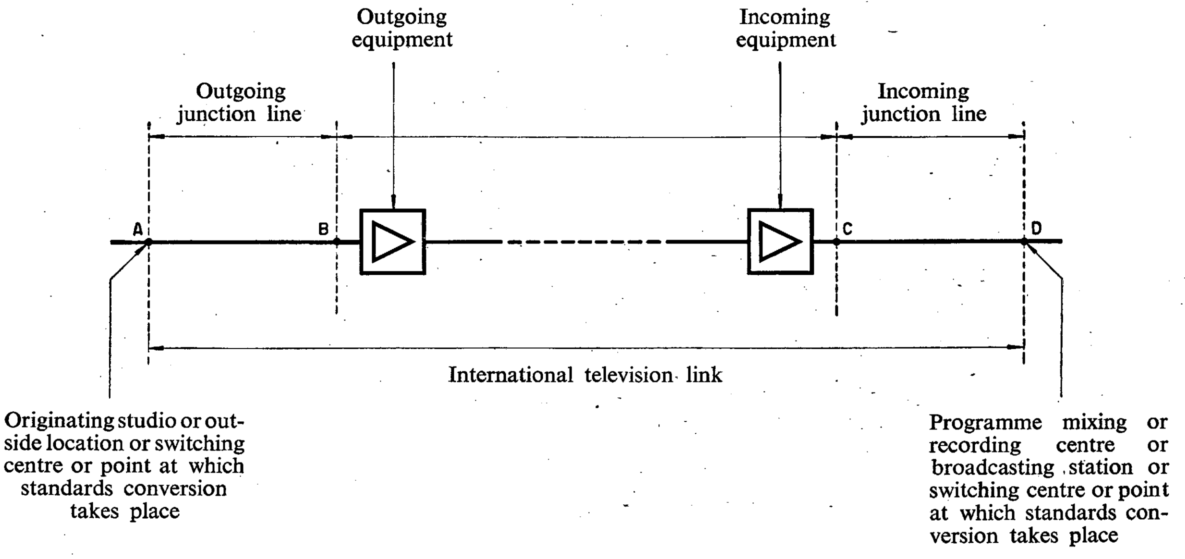


FIGURE 1

Plan of an international television link

* This Report was adopted unanimously.

(a) the point to be considered as the beginning of the international television link, point A, may be the point at which the programme originates (studio or outside location) or a television switching centre or a point at which standards conversion takes place;

(b) the junction line connecting the point A to the terminal station, point B, of the international television line;

(c) the long-distance international television line, BC, comprising a chain of national and international television transmission circuits, the national circuits having the same performance as the international circuits;

(d) the junction line connecting the terminal station C to the final destination of the television signals, point D;

(e) the point D, final destination of the television signals, which may be a programme mixing or recording centre, a broadcasting station, a switching centre or a point at which standards conversion takes place.

The combination AD of the long distance international line BC and the junction lines AB and CD constitutes the " international television link ".

The C.C.I.R. agrees to the adoption of this definition for radio relay systems or mixed cable and radio relay systems. It considers that the requirements given in Section II below can be regarded as applicable to the long-distance line BC. It is assumed that the junction lines AB and CD do not cause appreciable distortion.

2. *Hypothetical reference circuit*

The C.C.I.R. recommends for a radio relay link system a hypothetical reference circuit 2500 km long, having two intermediate points which divide the circuit into three equal lengths, and at which demodulation and remodulation of the signal takes place.

Note :

The hypothetical reference circuit is assumed to contain no standards conversion or synchronising-pulse regeneration equipment.

3. *Video connection points*

In some cases the precise points to be regarded as the terminals B and C of a long distance line may not be immediately apparent. In such cases, the points to be regarded as the terminations of the long-distance line shall be nominated by the authorities concerned.

II. Requirements for the transmission of monochrome television signals.

Note :

In the following list of requirements, paragraphs 1, 2 and 3 refer to parameters at the terminals of any long distance video-to-video link, whatever its length, while paragraphs 4, 5, 6, 7 and 8 refer to the performance requirements for a circuit corresponding to the hypothetical reference circuit defined in Section I, § 2. It is assumed that the three video-to-video circuits included in the hypothetical reference circuit are lined up independently and the performance requirements should be met without overall adjustments.

The specifications given in paragraphs 4, 5, 6, 7 and 8 below are to be considered as design objectives and not as standards to be fulfilled by circuits either existing or under construction. Some of these specifications have, in the past, been considered as applicable only to circuits of 1000 km maximum length without intermediate video junction points, but the C.C.I.R. considers it extremely desirable that the specifications shall be accepted for all monochrome television systems for the hypothetical reference circuit of 2500 km with two intermediate video junction points.

The possibility of accepting these specifications as standards for the hypothetical reference circuit shall be studied as soon as possible by the joint C.C.I.R./C.C.I.T.T. group.

1. *Impedance.*

The impedances looking into the video input (point B) or output (point C) of a long distance line, or at intermediate video junction points between the points B and C, shall have a nominal value of 75 ohms with one terminal connected to earth, and a return loss * of not less than 24 db relative to 75 ohms.

2. *Polarity and D.C. component.*

The polarity of the signals at any video connection point shall be positive, i.e. such that passage from black to white produces an increase, in the algebraical sense of the word, of the potential at the terminal which is not connected to earth (see figure 2 below).

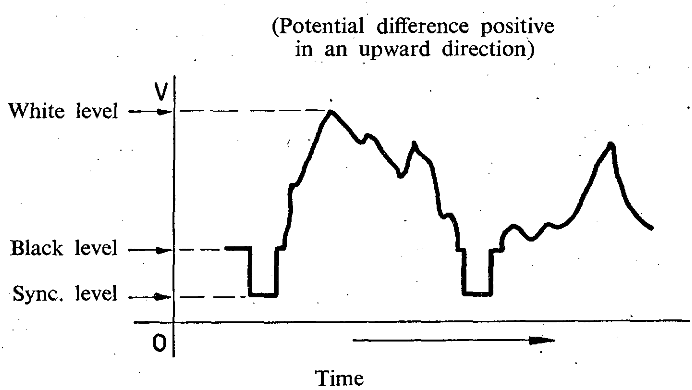


FIGURE 2

The useful D.C. component (i.e. the component which is related to the average overall illumination of the picture) may, or may not, be present in the signal from the video source and need not be transmitted over a link or delivered at the output terminals.

Any unwanted D.C. component accompanying the signal and quite unrelated to it (e.g. the component due to D.C. valve supplies) shall not cause more than 0.5 watt to be dissipated in the impedance (nominally 75 ohms) to which it is connected. Should this load impedance be disconnected, the voltage of the unwanted component shall not exceed 60 volts.

3. *Peak-to-peak amplitude of overall signal* **.

At the points B *** and C, nominated as the terminals of the long-distance line, the nominal peak-to-peak amplitude of the overall signal shall be one volt, the synchronising signal amplitude **** being 0.3 volt.

4. *Gain.*

The gain of the hypothetical reference circuit upon initial setting up as measured by the method given in the Recommendation No. 213 shall lie within the limits $\pm$ 1 db.

---

* The return loss of an impedance Z relative to 75 ohms is:

$$20 \log_{10} \left| \frac{75+Z}{75-Z} \right| \text{ decibels}$$

** Theoretically the amplitude should be measured with the useful D.C. component of the video signal restored, but in practice this is not necessary.

*** In cases where the connecting cable between the point B (see section I, 3) and the input terminals of the actual modulation equipment has an attenuation which is not negligible, the voltage at the terminals of the modulating equipment may be somewhat lower than one volt.

**** The synchronising signal amplitude is measured from the bottom of the signal to the blanking level.

5. *Gain stability.*

After initial setting up, the variation of gain of the hypothetical reference circuit shall not exceed the following limits:

(a) short-period variations (e.g. 1 second): ± 0.3 db,

(b) medium-period variations (e.g. 1 hour): ± 1.0 db.

6. *Non-linearity.*

When a circuit corresponding to the hypothetical reference circuit is tested in the manner described in Annex II of this Report, the linearity should be such that:

(a) For the picture signal: the amplitude of the high-frequency wave shall not at any point on the sloping edge of the sawtooth fall below 80% of its maximum value.

(b) For the synchronising signal: the amplitude of the synchronising pulses shall lie within + 10% to − 30% of the nominal value (0.3 volt) over the range of picture content provided by the test signal.

7. *Signal-to-noise ratio.*

The values given below should be achieved for not less than 99% of the time, the total observation period being 1 hour *.

The values quoted are a translation into decibels of the ratio:

$$\frac{\text{peak-to-peak amplitude of picture signal (excluding synchronising pulses)}}{\text{r.m.s. ** amplitude of noise in the bandwidth } (0 \text{ to } f_c)}$$

in the case of continuous noise, f_c being the upper limit of the frequency band for the system considered, and of the ratio:

$$\frac{\text{peak-to-peak amplitude of picture signal (excluding synchronising pulses)}}{\text{peak-to-peak amplitude of noise}}$$

in the case of periodic noise or discontinuous random noise.

Below are given, for the different systems, the figures for:

(a) continuous random noise with a uniform energy versus frequency spectrum;

(a') continuous random noise with the spectrum energy rising with frequency at a rate of 6 db per octave;

(b) periodic noise.

405-line system

(a) 48 db *(a')* 40 db	f_c = 3 Mc/s	Using the weighting network described in Annex III a figure of 54 db for the ratio of signal to weighted noise may be used for noise having any spectrum distribution of energy.

(b) 30 db for power-supply hum including lower order harmonics ***
50 db between 1 kc/s and 1 Mc/s
50 db at 1 Mc/s decreasing linearly to 25 db at 3 Mc/s.

* The precise meaning intended by "99% of the time" requires further study.

** The r.m.s. value for continuous random noise is recommended rather than the quasi peak-to-peak value specified in the draft report of Sub-Group XI-D (London, 1953, Vol. 1, p. 270) because there is some difficulty in fixing the ratio of the quasi peak-to-peak to r.m.s. values.

*** This means that the composite power-supply hum waveform, including harmonics, should have a peak-to-peak amplitude at least 30 db lower than that of the picture part of the signal and assumes that such interference can subsequently be substantially reduced by suitable clamp circuits. It refers to hum added to the signal and not to hum which in transmission has modulated the amplitude of the signal and which cannot be removed by clamping.

625-line and Belgian 819-line systems

(a) 48 db } f_c = 5 Mc/s when the r.f. channel is 7 Mc/s
(a') 41 db } f_c = 6 Mc/s when the r.f. channel is 8 Mc/s

(b) 30 db at 50 c/s
45 db at 100 c/s
50 db from 1 kc/s to 1 Mc/s
50 db at 1 Mc/s decreasing linearly to 30 db at f_c

819-line system

(a) * } f_c = 10 Mc/s
(a') 37 db }

(b) linear variation between the points:
30 db at 50 c/s
45 db at 100 c/s
50 db at 1 kc/s and 1 Mc/s
20 db at 7 Mc/s
20 db from 7 Mc/s to 10 Mc/s

8. *Transmission response.*

A. *Transient response*

The transient response of the line will be measured for three ranges of frequencies:

- low frequencies
- middle frequencies
- high frequencies

The limits imposed at low and middle frequencies are valid for all monochrome television systems.

Low frequencies

Test signal No. 1 as described in Annex I.
Tilt not to exceed ± 10%.

Middle frequencies

Test signal No. 2 as described in Annex I.
Tilt not to exceed ± 5% (desirable value ± 3%)
(Only the part of the signal between times $t_1 + 1\ \mu s$ and $t_2 - 1\ \mu s$, t_1 and t_2 being the times at which the signal passes through the half-amplitude values, should be considered).

High frequencies

405-line system.

Test signal No. 2 as described in Annex I, including sine-squared pulse (T-duration). For the 405-line monochrome television system on the hypothetical reference circuit of 2500 km an overall rating factor ** not exceeding 5 % (K = 0.05) should be taken as the design objective. In addition as a precaution against possible overloading effects, it is recommended that the gain at any frequency in the signal band should not exceed the gain at line-repetition frequency by more than 5 db.

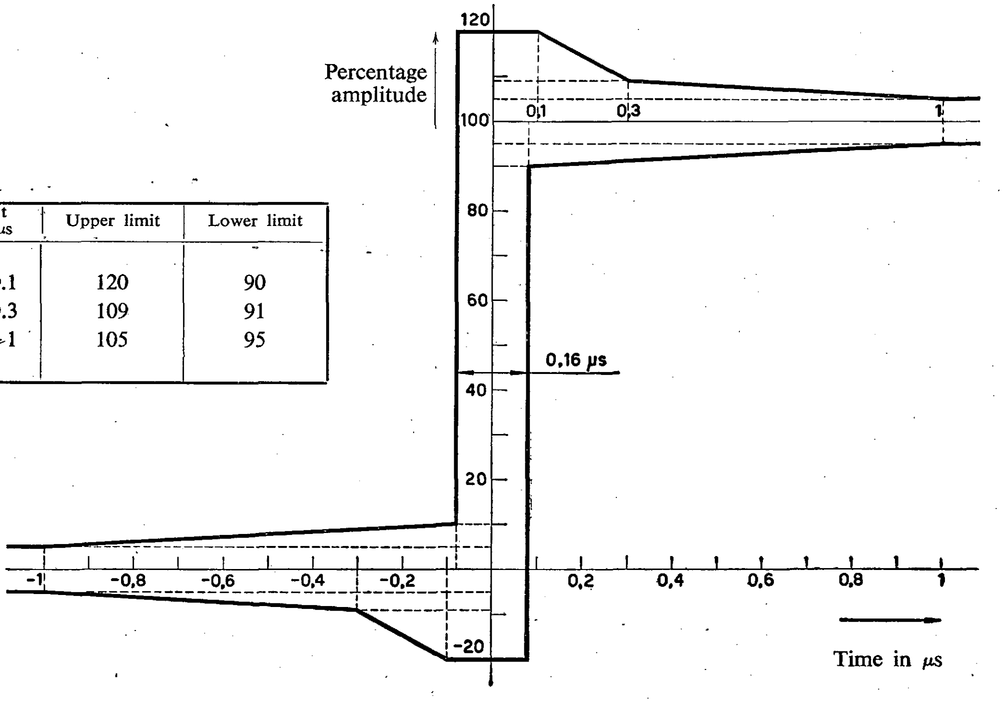
625-line (7 Mc/s radio-frequency channel) and 819-line Belgian systems

Test signal No. 2 as described in Annex I.
Response to lie within tolerances given in Fig. 3 for a 2500 km hypothetical reference circuit.

---

* Noise of type *(a)* only arises in transmission by coaxial cable and no value is given as this type of transmission is not at present used for the 819-line system.

** Annex IV (Doc. 154, Warsaw 1956) describes a method of measuring the wave-form response of a television link, the result being expressed in terms of a percentage known as the " rating factor " or decimally in terms of " K " value.



t µs	Upper limit	Lower limit
0.1	120	90
0.3	109	91
⩾1	105	95

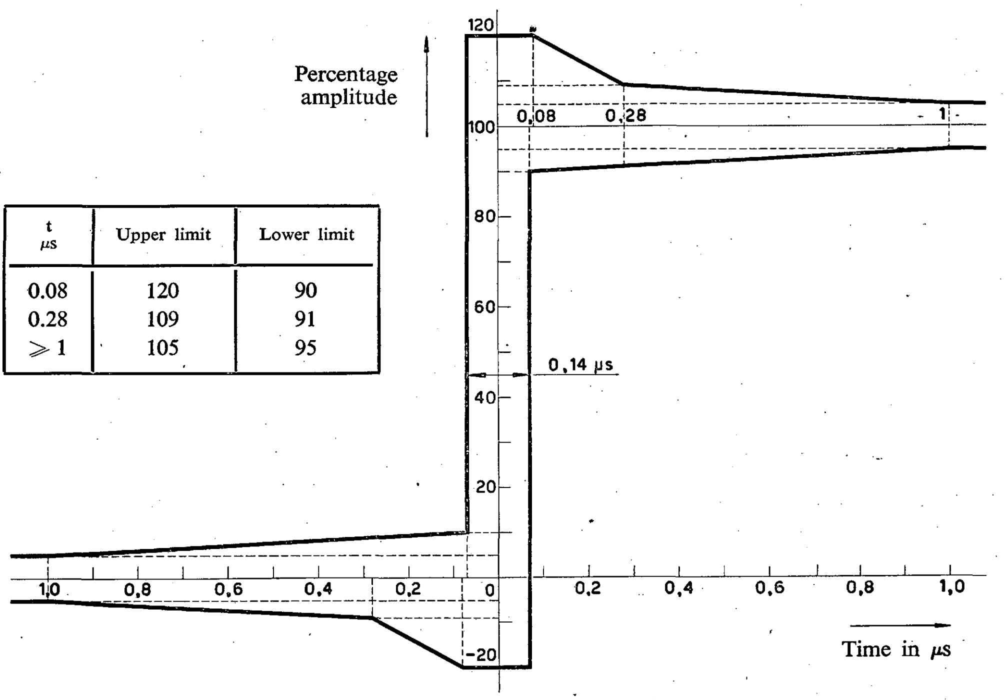
FIGURE 3

Limits on the transient response of test signal No. 2 for 625-line (7 Mc/s radio-frequency channel) and Belgian 819-line systems

625-line (8 Mc/s radio-frequency channel) system

Test signal No. 2 as described in Annex 1.

Response to lie within tolerances given in Fig. 4 for a 2500 km hypothetical reference circuit.



t μs	Upper limit	Lower limit
0.08	120	90
0.28	109	91
⩾ 1	105	95

FIGURE 4

Provisional limits on the transient response of test signal No. 2 for 625-line (8 Mc/s radio-frequency channel) systems

819 line system

Test signal No. 2 as described in Annex 1.
Response to lie within tolerances given in Fig. 5 for 2500 km hypothetical reference circuit.

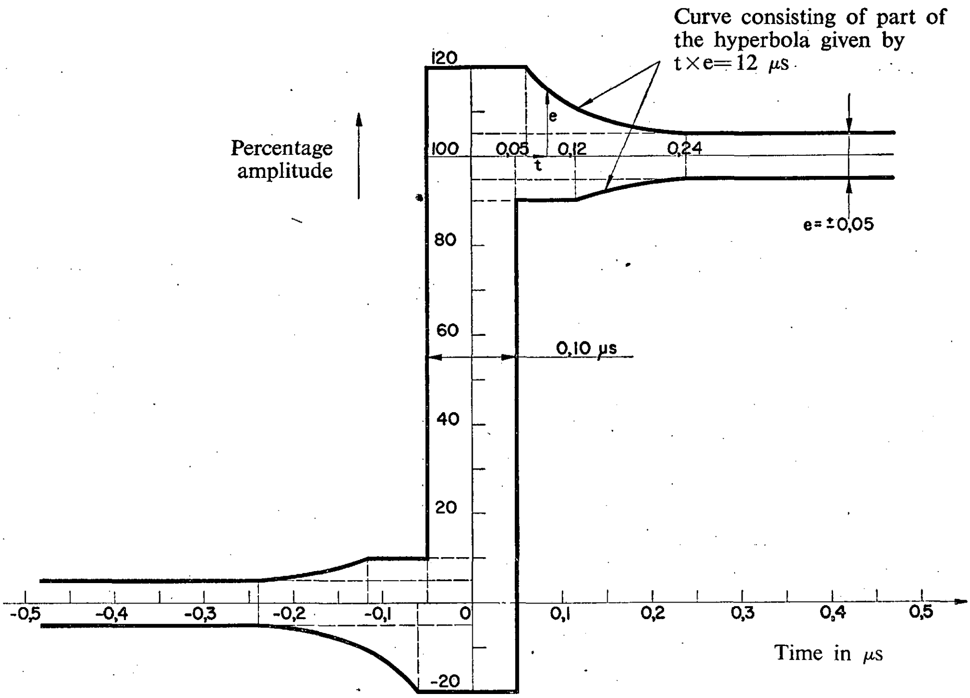


FIGURE 5

Limits on the transient response of test signal No. 2 for 819-line system

B *Steady state response*

405-line system

No specifications.

625-line systems and Belgian 819-line system

As additional information for guidance to designers the following specifications for the amplitude/frequency and phase/frequency characteristics are given:

1. *For channel width 7 Mc/s.*

Attenuation (db)

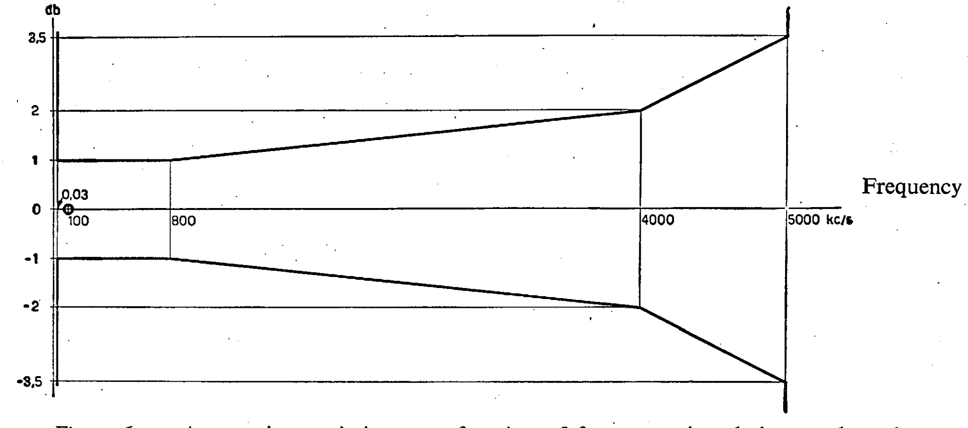


Figure 6. — Attenuation variation as a function of frequency, in relation to the value for 100 kc/s

Group delay (microseconds)

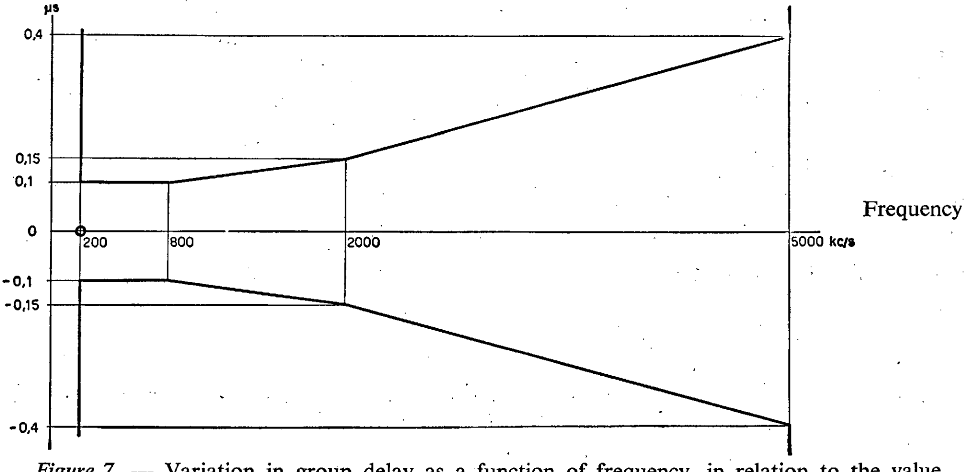


Figure 7. — Variation in group delay as a function of frequency, in relation to the value for 200 kc/s

FIGURES 6 AND 7. — *Amplitude and phase characteristics provisionally proposed for television transmission circuits (625-line system)*

Notes. — 1. Moreover, in an interval of 100 kc/s, the variation should not exceed 0.1 microsecond. The limits for envelope delay may appear somewhat wide; no closer limits can be fixed at present.

2. On the other hand, the " phase-change frequency " characteristic for 30 c/s to 200 kc/s should not deviate by more than ±6° from a straight line with an ordinate origin equal to 0 or to a whole multiple of 360°.

2. *For channel width 8 Mc/s* (as for 1), except that the frequency 5000 kc/s should be changed to 6000 kc/s.

819 line system

As additional information for guidance to designers the following specifications for the amplitude/frequency and phase/frequency characteristics are given:

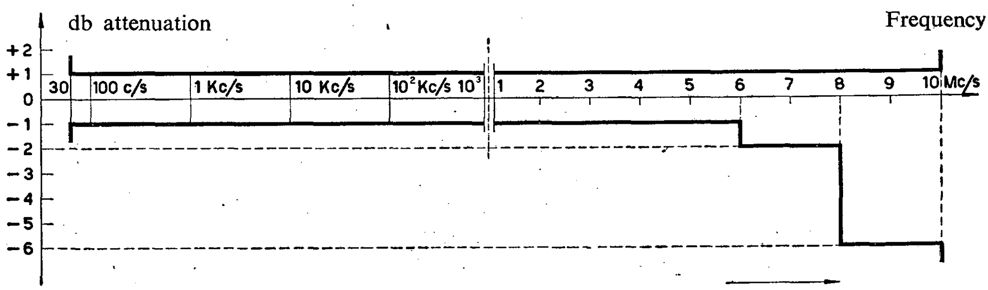
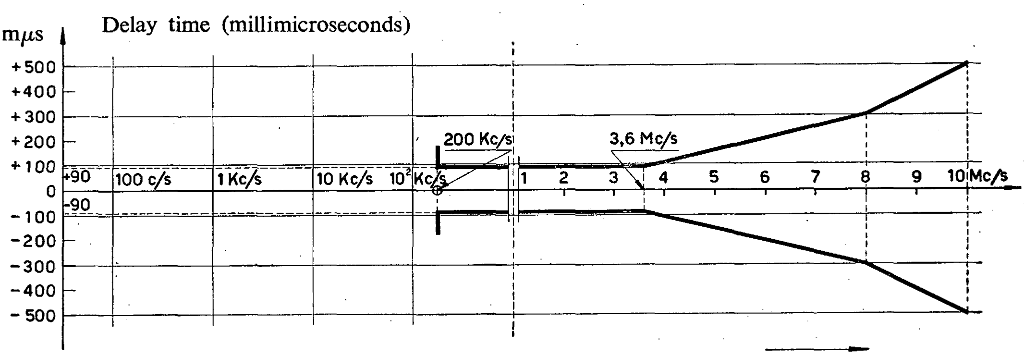


Figure 8. — *(a)* Attenuation variation as a function of frequency, in relation to the value for 100 kc/s



Note : ⊕ Normal starting point of the curve. 1 mμs=10^{-9}s.

Frequency

Figure 9. — Variation in group delay as a function of frequency, in relation to the value for 200 kc/s

FIGURES 8 AND 9. — *Amplitude and phase characteristics provisionally proposed for television transmission circuits (819-line system)*

III. Requirements for the transmission of colour television signals.

In the absence of theoretical or experimental data on the colour systems that may be brought into use, at least in Europe, it is impossible at present to indicate, even approximately, the corresponding requirements. It is reasonable to expect, however, that the requirements given in Section II for the transmission of monochrome signals might have to be modified to some extent.

ANNEX I

Transient response test signals

The test signals Nos. 1 and 2 given in Figures 10 and 11 of this Annex are recommended for testing the transient response of a television circuit.

The test signal No. 1 is used for testing the response to low frequencies. It comprises a square wave of field frequency superimposed upon normal synchronising and blanking signals with or without set-up.

The test signal No. 2 is used for testing the response to middle and high frequencies and may also be used for testing the gain as described in Recommendation No. 213. If desired an additional feature such as a sine-squared pulse or a high-frequency burst can be added in the space marked *(a)*. The set-up is shown as 5% but this may be reduced to 0 to simplify the test equipment if desired. The rise-time of the half-line bar is controlled by means of a shaping filter of the form described by W. E. Thomson. (Proc. I.E.E., Part III, 1952, Vol. 99, p. 373). Design-details of the filter suitable for measurements on a 3 Mc/s circuit are given in Annex IV of this Report. The shaping filter is designed to give a rise-time $T = \frac{1}{2f_c}$ but optionally a second filter giving a rise-time of 2 T may be used if desired.

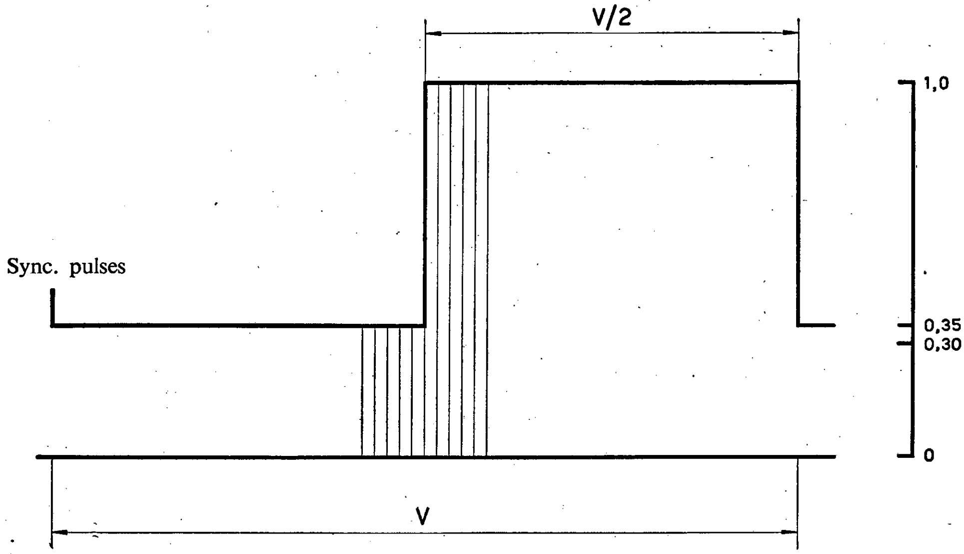
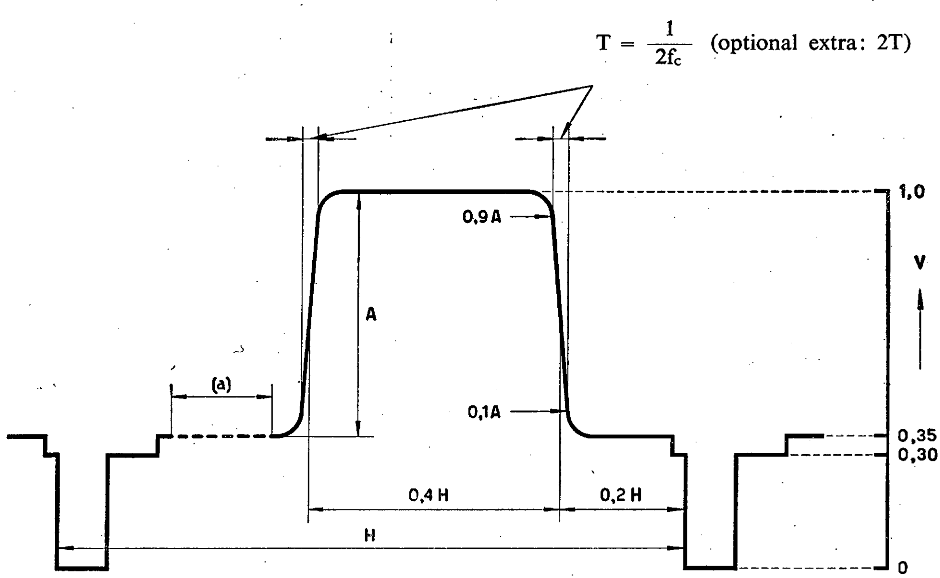


FIGURE 10

Test signal No. 1



(a) — space available for additional waveforms, e.g. sine-squared pulse, high-frequency burst, etc.

FIGURE 11

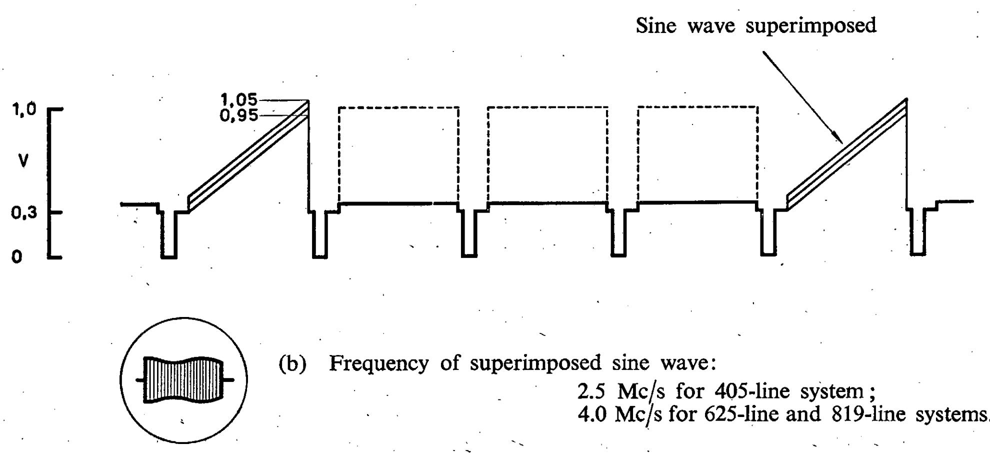
Test signal No. 2

ANNEX II

Linearity test signal

For assessing the linearity of a television circuit the following test is recommended. The test signal No. 3, given in Figure 12, is applied at the input of the circuit, first with the intermediate lines at black level and then with them at white level. The amplitude of the superimposed sine wave on the received signal at the output of the circuit is a measure of the linearity of the circuit over the picture part of the signal range. This amplitude may conveniently be displayed on an oscilloscope with the time base running at line-frequency by using a high-pass filter to separate the sine wave from the rest of the signal. The display then has the form indicated at *(b)* and non-linearity is indicated by changes of amplitude across the display.

Non-linearity as it affects the synchronising signals is assessed by direct measurement of the synchronising pulse amplitude, first with the intermediate lines at black level and then with them at white level.



(b) Frequency of superimposed sine wave:
2.5 Mc/s for 405-line system;
4.0 Mc/s for 625-line and 819-line systems.

Figure 12

Test signal No. 3

ANNEX III

Noise weighting network for the 405-line monochrome system

1. *Introduction.*

Brussels Document No. 51 gave details of a weighting curve which has been derived experimentally for noise in a 405-line monochrome television system. Clearly a network having a loss/frequency characteristic which is the inverse of this curve can be used as a weighting network for the measurement of noise in a television circuit and the ratio of signal to weighted noise at the threshold of visibility will then be the same for noise having any spectral distribution of energy. A simple network having the required characteristic is described in this paper and the conditions under which it may or may not be used are discussed.

2. *Network.*

A suitable constant-impedance 75-ohm network comprises two sections in tandem each having a time constant of 0.18 μs as shown in Figure 1. Its loss/frequency characteristic together with the desired weighting curve are shown in Figure 2.

The loss of the network to white noise in the band 0-3 Mc/s has been calculated and is 6.4 decibels; similarly for triangular (FM type) noise in the band 0-3 Mc/s it is 14.1 db. The lowest permissible signal-to-noise ratios for transmission over the hypothetical reference circuit are 48 and 40 db respectively (Doc. 153, Warsaw) so that the corresponding ratios of signal to weighted noise are 54.4 and 54.1 db respectively. A single figure of 54 db is sufficiently accurate for all practical purposes.

3. *Limitations on the use of the network.*

The network is suitable for use in the measurement of noise on circuits for the transmission of 405-line monochrome television signals when the noise is not substantially greater than the permissible value.

The network is not suitable for use with substantially higher levels of noise because:

(a) clamping equipment in a transmission circuit may convert high-frequency noise into low-frequency whole-line streaking effects of much greater subjective visibility,

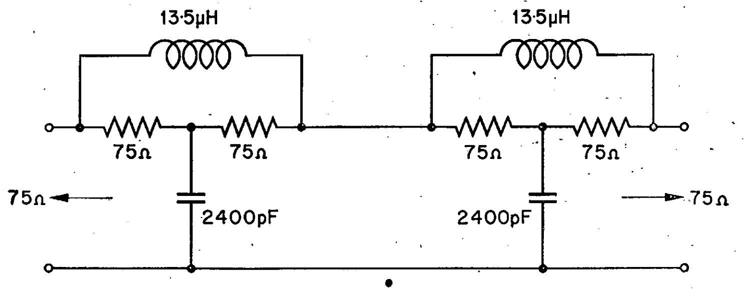
(b) where non-linear processes are involved at the end of a transmission circuit, e.g. in tele-recording, noise energy from the top end of the spectrum may be converted into effects corresponding to noise at much lower frequencies with a much higher subjective visibility.

The network is not suitable for the measurement of noise on circuits for the transmission of colour-television signals in cases when the chrominance signal is accommodated within the luminance band, but would be suitable for measurements on a separate luminance channel.

The network is not suitable for assessing the performance of cameras or other picture generating devices in which the noise level varies with luminance owing to gamma correction.

4. *Conclusion.*

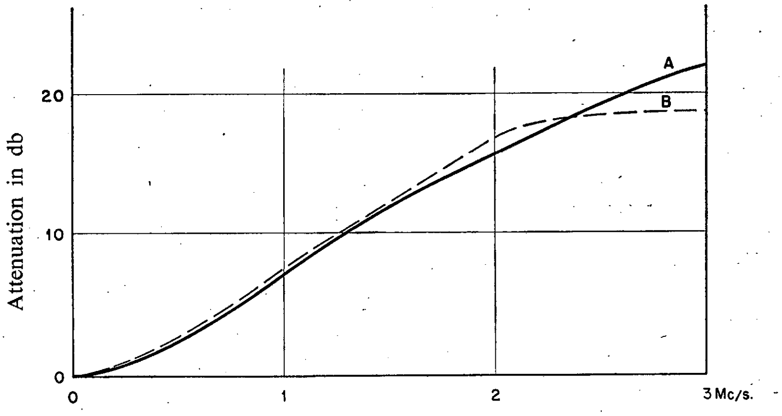
A network comprising two sections in tandem, each with a time constant of 0,18 μs is suitable for weighting noise in a 405-line monochrome television transmission circuit provided the noise level is not substantially greater than the permitted value.



Insertion loss=10 $\log_{10}$ $[1+2\ (\omega\tau)^2+(\omega\tau)^4]$ where $\tau=2400\times10^{-12}\times75=0\cdot18\mu s$

FIGURE 13

Constant impedance weighting network



A—Network insertion loss B—Inverted weighting curve

FIGURE 14

Loss characteristic of network

ANNEX IV *

WAVEFORM-TRANSMISSION PERFORMANCE OF TELEVISION LINKS AND EQUIPMENT FOR 405-LINE 3 MC/S MONOCHROME SYSTEMS

1. *Scope.*

This Document describes two complementary methods of specifying transmission performance, between video input and output terminals, of television links and equipment intended for use in 405-line 3-Mc/s monochrome systems. Distortions due to non-linearity are dealt with elsewhere.

2. *General.*

The present limitations of available waveform-measuring equipment make it necessary to distinguish two complementary methods of testing performance. The first, or " routine-test ", method is rapid but less precise because it relies on direct oscilloscopic observations of the responses to prescribed test signals, and because the spectrum of one of these signals unavoidably extends beyond the 3 Mc/s limit of interest. The second, or " acceptance-test ", method is slow but more precise because a computational process applied to a series of waveform ordinates (measured by travelling microscope on a photographic record, or by other means) enables irrelevant information to be eliminated and certain measuring-equipment errors to be corrected.

The routine-test method may be used for *(a)* checking the performance of a batch of items when type-approval has been given after a full acceptance test on one item, *(b)* detecting gross distortion during the initial tests of a new item, and *(c)* checking the performance of temporary links and similar items when conditions do not permit of a full acceptance test.

The performance limits are given in terms of a rating factor, K, for which numerical values are assigned in the individual specifications for links and equipment. Rating factors may range from several per cent for a complex system down to less than ½% (K = 0.005) for a simple video amplifier. The basis of reference of the rating-factor method is distortion consisting only of a single long-term echo, the rating factor then being numerically equal to the relative amplitude of the echo.

3. *Test-signal waveforms.*

The following four test signals are required for the routine-test method; only three of these are required for the acceptance-test method. All have a 1 volt peak-to-peak amplitude and include normal 0.3 volt line-synchronising pulses of 10 μs duration and 10 kc/s repetition frequency.

3.1 *T-pulse test signal.*

The T-pulse is of approximately sine-squared shape with a half-amplitude duration of 0.17 μs (a half-period of 3 Mc/s) and a repetition frequency of 10 kc/s. It is associated with synchronising pulses and may, in addition, be combined with the " 40-bar " in a composite pulse-and-bar test signal as shown in Fig. 15 *(a)*. The precise shape and duration of the T-pulse are determined by the pulse-shaping network detailed in Fig. 16, operated under the indicated conditions or their equivalent.

* Warsaw doc. No. 154 (United Kingdom).

3.2 *2T-pulse test signal.*

The 2T-pulse is similar to the T-pulse in all respects except that the half-amplitude duration is 0.33 μs (a whole period of 3 Mc/s). It is used only in the routine test method.

3.3 *40-bar test signal.*

This waveform consists of a " smoothed bar " of 40 μs duration, associated with synchronising pulses as shown in Fig. 15 *(a)*. Each of the bar transitions has approximately an integrated sine-squared shape with a 10-90% rise time of 0.33 μs. These transitions are determined by a pulse-shaping network identical with that detailed in Fig. 16 for the 2T-pulse, the driving waveform being specified to have transitions with 10-90% rise times not exceeding 0.07 μs.

3.4 *50-c/s square-wave test signal.*

This consists of a 50 c/s square wave associated with synchronising pulses as shown in Fig. 15 *(b)*.

4. *Routine-test method.*

To meet a specified rating factor K, the responses to the various test signals should fall within the limits stated in the following sub-sections.

4.1 *40-bar response.*

The limits are indicated by the oscilloscope mask shown in Fig. 17 *(a)*. In effect, the oscilloscope controls are to be adjusted so that the mid-points of the bar transitions coincide with M_1 and M_2, and the mid-points of the 40 μs " black " and " white " portions coincide with B and W respectively. The response should then fall within the $\pm$ K limits indicated by the full lines, which extend to 1 μs from each transition.

4.2 *2T-pulse response*

The limits are indicated by the oscilloscope mask shown in Fig. 17 *(b)*. In effect, the oscilloscope controls are to be adjusted so that *(a)* the sweep velocity corresponds with the time scale indicated, *(b)* the " black " level of the response coincides with the horizontal axis, *(c)* the peak of the response falls on the unit-amplitude line, and *(d)* the half-amplitude points of the response are symmetrically disposed about the vertical axis.

4.3 *Bar/pulse ratio*

The ratio of the amplitude of the 40-bar response to the amplitude of the 2T-pulse response should fall within the limits $1 \pm 4K$. The amplitude of the bar is taken as the amplitude-difference between the points B and W already defined; the amplitude of the pulse is the difference between the " black " level and the peak of the response. These limits are also shown in Fig. 17 *(a)*.

4.4 *T-pulse response.*

In the routine-test method, only a few features of the T-pulse response need to be specified. The normal limits for these are given in the following table:—

Features	Rating factors					
	1%	2%	3%	4%	5%	6%
Half-amplitude duration, maximum, μs	0.245	0.250	0.255	0.260	0.265	0.270
Ringing frequency minimum, Mc/s	3	3	3	3	3	3
First lobe (negative), leading or trailing, maximum, %	10	12	14	16	18	20
Second lobe (positive), leading or trailing, maximum, %	6	8	9	10	11	12

Because the T-pulse has a frequency spectrum with appreciable components above 3 Mc/s, the responses of links or equipment depend to some extent upon their upper cut-off characteristics. For this reason, link or equipment specifications permitting the use of the routine-test method may in some cases call for limits different from those given above.

4.5 *50 c/s square-wave response*

The limits are indicated by the oscilloscope mask shown in Fig. 17 *(c)*. As for the 40-bar response, the oscilloscope controls are to be adjusted so that the waveform passes through the four marked points, the synchronising pulses being ignored.

5. *Acceptance-test method.*

5.1 *40-bar response.*
The limits are identical with those given in paragraph 4.1 for the routine-test method.

5.2 *T-pulse response.*

From the measured T-pulse response and the measured or assumed response of the measuring equipment itself, the " filtered impulse response " is derived and expressed in the form of a normalised time series. The " main " term of this series represents the ideal or non-distorting part of the transmission properties of the item under test, while the " echo " terms represent the distorting part. To meet a specific rating factor, K, the amplitudes of the echo terms should be such that each of the following four restrictions is met.

Let the time series representing the filtered impulse response be

$$B(rT) = \ldots B_{-r} \ldots B_{-1}, B_o, B_1, \ldots B_r \ldots$$

and assume that this has already been normalised so that $B_o = 1$.
Let the serial product of B(rT) and the series [½, 1, ½] be

$$C(rT) = \ldots . C_{-r}, \ldots C_{-1}, C_o, C_{+1}, \ldots C_{+r}, \ldots$$
$$\text{where } C_r = \tfrac{1}{2}B_{r-1} + B_r + \tfrac{1}{2}B_{r+1}$$

Restriction (i) is then given by:—

$$\frac{1}{8}\left|\frac{C_r}{C_o} - \frac{1}{2}\right| \leqslant K \qquad r = \pm 1$$

and

$$\frac{1}{8}\left|r\,\frac{C_r}{C_o}\right| \leqslant K \qquad \begin{cases} -8 \leqslant r \leqslant -2 \\ +2 \leqslant r \leqslant +8 \end{cases}$$

and

$$\frac{C_r}{C_o} \leqslant K \qquad \begin{cases} r < -8 \\ +8 < r \end{cases}$$

Restriction (ii) is given by:—

$$\frac{1}{4}\left|\frac{1}{C_o}\left(\sum_{-8}^{+8} B_r\right) - 1\right| \leqslant K$$

Restriction (iii) is given by:—

$$\frac{1}{6}\left|\sum_{-8}^{+8} B_r - 1\right| \leqslant K$$

and restriction (iv) is given by:—

$$\frac{1}{20}\left(\sum_{-8}^{+8} |B_r| - 1\right) \leqslant K$$

The series C(rT) represents fairly closely the response to a 2T-pulse. Retriction (i) is thus approximately equivalent to the limits indicated in Fig. 17 *(b)* for the 2T-response in the routine-test method. Restriction (ii) is similar to the limits placed on the bar/pulse ratio in the routine-test method. Restriction (iii) is equivalent to limits placed on the bar/pulse ratio of the response to a hypothetical pulse-and-bar test signal in which the pulse is an ideal filtered impulse. Restriction (iv) is an upper limit placed on the average amplitude, ignoring signs, of the 16 central echo terms.

5.3 *50 c/s square-wave response.*

The limits are identical with those given in paragraph 4.5 for the routine-test method.

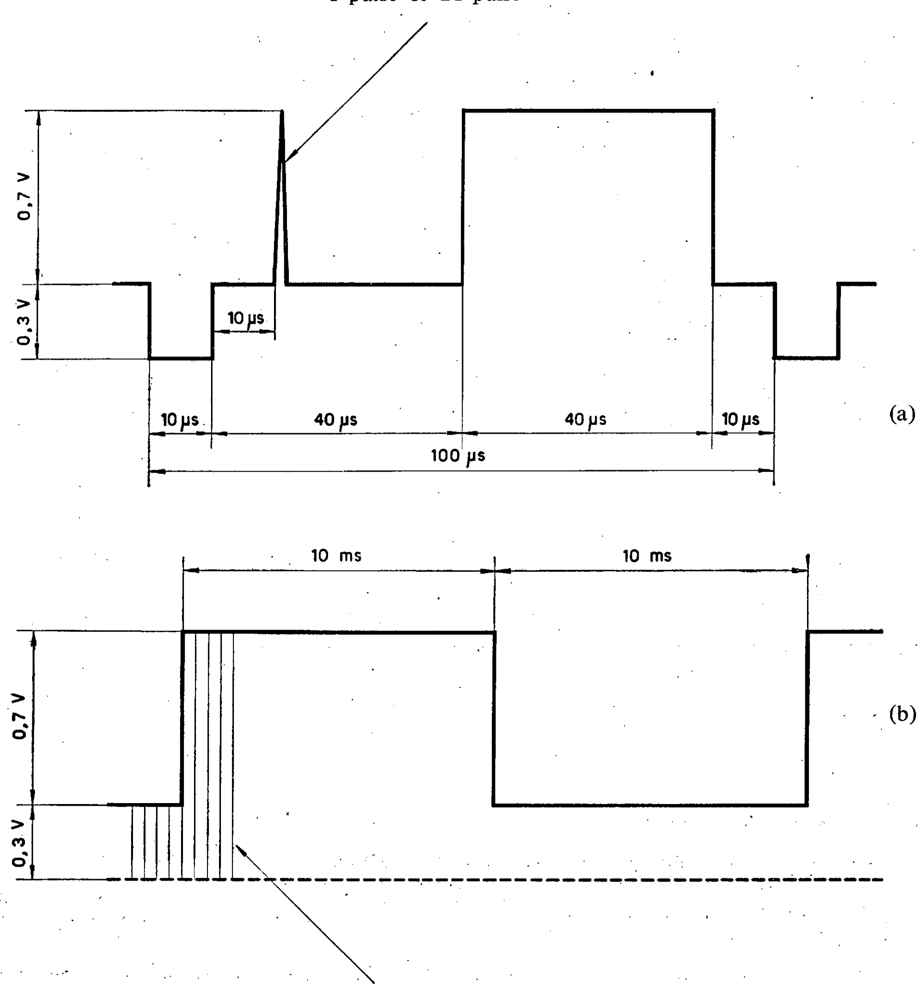
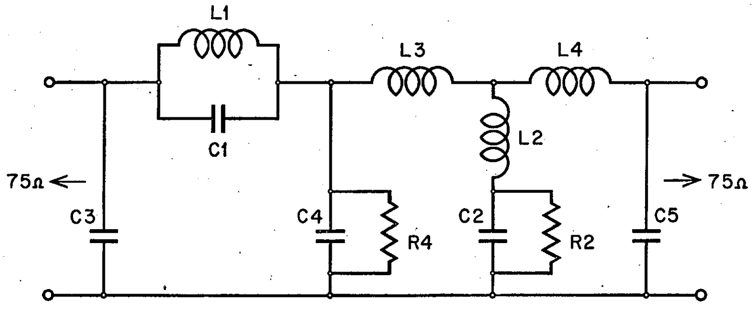


FIGURE 15
Test-signal waveforms

(a) T-pulse or 2T-pulse, and 40-bar
(b) 50 c/s square-wave



Component	Value		Tolerance	Q
	H.A.D. = 1/6 μs	H.A.D. = 1/3 μs		(Note 3)
L1	1.580	3.159	±1%	⩾ 70
L2	0.308	0.617	(Note 2)	⩾ 50
L3	3.091	6.182	±1%	⩾100
L4	3.035	6.069	±1%	⩾100
C1	79.22	158.4	±2%	
C2	2168	4335	±0.5%	
C3	75.92	151.8	±2%	
C4	566.4	1133	±0.5%	
C5	166.4	332.9	±2%	
R2	1300	1300	±5%	
R4	5100	5100	±5%	

FIGURE 16
Sine-squared pulse shaping network

Notes.

1. Inductances are given in μH, capacitances in pF, resistances in ohms.
2. Inductor L2 should be adjusted to make the insertion loss a maximum at 6.156 Mc/s for the 1/6 μs network, and at 3.078 Mc/s for the 1/3 μs network.
3. The values of Q should be measured at 4 Mc/s for the 1/6 μs network, and at 3 Mc/s for the 1/3 μs network.
4. The network should, if necessary, be connected between masking pads designed to present impedances of 75 ohms ± 1% to the network under operating conditions.
5. An allowance for stray capacitance should be made in the value of any capacitor if the total capacitance would otherwise exceed the given limit.
6. The design is from " solution 3 " given by W. E. Thomson " The synthesis of a network to have a sine-squared impulse response " proc. I.E.E., Vol. 99, part III, p. 373, 1952.
7. The half-amplitude durations of the driving pulses should not exceed 0.035 μs and 0.07 μs for the 1/6 μs and 1/3 μs networks respectively.

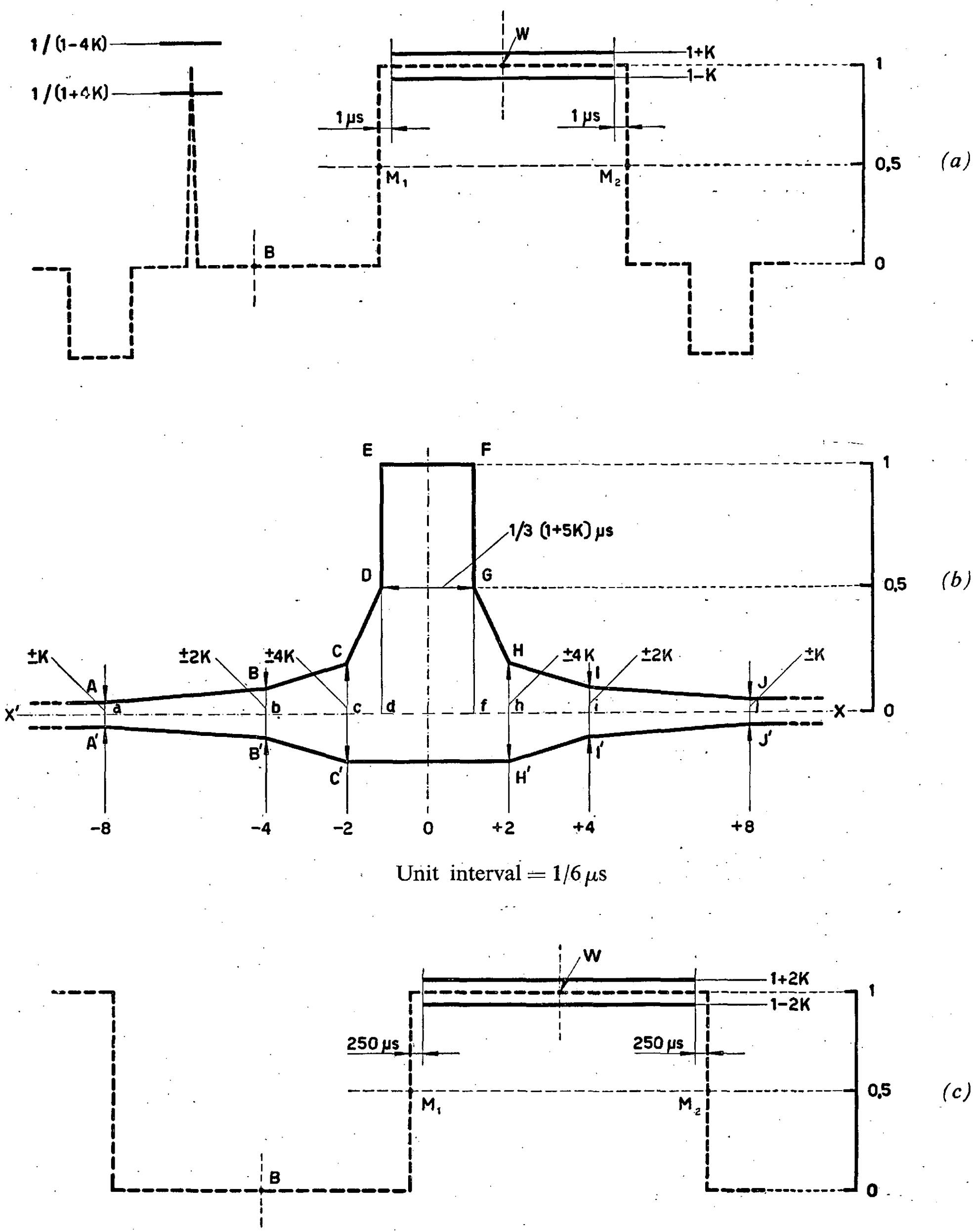


FIGURE 17

Waveform response limits

(a) Response to 40-bar test signal
(b) Response to 2T-pulse test signal
(c) Response to 50 c/s square wave test signal

REPORT No. 85 *

ADVANTAGES TO BE OBTAINED FROM CONSIDERATION OF POLARISATION IN THE PLANNING OF BROADCASTING SERVICES IN THE VHF (METRIC) AND UHF (DECIMETRIC) BANDS

Television and sound

(Question No. 101 (V))

(Warsaw, 1956)

Investigations have been conducted in several countries in order to ascertain the advantages which can be obtained in sound and television broadcasting by using polarisation discrimination in reception. Doc. 435 (Warsaw) describes an extensive study made in the United Kingdom at frequencies between 41 and 191 Mc/s and over distances from 20 to 280 km. Other more limited experimental work is described in Warsaw Docs. Nos. 267 (Netherlands), 512 (France) and Brussels Doc. No. 7 (Federal German Republic).

From these studies it is concluded that the median value of discrimination achievable at normal receiving sites by the use of orthogonal polarisation may be as much as 18 db, and that under these conditions the values exceeded at 90% and 10% of the receiving sites are about 11 db and 25 db respectively. These values of discrimination are likely to be better in open country, where the median value may be as much as 30 db, and worse in heavily built-up areas or places where the receiving aerial is surrounded by obstacles. For domestic installations in densely populated districts, a median value somewhat lower than 18 db should be adopted for planning purposes in the metric band. No significant changes in the polarisation of metric waves due to transmission through the troposphere have been observed.

It is considered that this report provides a partial answer to Question No. 101; further study is required, however, in order to furnish a complete answer to the question and this work should be undertaken by Study Group No. V.

Every effort should be made to complete the study of this question before the next conference on the assignment of frequencies in the bands mentioned above.

REPORT No. 86 **

DESIGN OF TRANSMITTING AERIALS FOR TROPICAL BROADCASTING

(Question No. 70)
(Study Group No. XII)

(London, 1953 — Warsaw, 1956)

This Report summarises the information submitted to the C.C.I.R. in answer to the three questions to be studied under § 1, 2 and 3, of Question No. 70.

1. The transmitting aerial should be situated as near to the centre of the reception area as possible.

   For aerials relying on ground reflection for their vertical directivity the site should be chosen where the soil is of good conductivity, though, in cases where this is not possible, an earth

* This Report was adopted unanimously.

** This Report replaces Report No. 36. (See Report No. 87).

mat can used. This could consist of a number of parallel wires spaced not more than one tenth of a wavelength apart, parallel to the dipoles and extending for half a wavelength beyond the extremities of the aerial array.

Where it is not possible to site the aerial at the centre of the reception area, it is possible, with multi-element transmitting aerials, to slew the beam away from the vertical in the direction of the main reception area (see Annex). Angles of slew greater than about 15 degrees often produce large side lobes which may cause interference outside the reception area.

If there are no adjacent reception areas, for example, where the area to be served is an isolated island, central siting is less important.

2. The transmitting aerial for tropical broadcasting should be designed to produce a more or less uniform field, with no skip zone, and of as high a value as possible throughout the reception area. Beyond this area the field strength should decrease as rapidly as possible. The aerial should be economical in design and simple in operation.

The aerial should therefore be designed to produce the greatest high-angle radiation possible consistent with adequate radiation down to the angle of radiation used to serve the fringe of the service area (see National Bureau of Standards Circular No. 462, p. 106). Thus for instance, a service area having an outer radius of about 800 km may require a low directivity aerial consisting of a simple dipole between a quarter and a half wavelength above earth but, for smaller areas, more directive multi-element aerials would be desirable in order to reduce the low-angle radiation * (see Annex).

It is considered desirable that the C.C.I.R. should include the curves shown in the Annex, or similar ones, in its antenna charts.

It is possible that the siting of the transmitting aerial used for tropical broadcasting with respect to the magnetic meridian has an influence on the field produced by reflection from the ionosphere. It is therefore requested that in answer to Question No. 69 (XII) dealing with propagation in the tropical zone, reference should be made to this point.

3. For the great majority of domestic tropical broadcast listeners only simple aerials are possible and the directivity of such aerials cannot be relied upon to improve the signal-to-noise ratio.

The aerial has to be both cheap and simple to install and has to be used on a number of frequencies, with fields corresponding to varying angles of incidence. It appears reasonable to assume that the average listener's aerial cannot be better than that given in the report of the Geneva Planning Committee; this consists of an L type aerial with horizontal and vertical limbs 16 feet in length (4.80 metres).

ANNEX

Notes on the performance of arrays of horizontal dipoles arranged for vertical incidence

1. *General.*

Arrays of this type consist of a number of rows of $\frac{\lambda}{2}$ dipoles end to end, the rows being $\frac{\lambda}{2}$ apart, and all the same height above ground. In passing, it should be noted that the simplest case of all, that of a single dipole, is the array of this type most commonly in use. For a complete knowledge of the performance of such an array the vertical polar diagram should be known for all angles of azimuth. In practice, however, a knowledge of two polar diagrams, that in the vertical plane containing the dipoles, and that in the vertical plane at right-angles to the dipoles is sufficient to estimate the performance.

* "High-frequency broadcast transmission with vertical radiation", P. Adorian and A. H. Dickenson, *Journal of the British Institute of Radio Engineers*. February 1952.

2. *Polar diagrams.*

Figures 1, 2 and 3, show the polar diagrams in the two vertical planes for three types of array:

Figure 1 — A single dipole.

Figure 2 — Two rows, each of two dipoles.

Figure 3 — Four rows, each of four dipoles.

The polar diagram in the vertical plane parallel to the dipoles depends solely on the number of dipoles in a row. The polar diagram in the plane at right-angles to the dipoles depends solely on the number of rows of dipoles. It is thus possible from the polar diagrams shown in figures 1, 2 and 3 to assess the performance of arrays with up to four dipoles per row and up to four rows of dipoles. For example, for an array consisting of two rows each of four dipoles, the polar diagram in the plane containing the dipoles would be that of curve *(a)* Fig. 3, and the polar diagram in the plane at right-angles to the dipoles would be that of curve *(b)* Fig. 2.

3. *Height of array above ground.*

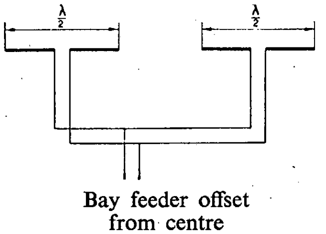
For the vertical radiated field to be a maximum, the optimum height of the dipoles above ground is $\frac{\lambda}{4}$ but the height is not critical. Fig. 1, 2 and 3 correspond to a height of 0.2 λ above ground, but each of the curves shown may be converted to apply to any height of h wavelengths above ground, by multiplying by:

$$\frac{\sin (2 \pi h \cos \theta)}{\sin (0.4 \pi \cos \theta)}$$

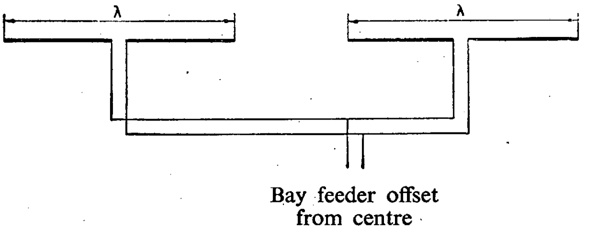
4. *Slewing.*

Polar diagrams shown in Fig. 1, 2 and 3 assume equal co-phasal currents in all the half-wave dipoles, and as may be seen, this results in a polar diagram suitable for a station situated in the centre of the service area. If it is desired to site a station away from that area, the direction of the vertical beam can be slewed by dividing each row of dipoles of the array into two halves and driving these two halves with currents in different phases. It follows that the array of Fig. 1, a single dipole, cannot be slewed.

This method of slewing is most easily applicable to arrays of two or four dipoles per row and the following sketches indicate the method of feeding:



Slewing of array
2 dipoles wide



Slewing of array
4 dipoles wide

This method of slewing results in the main lobe being slewed in the plane containing the dipoles, whilst the polar diagram in the plane at right-angles to the dipoles remains unchanged.

In the case of an array with two dipoles in each row the polar diagram will be modified by multiplying by:

$$\frac{\cos\left(\frac{\pi}{2}\sin\theta + \frac{\varphi}{2}\right)}{\cos\left(\frac{\pi}{2}\sin\theta\right)}$$

In the case of an array with four dipoles in each row, the polar diagram will be modified by multiplying by:

$$\frac{\cos\left(\pi\sin\theta + \frac{\varphi}{2}\right)}{\cos\left(\pi\sin\theta\right)}$$

where φ is the phase difference between the currents in the two halves of the array. The approximate angle of slew, in terms of the phase difference between the two halves of the array is:

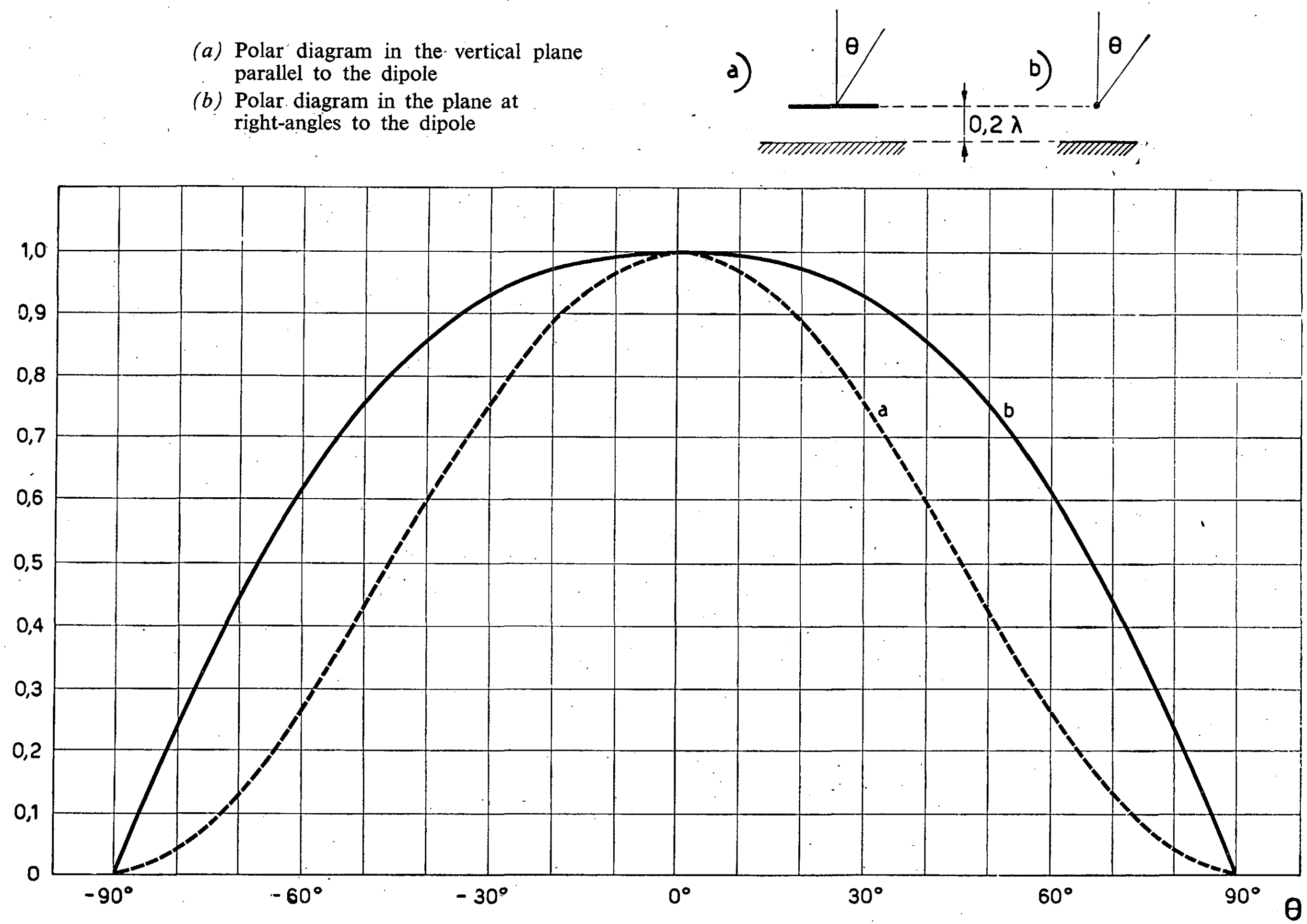
$\mathrm{Sin}^{-1}\,\frac{\varphi}{\pi}$ for the array two dipoles wide

$\mathrm{Sin}^{-1}\,\frac{\varphi}{2\pi}$ for the array four dipoles wide

It is inadvisable to slew the main lobe more than approximately 15°, as large side lobes will otherwise form which may cause interference outside the service area.

5. *Ground conductivity.*

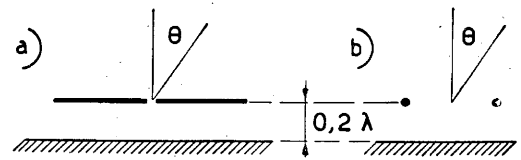
In many cases, the conductivity of the ground is such that the efficiency and the polar diagram may be degraded if an earth mat is not placed under the array. This earth mat should consist of a number of parallel wires, spaced 0.1 λ apart and run parallel to the dipoles. The length of the wires and the number of wires should be such that the earth mat extends $\frac{\lambda}{2}$ beyond the extremities of the array when viewed in plan.

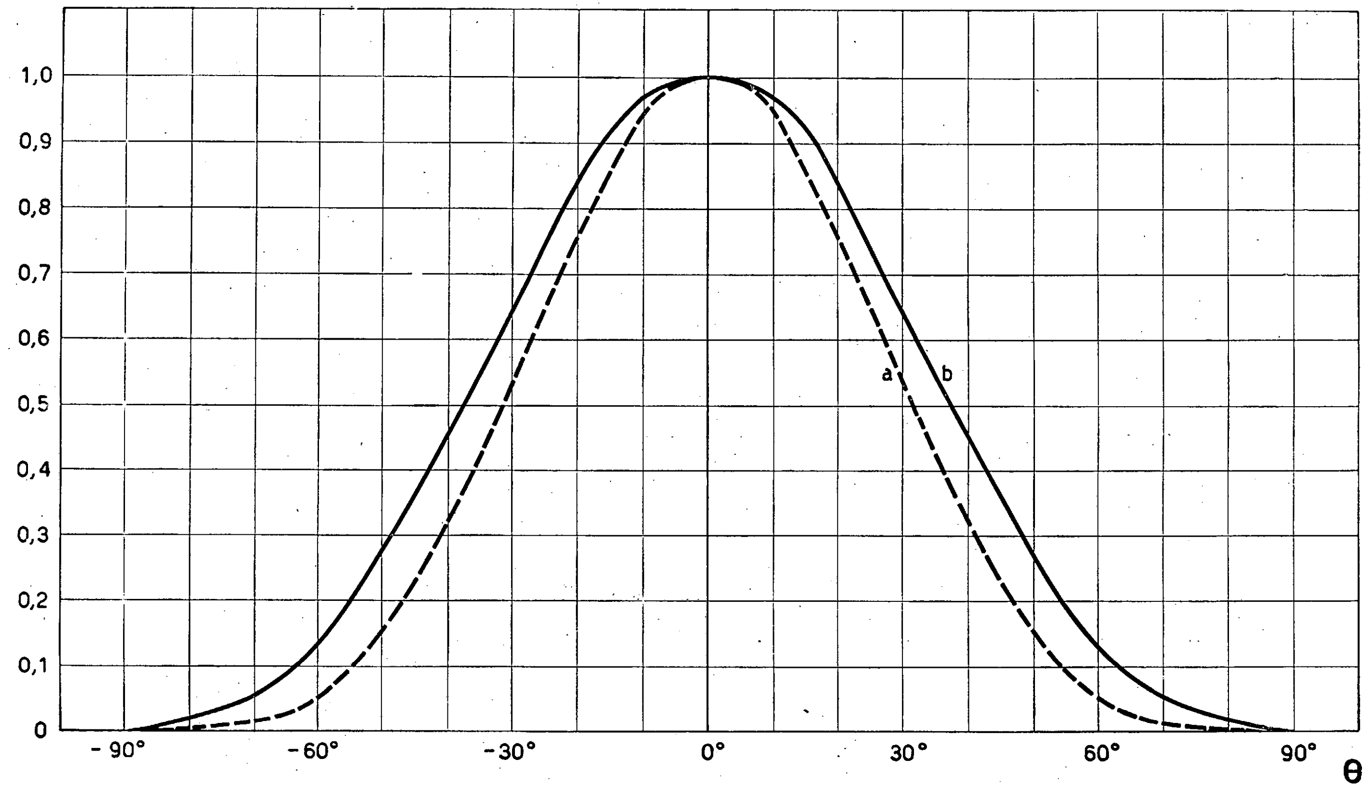


Polar diagram of a single $\frac{\lambda}{2}$ *horizontal dipole*

FIGURE 1

(*a*) Polar diagram in the vertical plane parallel to the dipoles
(*b*) Polar diagram in the plane at right-angles to the dipoles



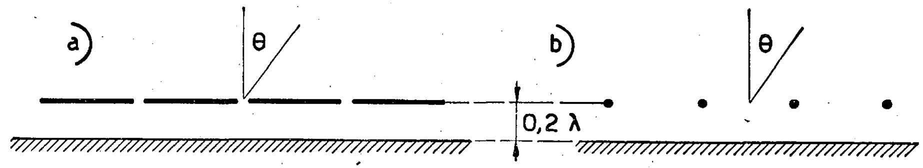


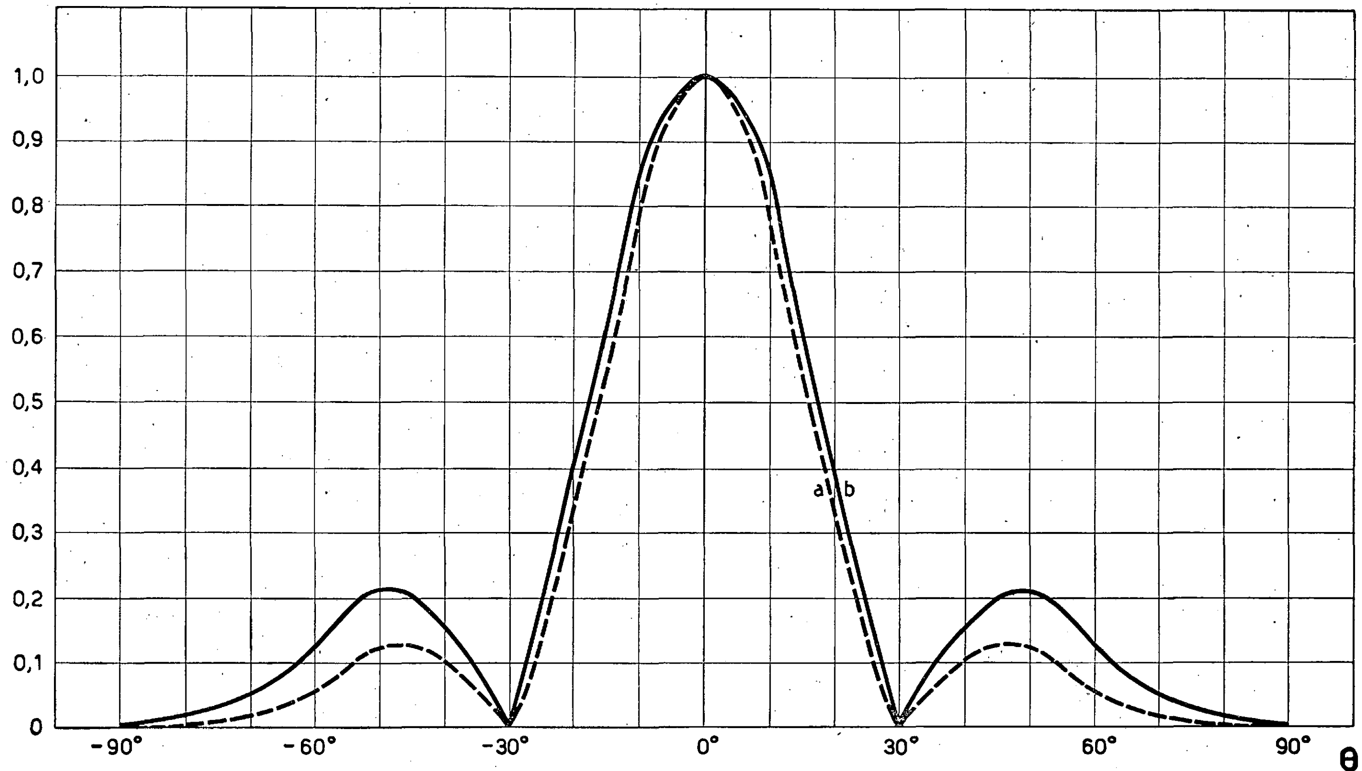
Polar diagram of an H2/2 array on its back

FIGURE 2

(*a*) Polar diagram in the vertical plane parallel to the dipoles

(*b*) Polar diagram in the plane at right-angles to the dipoles





Polar diagram of an H4/4 array on its back

FIGURE 3

REPORT No. 87 *

DESIGN OF TRANSMITTING AERIALS FOR TROPICAL BROADCASTING

Complement to Report No. 86

(Question No. 156 (XII))

(Warsaw, 1956)

1. Doc. No. 470 (Warsaw) from the United Kingdom describes briefly the measurements carried out in Barbados of short-wave (decametric) broadcast transmissions from Trinidad (350 km) on 3 and 6 Mc/s and the attempts made to observe the field intensities of transmissions from Jamaica.

2. Consideration of the data indicates that a vertical incidence 4-element aerial 1/4-wavelength above ground will be useful for minimising low-angle radiation beyond a service area limited to about 350 km and thus reduce the value of received signal level. For greater distances such an aerial will not provide so high a desired field as a simple dipole, especially one with a height approaching half a wavelength above ground.

3. It is considered that further studies should be undertaken to collect data on aerials which will enable radiation to be maintained at the necessary angle of elevation to provide a service at distances of the order of 800 km, while, at the same time, minimising radiation at lower angles than this.

4. It is also desirable that whilst communicating data on frequency requirements, administrations should define the area for which the broadcast service is intended.

REPORT No. 88 *

BEST METHOD FOR CALCULATING THE SKYWAVE FIELD STRENGTH PRODUCED BY A TROPICAL BROADCASTING TRANSMITTER

(Question No. 154 (XII))

(Warsaw, 1956)

1. Two documents (Doc. No. 229 by the United Kingdom and No. 357 by India) were presented at this session.

2. Document No. 229 states that both the currently used methods (CRPL and SPIN) for calculation are base on a highly simplified non-deviative absorption model, which appears to be inadequate in the case of tropical broadcasting zone. Some of the factors which require to be taken into account are:

* This Report was adopted unanimously.

the possibility of high E layer critical frequencies during the daytime; the higher absorption due to the earth's magnetic field being nearly horizontal; the lower effective values of gyro-frequency and the variations in the structure of the reflecting layers in the lower altitudes.

The document mentions that a revised technique for calculating field-strengths at low latitudes is under consideration.

3. Document No. 357 (India) discusses the CRPL and SPIN methods of calculation and on the basis of ionospheric absorption measurements has indicated that:

(i) the diurnal variation factor of ionospheric absorption is proportional to $(\cos \chi)^{0.62}$ at Delhi.

(ii) there is considerable absorption at night at Delhi.

These data have further been utilised to show the relative increase of absorption to be expected over the method presented by CRPL.

4. The data available at present are inadequate to answer the question even partially and further continued studies are necessary before a theoretical formula can be suggested for calculating the skywave field intensity of a broadcast transmitter in the tropical zone.

REPORT No. 89 *

INTERFERENCE IN THE BANDS SHARED WITH BROADCASTING

(Question No. 102 (XII) and Study Programme No. 113 (XII))

(Warsaw, 1956)

This Report summarises the results of the studies, contained in Warsaw Docs. Nos. 356, 231 and 553, that were carried out to determine by subjective tests the ratios of wanted-to-unwanted signal required to satisfy various percentages of broadcast listeners. It also summarises the views expressed in the Study Group meetings at Warsaw.

Warsaw Doc. No. 356 (India) gives the results of an extensive series of subjective tests carried out under conditions which, it is claimed, simulate generally those of actual domestic broadcasting listening in the absence of fading. A broadcast receiver with a response substantially flat to about 4 kc/s but with a filter giving an attenuation of about 8 db at 5 kc/s and a sharp cut-off above this frequency was used.

For unwanted signals of A2 and A3 classes of emission and for various frequency separations between the carriers of the wanted and unwanted signals, listeners were presented with various ratios of wanted-to-unwanted signal in random order and asked to state whether they considered the reception satisfactory or unsatisfactory. The curves given in the Annex show, for unwanted signals of A2, A3 telephony and A3 broadcasting classes of emission and for various frequency separations up to 5 kc/s, the wanted-to-unwanted signal ratios required to provide 90%, 70% and 50% listener satisfaction. Table I gives the same information for:

(a) exact frequency separations of 0 kc/s and 5 kc/s;

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* This Report was adopted unanimously.

(b) nominal frequency separations of 0 kc/s and 5 kc/s under the most unfavourable conditions that could arise within the maximum permissible frequency tolerances of both wanted and unwanted signal as specified in the Radio Regulations, (Atlantic City 1947).

Doc. No. 231 (United Kingdom) gives details of the results of subjective tests made to determine the ratio of wanted-to-unwanted signal as a function of the frequency separation of the carriers of the two signals. Two typical broadcast receivers were used having a fairly uniform response up to about 4 kc/s falling to about -8 db to -10 db at 5 kc/s. The unwanted signal was modulated by speech with a frequency range limited to 3 kc/s. The ratio necessary to satisfy nearly all listeners varied from about 54 db at 1 kc/s separation to a maximum of 56 db between 2 and 3 kc/s separation, falling to 52 db at 5 kc/s separation. The corresponding ratios when nearly all the listeners found the conditions unsatisfactory were about 15 db lower. Subsequent tests to determine the ratio at which interference was " perceptible " gave intermediate values.

Doc. No. 553 (Federal German Republic) gives the results of similar tests made with two types of receiver, one a narrow-band receiver with considerable attenuation above 3 kc/s and the other a wider-band receiver with an attenuation of about 8 db at 5 kc/s. For the wide-band receiver, as commonly used for broadcast listening, the wanted-to-unwanted signal ratio for various frequency separations follows the same general curve as before and at a frequency separation of 5 kc/s is 43 db for 90% listener satisfaction.

Comparison of the results arrived at in the three documents show that there is a considerable degree of agreement. The values are within ± 5 db and those in the U.K. and F.G.R. documents bracket those in the Indian document. There is therefore enough justification to assume that the values of the wanted-to-unwanted signal to provide the various degrees of listener satisfaction given in Table I and the annexed curves are reliable.

From an examination of Table I, it will be seen that when the unwanted signal is an A3-mobile emission, there is a considerable increase in the required wanted-to-unwanted signal ratio when allowance is made for maximum frequency tolerances. The possibility of interference to broadcasting services from mobile services would be appreciably reduced, particularly where the two services have the same nominal frequency, if the mobile services operated within closer frequency tolerance, if possible with the same tolerance as the fixed and broadcasting services.

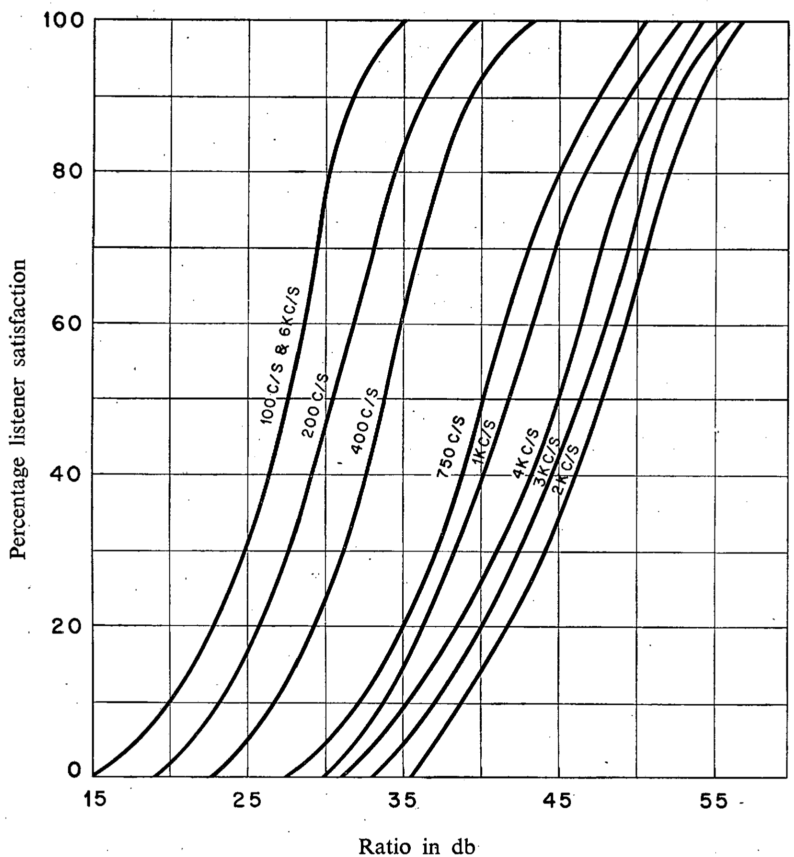
Although the sidebands of the unwanted signal contributed to some extent to the interference, the heterodyne beat note between the carriers of the wanted and unwanted signal was always predominant. This was the case for a frequency separation of 5 kc/s between the two signals and although the receivers used provided an attenuation of some 8-10 db to the beat note, the use of a filter to provide further attenuation would have reduced the required wanted-to-unwanted signal ratio. Further studies are needed to ascertain what additional attenuation at 5 kc/s could usefully be provided and what would then be the required wanted-to-unwanted signal ratio. For this purpose consideration should also be given to the possibilities of providing suitable filters in new and existing receivers.

It is agreed that since the figures shown in Table I are derived from measurements made under steady-state conditions, appropriate allowance should be made for fading when using these figures to derive the protection ratios to be used in practice. The value of fading allowance to be used for tropical broadcasting requires further study.

India wishes to record her opinion that protection ratios should be based on those figures in Table I that provide 90% listener satisfaction and that the figures for 70% and 50% are for information only and should not be regarded as the lower limits of acceptability. Australia and South Africa and the French Oversea Territories are of the opinion that a listener satisfaction higher than 50% should be provided. South Africa and Australia consider it would be impracticable to achieve 90% listener-satisfaction from the aspect of signal-to-noise ratio, particularly

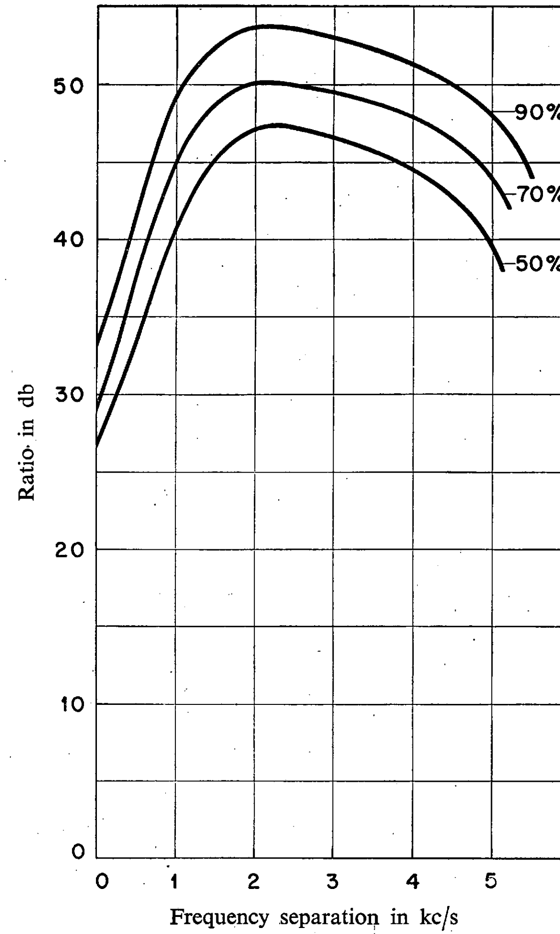
TABLE I

1	2	3	4	5	6	7	8	9
Interfering emission	Maximum frequency tolerance (Rad. Regs.)	Frequency separation	Signal/interference ratios for 90%, 70% and 50% listener satisfaction					
			ignoring frequency tolerances			allowing for maximum frequency tolerances		
			90%	70%	50%	90%	70%	50%
A2 — fixed (525 c/s tone)	150 c/s	0 kc/s	35 db	31 db	28 db	42 db	38 db	34 db
A2 — mobile (525 c/s tone)	1000 c/s	0 kc/s	35 db	31 db	28 db	49 db	45 db	42 db
A3 — fixed (3 kc/s max. modulation)	150 c/s	0 kc/s	33 db	30 db	28 db	40 db	36 db	33 db
A3 — mobile (3 kc/s max. modulation)	1000 c/s	0 kc/s	33 db	30 db	28 db	50 db	47 db	44 db
A3 — broadcasting	150 c/s	0 kc/s	33 db	30 db	28 db	44 db	40 db	36 db
A2 — fixed (525 c/s tone)	150 c/s	5 kc/s	39 db	37 db	36 db	43 db	40 db	38 db
A2 — mobile (525 c/s tone)	1000 c/s	5 kc/s	39 db	37 db	36 db	49 db	46 db	43 db
A3 — fixed (3 kc/s max. modulation)	150 c/s	5 kc/s	48 db	44 db	40 db	50 db	46 db	42 db
A3 — mobile (3 kc/s max. modulation)	1000 c/s	5 kc/s	48 db	44 db	40 db	52 db	48 db	45 db
A3 — broadcasting	150 c/s	5 kc/s	48 db	46 db	44 db	49 db	46 db	44 db



(a)

Main programme: speech
Interference: A2 telegraphy

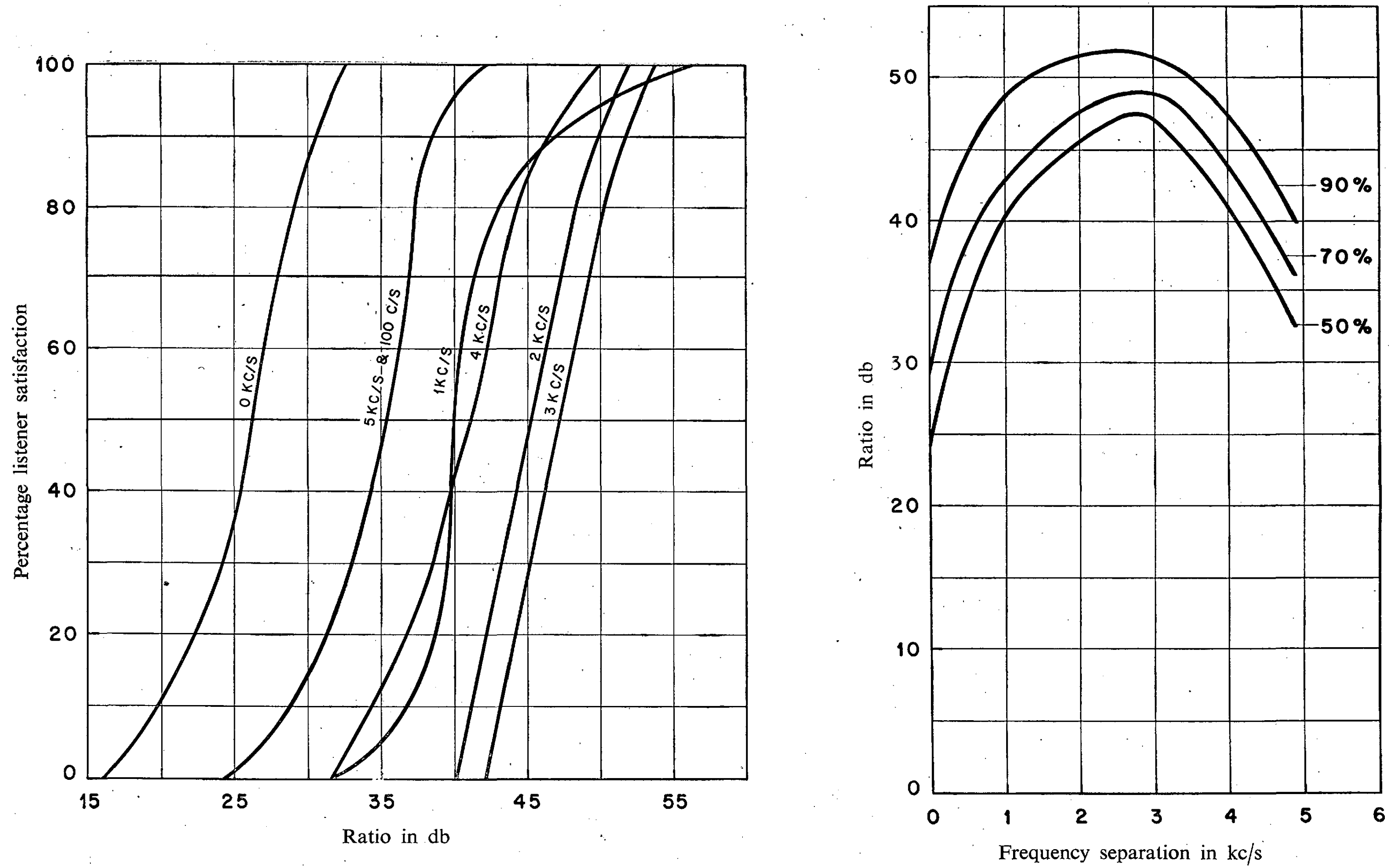


(b)

Ratio of wanted to unwanted signal for 90%, 70% and 50% satisfaction

FIGURE 1

Wanted to unwanted signal ratio required in the case of interference from A2 telegraphy



(a)

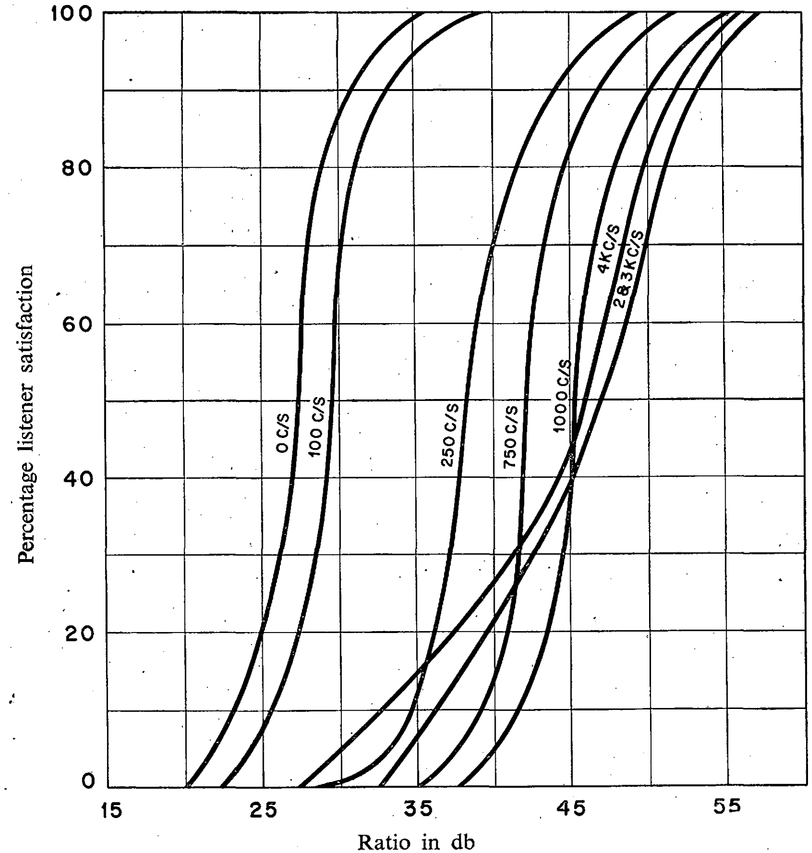
Main programme: speech
Interference: A3 telephony

(b)

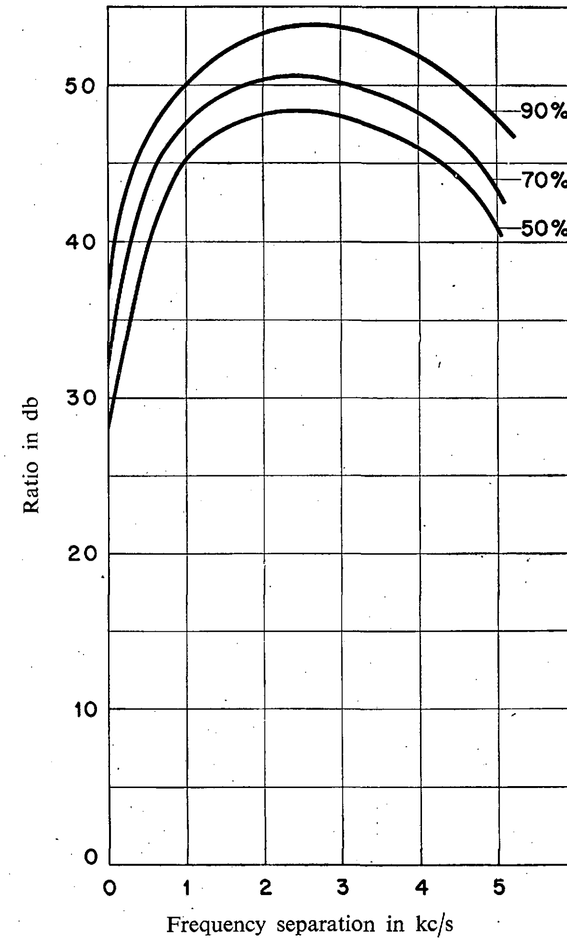
Ratio of wanted to unwanted signal for 90%, 70% and 50% satisfaction

FIGURE 2

Wanted to unwanted signal ratio required in the case of interference from A3 telephony



Main programme: speech
Interference: A3 broadcasting (music)



Ratio of wanted to unwanted signal for 90%, 70% and 50% satisfaction

FIGURE 3

Wanted to unwanted signal ratio required in the case of interference from broadcast transmission under heavy static conditions, and therefore to aim to achieve about 80% listener-satisfaction for signal-to-interference would be more realistic. The United Kingdom is of the opinion that the wanted-to-unwanted signal ratios given in Table I are based on too critical an assessment and that lower figures would be generally acceptable. The United Kingdom is also of the opinion that from practical considerations, protection ratios will have to be based on figures providing about 50-70% listener satisfaction.

REPORT No. 90 *

PUBLICATION OF SERVICE CODES IN USE IN THE INTERNATIONAL TELEGRAPH SERVICE

(Resolution No. 18)
(Study Group No. XIII)

(Warsaw, 1956)

1. In conformity with the C.C.I.T. proposal (Doc. No. 471), the separate volume of codes to be published by the Secretary-General should contain the following documents:

   1.1 Radio Regulations Appendix 9, Section II: Miscellaneous Abbreviations and Signals.

   1.2 Radio Regulations Appendix 11, paragraph 3 (1): Spelling Analogy Code.

   1.3 C.C.I.R. Recommendation 221: Sinpo Code.

   1.4 C.C.I.R. Recommendation 221: Sinpfemo Code.

   1.5 The Cable and Wireless Limited Facsimile Reporting Code.

   1.6 C.C.I.T. Recommendation H.1, Article 26: Code Expressions used in the International Telex Service.

   1.7 The International Telegraph Regulations.

   1.8 Radio Regulations Appendix 9, Section I: Q-code.

   1.9 The Cable and Wireless Limited Service Code.

   1.10 The Cable and Wireless Limited Z-code.

2. *Remarks.*

   2.1 The documents indicated under 1.1 to 1.6 inclusive are to be included in the code book without any alteration, on the understanding, however, that one item should be added to the code under 1.6 viz:

   SVH Safety of life telex call

   and two items to the code 1.1 viz:

   SLT Ship Letter Telegram
   OL Ocean Letter

* This Report was adopted unanimously.

2.2 The documents summarised under 1.7 to 1.10 inclusive are to be included in the code book in part only as indicated below (see para. 3).

2.3 The C.C.I.R. is of the opinion that in addition to the code documents mentioned above and proposed by the C.C.I.T. to be included in the code book, there exist one or two very important code documents which are not in the competence of the I.T.U., but nevertheless, are widely in use in the maritime mobile and aeronautical services, (e.g. *(a)* The International Code of Signals, Vol. II and *(b)* Communication Codes and Abbreviations published by the International Civil Aviation Organisation. However, their incorporation in the code book would make it too heavy and bulky and in consequence the C.C.I.R. proposes to the C.C.I.T. that only reference be made to them in the code book (see para. 7.3).

3. *Appendix 2 to Doc. No. 471 (International Telegraph Regulations).*

3.1 The C.C.I.R. is of the view that the suggestion made by the C.C.I.T. as to the part of the International Telegraph Regulations to be inserted in the book should be accepted.

3.2 There is a possibility that the code words taken from the Cable and Wireless Service Code resemble some aeronautical call signs, but this does not seem to be very serious as, to the knowledge of the C.C.I.R., no cases of confusion have ever arisen.

4. *Appendix 3 to Doc. No. 471. (Q-code).*

4.1 The five new code words put forward by the C.C.I.T. are acceptable. They have been notified to administrations by the Secretary-General in his half-monthly Notifications issued since the Atlantic City Radio Conference.

4.2 The C.C.I.R. agrees to the C.C.I.T. suggestion to include only that part of the Q-code which is reserved for all radio services (QRA-QUZ). The parts (QAA-QNZ and QOA-QQZ) which are reserved for the aeronautical and maritime services respectively, should not be inserted. This suggestion is also supported by I.C.A.O.

5. As to the Cable and Wireless Ltd. code and the Italcable code " Dizionario delle Abbreviazioni Telegrafiche ", Appendices 4 and 6 to the C.C.I.T. document, respectively, the C.C.I.R. has no comment. The Appendices should be accepted as they stand.

6. *Appendix 5 of Doc. No. 471 (Cable and Wireless Ltd., Z-code).*

6.1 This code, as stated in the last paragraph of item 8 of the C.C.I.T. document, is widely used in the fixed services.

6.2 Should, however, this Z-code be included in the code book then the telegraph services will be faced with the possibility of confusion with respect to the Z-series of call signs.

6.3 In view of the shortage of call signs, it would be out of the question to withdraw the Z series from the Allocation Table of Call Signs laid down in Article 19 of the Radio Regulations.

6.4 However, as far as the C.C.I.R. is aware, no such confusion has ever occurred in the past, very probably because of the Z-code being used in service messages only.

6.5 The C.C.I.R. therefore accepts the C.C.I.T. suggestion to include the Z-code on the understanding that the C.C.I.R. should re-examine the matter if any confusion with Z-call signs should arise in the future.

7. *Appendix 7 of Doc. No. 471 (Arrangement of material within the code book).*

7.1 In paragraph 2 of Appendix 7 of Doc. No. 471 the C.C.I.T. suggests that the book be divided into three main sections.

7.2 Referring to paragraph 2.3 of this report, the C.C.I.R. accepts that the code documents mentioned there be inserted in the code book in a separate section.

7.3 As, however, they can be considered as belonging to the Miscellaneous Section (see section 4, Appendix 7, Doc. No. 471) it could be divided into two sub-sections, the first sub-section containing Sinpo, Sinpfemo, the Spelling Analogy Code and the Cable and Wireless Ltd. Facsimile Reporting Code (paras. 1 and 2 of Appendix 7), and the second sub-section containing a reference to codes not included in the book e.g. the International Code of Signals, Vol. II and the I.C.A.O. book on communication codes and abbreviations (see para. 2.4).

8. *Title of the code book.*

Taking into account the inclusion of codes relating to the telephone services and the references to non I.T.U. codes, the C.C.I.R. proposes that the C.C.I.T. suggestion concerning the title (page 4, Doc. No. 471) should be amended as follows:

" Codes and Abbreviations for the International Telecommunication Services, published by the International Telecommunication Union."

9. *Unification.*

9.1 The C.C.I.R. is of the opinion that it will be necessary for an operational need to be apparent and for operational experience to be obtained, before a study can be made of the unification of codes.

9.2 For this purpose Resolution No. 18 has been modified as follows:

Item 3 of Resolution No. 18 has been deleted and replaced by:

" 3. That administrations should consider whether there is an operational need for the unification of codes." (See Resolution No. 33).

REPORT No. 91 *

IDENTIFICATION OF RADIO STATIONS

(Question No. 104 (VIII) ** — Study Programme No. 115 (VIII)
(Study Group No. XIII)

(Warsaw, 1956)

This Report summarises the contributions to, and the discussions on, the identification of radio stations at the VIIth and VIIIth Plenary Assemblies, except for those covered by Recommendation No. 220.

1. In the interval between the VIth and VIIth Plenary Assemblies some progress was made in the study of methods of transmitting call signs on channels using F1, on single-sideband emissions, and on channels using four-frequency diplex and twinmode cable-code transmissions (Doc. No. 56, London).

1.1 Whereas a method for identifying F1 emissions by superimposing the call signals in Morse code, by amplitude modulation, on the F1 emission has been recommended in point 3.1 of Recommendation No. 220, it has not been found generally applicable for economic reasons because the method used employed high-level modulation. It is believed, however, that if a convenient and economical method of applying the amplitude modulation

* The Bielorussian S.S.R., the P.R. of Bulgaria, the Ukrainian S.S.R. and the U.S.S.R. reserved their opinion on this Report.
** The study of this Question has been transferred from Study Group No. XIII to Study Group No. VIII.

could be devised, identification by this method would find application on circuits employing F1 emission, particularly on leased circuits when it is not convenient or desirable to interrupt the subscriber's use of the circuit in order to transmit call signs.

1.2 A suggested method for identifying single-sideband multichannel systems by the insertion of a Morse keyed audio tone one on of the channels was found to be unsatisfactory particularly due to the difficulties encountered by monitoring observers.

1.3 As a result of further tests a method for identifying single-sideband reduced carrier transmissions by amplitude keying of the reduced carrier in Morse Code as recommended in Point 3.2 of Recommendation No. 220 has been adopted for application by the operating company which conducted the tests. A detailed description of the method is furnished in Annex II of Document No. 56 (London).

1.4 Tests have been conducted on a method of transmitting identification signals on a cable code, 3-unit, F1 twinplex system and a 4-channel twinmode system. While satisfactory results in identification were observed by monitoring stations the method requires interruption of traffic on the channels used for transmission of call signs.

2. A method has been proposed (Doc. No. 468, Warsaw) for identifying complex emissions employing frequency-shift keying by means of a superimposed audio modulation which produces a phase modulation at the transmitter output. A low level amplitude modulation is applied to the exciter and this ultimately produces phase modulation through the limiting action of the following class C amplifier. The audio tone is keyed and applied across the common cathode resistor of the balanced modulator. This results in the production of two additional sidebands on either side of the main carrier with the displacement depending on the frequency of the audio tone employed.

It has been found that satisfactory identification is obtained without interference to traffic if the amplitude of the sidebands is about 32 db below that of the carrier. Continuous repetition of the call sign at a rate of 8 wpm was used in the tests. The keying device consisted of a notched " keying wheel " through which a beam of light was projected thereby operating a photo-electric cell. An ordinary communications receiver with the beat-frequency oscillator turned off was used for reception of the keyed identification signal.

3. It has also been suggested that it would simplify the problems and ease the economic burden for operating companies if identification could be accomplished, when inserting or superimposing identification signals simultaneously with traffic, by the use of a common means of identification on all transmitters at a particular transmitting centre. The common means of identification might link the name of the operating company and the location of the transmitting centre. In addition a specific individual call sign might be employed to supplement the use of such a common identification signal where necessary, when initiating or terminating operation on any particular transmitter.

4. In order to assist monitoring stations it is suggested that when transmitting radio station identification by a superimposed identification signal, the identification should include a designator indicating the type and bandwidth of the emission, particularly in the case of complex emissions. In this connection reference is made to Article 2, Section I and Section II of the Radio Regulations, Atlantic City, 1947.

REPORT No. 92 *

MARINE IDENTIFICATION DEVICES

(Question No. 105 **)
(Study Group No. XIII)

(Warsaw, 1956)

1. *General.*

Two documents, No. 53 (United Kingdom) and No. 71 (United States of America) were submitted to the VIIIth Plenary Assembly in response to Question No. 105 ** on the identification of a response on a marine radar display.

This report summarises the nature of the problem, the work that has been done, as described in the two documents, and the main points arising out of the discussions at the VIIIth Plenary Assembly.

2. *Nature of Problem.*

There is a growing use of radar on ships to assist navigation and to prevent collision. Ideally, it would be desirable for radar to give the navigator the same kind of information that he would obtain visually in clear weather. But in the present state of radar development, experience has shown that the radar information might, with advantage, be supplemented by additional information, although there is not, as yet, uniformity of opinion among those concerned with marine navigation, on the type of additional information that would be most helpful to the navigator.

The radar installation on a ship gives, at any instant, only the bearing and position of the other ships. The course and speed of another ship by this means can then be obtained only by plotting; and, in any case, the radar cannot give the future intentions of the other ship. This points to the need for an appropriate communication link as an element of any effective marine identification device employing the types of radar installation in current use.

An identification device should be unambiguous and should be at least as good as the resolution of the associated radar, so that there would be no confusion concerning the identification of two adjacent echoes on the same bearing or at the same range. The additional information required, for example, might be the call letters of the other ship so that communication could be established; or it might be the course and speed, or the aspect, of the other vessel.

So far, research has been directed towards the development of devices that would identify uniquely a particular echo of a ship on the radar screen of another ship or of a shore-based station. Various proposals, e.g. the use of transponder techniques, have been given in the two documents mentioned and are described briefly in Sections 3 and 4 below.

3. *Summary of Doc. No. 53 (United Kingdom)*

3.1 *Harbour radar identification.*

It was considered that suitable devices of the transponder type might facilitate the movement of vessels in the approaches to a port or in a harbour so that the echo of the ship could be identified on the harbour radar and communication established as required. Identification in range and bearing would be essential, so that identification by the use of

* This Report was adopted unanimously.

** This Question has been replaced by Question No. 158 (VIII).

normal direction finding (bearing only) would not normally be sufficient. There is legs likelihood of confusion in harbour radar identification because ships would be identifyins themselves to a single harbour radar.

These transponder devices are used in conjunction with a radiocommunication link between the ship and the shore. On the ship either portable equipment or the ship's own radio installation may be used.

Portable radar transponders have been developed which operate in the 3 cm band of the harbour radar. The transponders, and, if necessary, the portable radiocommunication equipment, are taken on board the ship by the pilot. Identification is established by the Harbour Controller requesting the pilot to switch on the transponder, when the response is seen on the harbour radar as a bright line on the bearing of the ship's echo, with a gap, corresponding to 1 mile range, commencing at the ship. The ship is thus identified in range and bearing. The range of the " black-gap " transponder is about 17 nautical miles.

This system would be suitable for use with any harbour radar operating in the 3 cm band and no modification of the harbour radar would be required.

Another type of equipment has also been developed in which the output of a crystal receiver is used to modulate a VHF " walkie-talkie " transmitter which also serves to provide communication with the shore. At the harbour station, the VHF response from the ship is fed into the video stage of the harbour radar. This gives a long radial echo along the bearing of the ship and commencing at a range slightly greater than the ship's echo.

3.2 *Inter-ship radar identification.*

The former type of transponder mentioned above would not be satisfactory for inter-ship identification because it might well be impossible to establish communication with a particular unknown ship to request that the transponder be switched on; and, moreover, ambiguity would be unavoidable when several independent identification processes were taking place on the same channel.

4. *Summary of Doc. No. 71 (United States of America).*

4.1 The contribution of the United States, Doc. No. 71 (Warsaw) is based upon limited experience in the use of marine radar identification devices but also covers considerable study of the problem by the R.T.C.M. whose report thereon is attached to the cited document as Annex 3. In summary it is observed that:

(a) there are a number of technical methods for the identification of a radar response as coming from a particular source. All known methods, however, require that the source have an active radar beacon to co-operate with the calling vessel. One solution might be in the direction of a system similar to that used by the military (I.F.F., Identification Friend or Foe) and now coming into use for civil aviation in the United States of America for identification of aircraft to airport radars.

(b) In this type of system each ship-borne radar should be capable of emitting a particular calling or interrogating pulse or code. All vessels would maintain a beacon on continuous alert so that on receipt of the interrogating pulse each beacon would reply with a specific code identifying the vessel. This code when displayed on the interrogating vessel's P.P.I. adjacent to the radar echo from the vessel carrying the beacon would positively identify that echo. Having identified all ships in the vicinity, a radar observer could then contact any one of them directly by whatever communication means are available. Considerable experimentation has been carried out in order to realise a simplified version of this method.

(c) The use of a radar beacon system of the I.F.F. type for marine identification would require considerable expansion of the coding and display features of any equipment known to be currently available. It appears that no attempts to do this have as yet been made in the commercial marine field.

The relatively simplified technique where identification is obtained by energising the radar beacons one at a time in response to a demand via a communications link, has been reduced to a practical method and considerable related experimentation has been carried out in connection with harbour radar installations. The feasibility of this system has therefore been demonstrated although the necessary beacons are not yet commercially available.

(d) The principal practical aspect is that there is no need to identify a particular radar echo unless it is desired to communicate with the vessel associated with the echo. In narrow congested waters this must be practically instantaneous. This seems to require a radiotelephone circuit connecting the observer of the ship-borne radar directly to his counterpart on the bridge of the associated vessel. Ocean-going vessels, however, are not generally equipped with such means of communication. Further, the multiple language problem requires consideration in any international study of this subject. The Great Lakes area of North America, where nearly all merchant ships are fitted with radar and radiotelephone and navigators speak the same language, is an outstanding exception. Operational investigations of ship to ship identification devices have been carried out therefore only in this area.

(e) The number of vessels involved poses a technical difficulty in adapting an I.F.F. system for marine use, if each vessel were to have a distinct identifying code.

(f) A system of the I.F.F. type in its present form, due to its cost even in a comparatively simple version, presents an economic factor of importance. The complexity of the microwave components which contribute most to the cost of such equipment would be double that required for primary radar alone. The economic factor, however, will undoubtedly be eased as time passes and new technical developments occur, as they have, for instance, in the field of television.

4.2 A number of different types of devices or methods suggested for accomplishing identification of a positive or limited nature are outlined in the R.T.C.M. study referred to above. These include:

responder beacons of various design,
passive devices,
D.F. identification using radar antenna,
suggestions other than identification.

For further details on such types of devices see Annex 3 to Doc. No. 71 (Warsaw).

5. *Discussion of documents.*

The discussion of the documents has brought out certain important differences in inter-ship identification and shore-based radar identification. In the former case, after the identity of the unknown ship has been established, there may well be difficulty in establishing communication because of differences in language, type of radio installation and watch-keeping. At present, there is no international code on navigational manoeuvres, and " navigation by communication " would probably necessitate revision of the International Rules for the Prevention of Collision at Sea; it would probably raise new legal problems, if for example, a ship were involved in a collision while executing a manoeuvre agreed in advance with another ship. On the other hand, the type of identification which is employed for harbour control does not usually involve such difficulties because the ship has on board a pilot who is receiving advice from, and may communicate with, his own harbour radar station. Rapid identification is also very desirable in all such devices.

An inter-ship identification system would only become effective when the majority of ships were suitably equipped; and it should be borne in mind that the ship does not receive any direct benefit from its own identification device. Thus, ships which themselves do not carry radar are not likely to fit identification devices, particularly if the cost of the device is comparable with that of a radar installation.

6. *Future work.*

It was generally agreed in the discussions that it would be most desirable, at this stage, for the C.C.I.R. to obtain from responsible shipping administrative authorities their views on the navigational requirements that should be met by radar identification devices. This is the subject matter of Recommendation No. 222.

It was also felt that the work that had already been done on radar identification, and the differences that had become apparent in inter-ship identification and harbour radar identification, should now be reflected in a revision of Question No. 105: this has been implemented in the new Question No. 158 (XIII), which replaces Question No. 105.

As far as is known, there is no identification device that would fulfil all the probable navigational requirements and the general study will be continued by the C.C.I.R.

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REPORT No. 93 *

HF (DECAMETRIC) AND VHF (METRIC) DIRECTION FINDING

(Question No. 106 **)
(Study Group No. XIII)

(Warsaw, 1956)

1. *Introduction.*

Two documents, No. 67 (United States of America) and No. 232 (United Kingdom) were submitted to the VIIIth Plenary Assembly in response to Question No. 106.** A summary of these two documents, and of the discussion on them, is given below.

It was generally agreed that, whenever possible, the accuracy of bearings and positions and their classification, should be based on the probability concept.

The U.K. document expresses bearing accuracies in the form of errors that are exceeded on only one occasion in 20 and the U.S.A. document gives the standard deviation error. For ease of comparison of results, all accuracies have been expressed in a common form in this Report.

2. *Accuracy of HF (decametric) bearings.*

The accuracy of HF (decametric) bearings depends principally upon the following factors:

(a) type of direction finding (DF) equipment, for example, Adcock type,

(b) type of site,

(c) frequency,

(d) range and signal strength,

(e) ionospheric conditions, particularly diurnal variations,

(f) amount of interference,

(g) number of bearings taken,

(h) skill of the operator.

By day, the error which is exceeded on only one occasion in 20 (referred to subsequently as the 95% error) lies between about 3 and 10 degrees for ranges of the order of 500 to 4000 km, depending on the site, frequency, and whether a group of bearings is taken or only one snap bearing. More detailed data are given in the Annex. At night, errors are somewhat greater, by amounts of up to about 1 degree. At distances less than 500-1600 km (depending on ionospheric conditions) the error progressively increases, and may rise to as large as 10 to 20

* This Report was adopted unanimously.
** This Question has been replaced by Question No. 159 (XIII).

degrees until the ground wave or the E-layer mode of propagation predominates. In general, errors are less at the higher frequencies.

3. *Accuracy of VHF (metric) bearings.*

In the United Kingdom, the 95% error of VHF aeronautical DF stations is generally about 5 degrees, but in the U.S.A. it has been found that the 95% error is usually about 12 degrees on transmissions from aircraft. The difference is probably due mainly to the effects of differences of siting, since with refinements in siting, the 95% error is reduced to about 4 degrees in the U.S.A. At long ranges, beyond the normal service area, VHF DF bearings in the U.S.A. have been found to be sporadic but the accuracy is sometimes as good as 6 degrees.

4. *Accuracy of HF (decametric) position fixing.*

The accuracy of position fixing depends principally on the " geometry " of the DF network, its size and its disposition with respect to the transmitting station concerned, the degree to which the various stations can take simultaneous bearings and act in unison, and the number of stations in the network. The greatest accuracy is obtained when the most probable position of the transmitting station can be evaluated statistically, although in certain applications it is recognised that statistical evaluation may not be practicable or of operational importance. The accuracy of a DF fix can be expressed in terms of the size, position and orientation of the ellipse in which the transmitting station lies with a given probability. Various methods for deriving and plotting probability ellipses are given in the references in Doc. No. 232.

5. *Accuracy of VHF (metric) position fixing.*

The accuracy of VHF position fixing can be determined in a manner similar to that for HF. But in the aeronautical service, which is one of the main users of VHF DF, there is not usually sufficient time to evaluate the accuracy of a fix because of the high speed of the aircraft. At VHF, the problem may be simpler than at HF because the DF networks, in general, will be smaller and can more easily be controlled automatically and have a central automatic display.

6. *Classification of bearings in general.*

It was considered that it would be very advantageous to have a common classification system of bearings for all frequency bands (MF, HF and VHF) and for all types of service, for example, maritime and aeronautical.

7. *Classification of HF (decametric) bearings.*

The U.S.A. proposes a subjective method of classification by the operator for describing to the plotting centre the conditions under which a bearing has been taken. The factors that the operator should take into account are strength of signal, sharpness of the null, amount of fading and interference, the amount of goniometer swing required in taking the bearing and the number of bearings that have been taken in the time available. The proposed system of classification is as follows:

Class A — Bearing appears *GOOD* meeting the following requirements:

(1) strong signal
(2) definite indication (sharp null, etc)
(3) negligible fading
(4) negligible interference
(5) less than 3 degrees of arc of bearing swing
(6) observed repeatedly for an adequate period of time

Class B — Bearing appears *FAIR* being degraded by one or more of the following factors:

(1) marginal signal strength
(2) blurr (blunting) of indication

(3) fading and/or audio distortion
(4) light interference
(5) more than 3 but less than 5 degrees of arc of bearing swing
(6) short observation time

Class C — Bearing appears *POOR* being degraded by one or more of the following factors:

(1) inadequate signal strength
(2) severe blurr (blunting) of indication
(3) severe fading and/or audio distortion
(4) strong interference
(5) more than 5 degrees of arc of bearing swing
(6) insufficient observation time

The U.K. proposes that the accuracy of a bearing should be evaluated statistically from a knowledge of the five component variances which make up the total variance of the bearing, namely, instrumental, site, propagation, random-sampling and observational components. The bearing would then be classified as follows:

Class A:	Probability of less than 1 in 20 that the error exceeds	2 degrees
Class B:	,, ,, ,, ,, 1 ,, 20 ,, ,, ,, ,,	5 degrees
Class C:	,, ,, ,, ,, 1 ,, 20 ,, ,, ,, ,,	10 degrees
Class D:	Bearings whose accuracy is less than that of Class C.	

8. *Classification of VHF (metric) bearings.*

It was considered that time considerations alone prevent the classification of VHF bearings taken on transmissions from aircraft and it is not possible for the operator to classify bearings. But the U.K. suggested that it would be helpful if VHF aeronautical *stations* were classified, based upon flight-checking procedures. All bearings would then be given the classification of the station, unless they were taken under conditions inferior to those under which the station was calibrated.

9. *Classification of HF (decametric) position-fixes.*

It was generally agreed that the accuracy of a fix-position should, whenever time permits, be given in terms of probability ellipses. The U.K. proposed that no formal classification be adopted since the size and shape of the ellipse for a given probability depends upon the " geometry " of the network and the transmitting station, the ionospheric conditions, etc. Where time is of essence, the U.S.A. proposed that the most probable fix position would be given in degrees and minutes of latitude and longitude and should be classified as the equivalent circle in which the transmitting station probably lies as follows:

Classification	*Limit of Area*
Good	40 km, or less, radius
Fair	80 km, or less, radius
Poor	120 km, or less, radius
Estimated	More than 120 km radius

10. *Classification of VHF (metric) position-fixes.*

For the aeronautical service, it was considered that classification in terms of probability ellipses was not likely to be practicable or useful. The U.K. made no proposals on this point; the U.S.A. proposed the following classification:

Classification	*Limit of Area*
Good	4 km, or less, radius
Fair	8 km, or less, radius
Poor	12 km, or less, radius
Estimated	More than 12 km radius.

11. *Aeronautical aspects.*

It was considered that since VHF DF stations are widely used in civil aviation, administrations should be invited to seek the advice of the International Civil Aviation Organisation on all the aeronautical aspects of VHF direction finding and position finding.

12. *Revision of Recommendation No. 72 *.*

The only revision proposed is that in Point 8 of the recommendations the transmission period of 4 minutes should be amended to 5 minutes to permit at least 10 snap bearings being taken.

13. *Type of signal for VHF (metric) direction finding.*

In general, the signal for VHF direction-finding purposes should include long dashes of at least 5 seconds duration, but the DF station should also be permitted to specify the duration of the signal in certain circumstances. In the aeronautical service, the procedure laid down by the I.C.A.O. has been found satisfactory. This specifies two dashes of plain carrier, each of approximately 10 seconds duration, followed by the call sign of the aircraft, unless another signal has been requested or is known to be required by the DF station.

ANNEX

APPROXIMATE ERROR IN DEGREES WHICH MAY BE EXPECTED TO BE EXCEEDED ON ONLY 1 OCCASION IN 20

Conditions: *(a)* HF Adcock direction finder

(b) Daylight

(c) Ranges between about 500 and 4000 km.

Type of site	3 Mc/s		6 Mc/s		9 Mc/s	
	Single snap bearing	Mean of 10 bearings taken in 5 minutes	Single snap bearing	Mean of 10 bearings taken in 5 minutes	Single snap bearing	Mean of 10 bearings taken in 5 minutes
Very good	degrees 7	degrees 6	degrees 6	degrees 5	degrees 6	degrees 4
Good, average	10	9	8	7	7	6

REPORT No. 94 **

MEANS OF EXPRESSION

(Resolution No. 5, Recommendation No. 144)
(Study Group No. XIV)

(Warsaw, 1956)

A. *Vocabulary*

1. The VIIIth Plenary Assembly in Warsaw has taken note of the Preparatory List. The Chairman of Study Group XIV, in accordance with the task entrusted to him under para. 4.4 of Recommendation 144, has in this list assembled and systematically recorded the data

* This Recommendation has been replaced by Recommendation No. 217.

** This Report was adopted unanimously

at his disposal, bearing in mind the comments forwarded to him by the national correspondents and Study Group representatives, in accordance with the procedure outlined in that Recommendation (paras. 4.2 and 4.3).

2. The entries in the above list, grouped in 10 volumes according to subject matter, i.e.

   I. General terms,
   II. Wave guides,
   III. Aerials,
   IV. Transmitters,
   V. Receivers,
   VI. Propagation,
   VII. Broadcasting,
   VIII. Television,
   IX. Radio direction-finding and radar,
   X. Telecommunication and other terms used in radio,

have been carefully reviewed by Study Group No. XIV, in consultation with the other study groups specialising in the various subjects, with a view to amplifying them, amending where necessary, and grouping them in the following four categories:

" *Group B* ": terms to be *deleted* because they are composed of words whose sense is clearly defined in ordinary language, the whole term having a meaning which cannot lead to ambiguity.

" *Group C* ": terms and definitions to be retained for information purposes, but already existing in the I.E.C. draft vocabulary of December 1955, to which reference will be made;

" *Group D* ": terms to be retained for information purposes since they are now in common use and are derived from various vocabularies of national organisations, to which reference will be made;

" *Group R* ": terms of a *regulatory* nature and characteristic of the C.C.I.R., which are contained, and in most cases defined, in the Radio Regulations or in C.C.I.R. documents (Recommendations, Reports, Questions, etc.).

3. For the time being the text known as the " List of terms and definitions peculiar to the work of the C.C.I.R. ", referred to in para. 4.5 of Recommendation No. 144, will be limited to the latter group. This section will shortly be dealt with in the manner described in the above-mentioned Recommendation.

For information purposes the set of data classified in the above groups C and D will be appended to this section.

The " national correspondent " of the French Administration has agreed to carry out the routine, but nevertheless important, work of preparing this set of data; in the interests of speed, translation will be reduced to the minimum, and any translation into English will be done with the help of one of the " national correspondents " of the United Kingdom or the United States of America. This annexed set of data will serve both as a provisional working document for the Specialised Secretariat of the C.C.I.R. and the Member Administrations, and as a draft for the vocabulary to be prepared later.

B. *Graphical and letter symbols.*

In view of the work now being done by the International Electrotechnical Commission (I.E.C.) on this subject, it seems advisable, for the time being, to mark time and refrain from recommending any particular system of symbols. The chairman of Study Group XIV has been requested to ask the I.E.C. to give the C.C.I.R. every opportunity of following its work. About thirty copies of the various I.E.C. working documents will be required for any " national correspondents " of Study Group XIV who may ask to take part in the work. This would allow the I.E.C. to be approached where useful.

REPORT No. 95 *

DECIMAL CLASSIFICATION

Complement to Report No. 37

(Question No. 72 (XIV))

(Warsaw, 1956)

A report on the progress of the work of the S.C.I.C.T. (International Sub-Committee for the application of the Decimal Classification to Telecommunication), set up by the F.I.D. (Fédération Internationale de Documentation), is given in Doc. No. 380 (Warsaw). This document has been studied during the VIIIth Plenary Assembly of the C.C.I.R., and the Chairman of S.C.I.C.T., Mr. Ferrari Toniolo, gave his comments; he explained that he had submitted the document himself and that it was not an official communication of the F.I.D. After the document had been studied, the following conclusions were reached:

(a) From the existing data on the question it is not possible for the present Plenary Assembly to " decide on its possible use " (Report No. 37). The possibility of this decision is therefore referred to a later Plenary Assembly.

(b) For the time being, the C.C.I.R. will confine itself to accepting the following proposal made by the Chairman of the S.C.I.C.T., designed to show the possible application of the U.D.C. in the sphere of the C.C.I.R. The S.C.I.C.T., without the assistance of the C.C.I.R., will prepare a list, classified according to the present revised edition of the U.D.C., for the various official documents of the C.C.I.R. (Recommendations, Reports, etc.) which will be in force after the VIIIth Plenary Assembly, and for the whole set of working documents dealt with during the present Plenary Assembly.

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* This Report was adopted unanimously.

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RESOLUTION No. 5

MEANS OF EXPRESSION

Definitions, Vocabulary, Graphical and Letter Symbols

(Recommendations Nos. 26 and 34 of the C.C.I.R. and Resolutions Nos. 66, 67 and 175 of the Administrative Council of the I.T.U.)

(Study Group No. XIV)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that it is of the first importance to standardise the means of expression (terms, symbols, measurement units) with a view to better and more rapid understanding among the participants in the work of the C.C.I.s;

(b) that such standardisation is far from being accomplished;

UNANIMOUSLY RESOLVES

1. that each study group of the C.C.I.R. should establish a list of definitions of the principal terms and symbols used in the branch of radio communication with which it is concerned;

2. that the Director of the C.C.I.R., as his other duties permit, shall collect available information concerning the standardisation of means of expression (terms with their definitions, graphical and letter symbols);

3. that administrations should collaborate to their utmost in the preparation of a list of radio communication terms, by forwarding to the Director of the C.C.I.R. the glossary of technical terms and documents of national standards, if any, together with any other documents that may be of value in compiling a first draft list of terms and symbols;

4. that the Director of the C.C.I.R. should examine all the documentation he is thus able to collect and reach agreement with the chairman of the Study Group on Vocabulary as to subsequent work, with a view to examination by the VIIth Plenary Assembly of the C.C.I.R.;

5. that care should be taken not to duplicate work already carried out by national or other international organisations.

RESOLUTION No. 15 *

STANDARDISATION OF FACSIMILE APPARATUS FOR USE ON COMBINED RADIO AND METALLIC CIRCUITS

(Study Group No. III)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that a Joint Study Group of the C.C.I.T. and C.C.I.R., under the direction of the C.C.I.T., has already been formed for the study of certain aspects of " Transmission of half-tone pictures over combined radio and metallic circuits ";

* The present Resolution in conjunction with Recommendation No. 127 (replaced by Recommendation No. 227) and Question No. 95 (IX) completes the study of Question No. 58.

(b) that this Joint Study Group has not yet completed its work;

(c) that the C.C.I.R. takes considerable interest in C.C.I.T. Question No. 46 - Arnhem (i.e. Question No. VI.8 (amended) of the Geneva revision) concerning the characteristics of apparatus for the transmission by facsimile of:

— telegrams in the public telegraph service;
— business documents;
— documents of large size such as, for example, meteorological charts;

(d) that other questions concerning facsimile telegraphy which are of joint interest to the C.C.I.T. and the C.C.I.R. will probably arise;

UNANIMOUSLY RESOLVES

that the Joint Study Group of the C.C.I.T. and C.C.I.R. should remain in being to study these matters.

RESOLUTION No. 17

USE OF THE 26 Mc/s BROADCASTING BAND

(Study Group No. X)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that it is important that long-distance broadcasting should use all channels available to it;

(b) that, when the smoothed relative sunspot number reaches 70, long-distance broadcast transmissions can be carried out efficiently during daylight hours, over many routes, on frequencies within the 26 Mc/s broadcasting band;

(c) that hitherto these frequencies have been very little used;

(d) that such transmissions on these frequencies, whenever they are possible, are particularly advantageous because of the very low atmospheric noise intensity and the low absorption;

(e) that this band will not be fully used until receivers covering it are available;

UNANIMOUSLY RESOLVES

1. that administrations should bring to the notice of broadcasting organisations the advantages of the 26 Mc/s band for long-distance broadcasting when ionospheric conditions are favourable;

2. that, when broadcasting organisations have decided that they will make use of the 26 Mc/s band, they should make their intention known well in advance, in order to expedite the availability of suitable receivers.

RESOLUTION No. 19 *

IDENTIFICATION OF RADIO STATIONS

(Study Group No. XIII)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that the need for solution of the problems raised in Question No. 104 (VIII) ** and Study Programme No. 78 ** is rapidly becoming more acute, more widespread and increasing use is being made of the radio spectrum, as well as greater use of multi-channel and high-speed F1 systems, thus resulting in increased congestion in the radio-frequency spectrum, particularly below 27 500 kc/s;

(b) that only slight progress has been made in the study of Question No. 17 and Study Programme No. 26;

(c) that representations have been made by the I.F.R.B. to the C.C.I.R. to expedite satisfactory solutions of the problem posed in C.C.I.R. Question No. 17 and Study Programme No. 26 to facilitate the work of monitoring stations and to further the programme adopted by the E.A.R.C., Geneva, 1951;

(d) that increased emphasis is desirable in finding prompt and satisfactory solutions to the question of " Identification of Radio Stations ", and particularly that means should be found to superimpose, or otherwise transmit the call sign, preceded, when appropriate, by a special signal *** on radio transmissions employing multi-channel and high-speed F1 systems;

RESOLVES

that, in the meantime, and as a matter of urgency, administrations should take such measures as will ensure transmission of the call sign preceded, when appropriate, by a special signal ***, in a manner readily receivable and understandable by monitoring stations, as frequently as practicable, having regard to the present urgent need to facilitate international monitoring and more particularly to the furtherance of present efforts by administrations, assisted by the I.F.R.B., to carry out the decisions of the E.A.R.C., in Geneva, 1951.

RESOLUTION No. 20

MEASUREMENT OF UNWANTED RADIATIONS FROM INDUSTRIAL INSTALLATIONS

(Question No. 75 (I))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the C.I.S.P.R. has already studied, and continues to study extensively, the measuring methods for determining the level of interference from industrial, scientific and medical apparatus to sound and television broadcasting;

* The Bielorussian S.S.R., the P.R. of Bulgaria, the Hungarian P.R., the Roumanian P.R., the Ukrainian S.S.R. and the U.S.S.R. reserved their opinion on this Resolution.

** The study of Question No. 104 has been transferred from Study Group No. XIII to Study Group No. VIII. Study Programme No. 78 has been replaced by Study Programme No. 115 (VIII).

*** See Recommendation No. 220.

(b) that due regard should be given to the special requirements of radiocommunication services other than broadcasting;

UNANIMOUSLY RESOLVES

1. that the C.C.I.R. should consider whether it is practical to adopt the measuring methods which may be recommended by C.I.S.P.R. for determining the level of interference produced by industrial, scientific and medical equipments;

2. that the C.I.S.P.R. should be informed of the desirability of continuing the study of methods of measurement in portions of the radio-frequency spectrum other than those used for broadcasting.

Note. — The attention of the C.I.S.P.R. should be drawn to C.C.I.R. Study Programme No. 84 (I).

RESOLUTION No. 21

SUPPLEMENT TO C.C.I.R. ATLAS OF PROPAGATION CURVES

(Study Group No. IV)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the atlas of ground-wave propagation curves for frequencies between 30 and 300 Mc/s envisaged in Resolution No. 11 has now been published by the C.C.I.R.;

(b) that these curves refer to an effective earth radius of 4/3 times the actual radius;

(c) that under certain meteorological conditions the effective earth radius may differ considerably from the above value;

UNANIMOUSLY RESOLVES

1. that a supplement to the 1955 atlas of curves should be prepared which would present and explain the use of suitable mathematical transformations for the calculation of field-strength values for effective earth radii other than 4/3 and for other values of earth conductivity.

2. that the Director of the C.C.I.R. should be asked to undertake this work.

RESOLUTION No. 22

PUBLICATION OF NEW GROUND-WAVE PROPAGATION CURVES

(Study Group No. IV)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the atlas of ground-wave propagation curves for frequencies between 30 and 300 Mc/s envisaged in Resolution No. 11 has now been published;

(b) that the above curves relate to a range of distances, heights and frequencies of great importance to all types of radio transmission;

(c) that nevertheless, especially where high-flying aircraft are concerned, a greater range of distances, frequencies and heights is important;

UNANIMOUSLY RESOLVES

1. that a second atlas of curves be produced to meet the following conditions:

1.1 the calculations shall be made for frequencies of 30, 100, 300, 1000, 3000 and 10 000 Mc/s;

1.2 the maximum distance to be covered will be limited as follows:

(a) the curves shall not extend beyond 1000 km;

(b) the charts need not extend appreciably beyond the point at which the field strength falls below 0.1 microvolt per metre;

1.3 the minimum distance at which the actual fields will be presented will be in the vicinity of the first minimum of field-strength. At shorter distances, the envelopes formed by the maxima and minima of the field-strength will be shown. An indication of the number of maxima per unit distance at a number of distances over the useful range would also be useful;

1.4 the elevations of the transmitting antenna above the ground for which the curves shall be constructed are 0, 5, 20, 100, 500, 1000, 2000, 5000, 10 000 and 20 000 metres;

1.5 the elevations of the receiving antenna above the ground for which the curves shall be constructed are 5, 20, 100, 500, 1000, 2000, 5000, 10 000 and 20 000 metres;

1.6 vertical polarisation;

1.7 the curves shall be constructed for sea and land paths. For sea-water a relative dielectric constant of 80 and a conductivity of 4×10^{-11} e.m.u. (4 mhos/metre) shall be assumed. For land, the values shall be 10 and 10^{-13} e.m.u. (0.01 mhos/metre) respectively;

1.8 standard refraction shall be allowed for by employing an effective earth radius equal to 4/3 of the actual earth radius:

1.9 the curves shall refer to a half-wave transmitting dipole, the moment of which corresponds in free space to a radiation of 1 kW, i.e. to a field in the equatorial plane of

$$\frac{2.22 \times 10^5}{D_{km}} \mu V/m;$$

1.10 the general presentation and procedure followed should be the same as was used in the conduct of the work under Resolution 11;

1.11 if possible, a method of interpolation for antenna heights and frequencies different from those contained in the curves should be indicated;

1.12 attention should be drawn to the practical limits of application of the curves;

2. that the Director of the C.C.I.R. should be asked to undertake this work.

RESOLUTION No. 23

TROPOSPHERIC-WAVE PROPAGATION CURVES

(Study Group No. V)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the need exists for revision of the curves attached to Recommendation No. 111;

(b) that much data have become available since the publication of these curves;

(c) that during the VIIIth Plenary Assembly at Warsaw, there was insufficient time for the proper consideration of the data then available;

(d) that additional data are continually being made available particularly as regards the U.H.F. (decimetric) band;

(e) that to prepare for the next regional conference on frequency assignments for broadcasting (sound and vision), this revision should be completed;

RESOLVES

1. that an international Working Group should be established to examine all available data and to prepare provisional new curves intended to replace the curves of Recommendation No. 111;
2. that the Working Group be composed of members nominated by the Administrations of the United States, France, the Federal German Republic and the United Kingdom;
3. that the co-ordination of the work of the Group should be undertaken in the United Kingdom by the Radio Research Organisation of the Department of Scientific and Industrial Research under the direction of the Chairman of Study Group No. V;
4. that as soon as the curves are available they should be communicated to the Director of the C.C.I.R. by the Chairman of Study Group No. V and submitted for approval to all administrations. If approved, they should be considered valid for provisional use pending consideration by the IXth Plenary Assembly;
5. that as far as possible the work of the Group should be conducted by correspondence.

RESOLUTION No. 24

RADIO TRANSMISSION CAUSED BY INHOMOGENEITIES IN THE TROPOSPHERE (COMMONLY TERMED " SCATTERING ")

(Study Group No. V)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that experiments have already shown the possibility of utilising frequencies in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands for transmission by tropospheric scatter propagation to distances well beyond the horizon;

(b) that the utilisation of such frequencies over such distances may tend to reduce the rate of expansion of services in other frequency bands;

UNANIMOUSLY RESOLVES

1. that the attention of administrations and of the I.F.R.B. should be drawn to the potentialities of the frequencies in the VHF (metric), UHF (decimetric) and SHF (centrimetric) bands for fixed services over distances well beyond the horizon by means of tropospheric scatter propagation and should be invited to keep in touch with developments in this field (see Study Programme No. 91 (V)).

RESOLUTION No. 25

LOCAL LIGHTNING-FLASH COUNTERS

(Recommendation No. 121)
(Study Group No. VI)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the group which was formed in accordance with Recommendation No. 121 has made much progress;

(b) that it is possible that the group could come to a final result in the near future;

(c) that it would be in the interest of all concerned if the introduction by the W.M.O. of local lightning-flash counters could be organised before the next Plenary Assembly has formally adopted the result of the work of the group;

UNANIMOUSLY RESOLVES

1. that the group should continue its work as defined in Recommendation No. 121 until specifications for a local lightning-flash counter have been formulated;
2. that the group should present the final specifications to the Director of the C.C.I.R. through the Chairman of Study Group VI;
3. that the Director of the C.C.I.R. should take the necessary measures to facilitate the introduction by the W.M.O. of the local lightning flash-counters into regular use.

RESOLUTION No. 26

IONOSPHERIC SOUNDING STATIONS AFTER THE INTERNATIONAL GEOPHYSICAL YEAR

(Study Group No. VI)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

that at the termination of the International Geophysical Year a favourable opportunity will occur for the establishment of an improved world-wide network of permanent ionospheric sounding stations;

UNANIMOUSLY RESOLVES

that the attention of U.R.S.I. should be drawn to the desirability of a recommendation concerning the continuation or certain of the more useful ionospheric sounding stations after the International Geophysical Year for the purpose of making propagation forecasts.

RESOLUTION No. 27 *

NON-LINEAR EFFECTS IN THE IONOSPHERE

(Study Programme No. 61)
(Study Group No. VI)

The C.C.I.R., (Warsaw, 1956)

UNANIMOUSLY RESOLVES

that the U.R.S.I. be invited to inform the C.C.I.R. of any results from experiments and theoretical studies still continuing on the subject of ionospheric cross-modulation which may have important practical applications.

RESOLUTION No. 28

IONOSPHERIC SCATTER PROPAGATION

(Study Programme No. 95 (VI))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that experiments carried out in the arctic, temperate and tropical zones, on ionospheric scatter propagation in the frequency bands between 27.5 and 60 Mc/s, prove the possibility of utilising very high frequencies for long-distance (continental and intercontinental) fixed services;

(b) that regular layer propagation can also occur in the same frequency range for certain periods of time which increase in duration with solar activity;

(c) that problems connected with the occurrence of regular layer propagation may, in middle and low latitudes, make undesirable the use of the lower frequencies in the frequency bands in question in years of high solar or geo-magnetic activity;

(d) that experiments carried out since 1951 have shown that the use of a single frequency is sufficient for the operation of radio circuits of this type 24 hours a day, throughout the year, although in view of considerings *(b)* and *(c)*, this may not be practicable in all latitudes throughout the solar cycle;

(e) that a particular frequency can probably be shared by several scatter circuits suitably distributed over the world;

(f) that the utilisation of very high frequencies for fixed services over long distances may tend to reduce the rate of expansion of services in the medium and high-frequency bands;

(g) that the probable transfer of some of the long-distance fixed services from the medium and high-frequency bands to the very high frequency bands will reduce congestion in the former bands;

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* This Resolution replaces Study Programme No. 61.

(h) that the divergences between the regional allocations between 27.5 and 60 Mc/s made in the Atlantic City Table of Frequency Allocations, as laid down in Article 5 of the Radio Regulations, give rise to difficulties in exploiting the possibilities of ionospheric scatter propagation in relation to inter-regional communications and to possibilities of sharing;

(i) that such difficulties would be minimised if the frequency bands, or suitably selected portions of them, between 27.5 and 60 Mc/s were to be appropriately allocated on a world-wide basis;

RESOLVES

1. that the attention of administrations and of the I.F.R.B. should be drawn to the potentialities of very high frequencies for fixed services over long distances by means of ionospheric scatter propagation;

2. that the I.F.R.B. be invited

2.1 to include, in any studies of frequency utilisation which it may carry out in preparation for the next Administrative Radio Conference, the study of the consequences of these potentialities;

2.2 to keep in touch with developments in connection with Study Programme No. 95 (VI) (Ionospheric Scatter Propagation), and

2.3 to make the results of its study available to the Conference mentioned above.

RESOLUTION No. 29

OPERATIONAL CHARACTERISTICS OF LONG-DISTANCE RADIO RELAY SYSTEMS

(Question No. 116)
(Study Group No. IX)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the C.C.I.F. in Question No. 15 of its 5th Study Group, has requested the collaboration of the C.C.I.R. concerning information on a number of specified characteristics of long-distance radio relay systems;

(b) that a large volume of information has already been collected and published in Document No. 20 of the Geneva meeting of Study Group IX, September, 1954;

(c) that in the light of its experience in handling this information the C.C.I.R. has formed the view that it is difficult to obtain and to collate and is likely to be of little practical value for the purposes referred to in Question No. 116;

UNANIMOUSLY RESOLVES

1. that the attention of the C.C.I.F. be drawn to the information that has been gathered together and tabulated in Document No. 20 of the Geneva meeting of Study Group IX of the C.C.I.R., September 1954;

2. that the study of Question No. 116 be terminated.

RESOLUTION No. 30

WIDTH OF MAGNETIC TAPE

(Recommendation No. 135, para. 2)
(Study Group No. X)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

Report No. 80;

UNANIMOUSLY RESOLVES

1. that the members of the C.C.I.R., especially those who were unable to accept any amendment to paragraph 2 of Recommendation No. 135 * at the VIIIth Plenary Assembly, should proceed as soon as possible to hold an inquiry among interested organisations in their countries with a view to ascertaining:

(a) whether the following dimension and tolerance in regard to tape width could be agreed upon:
0.246 inches $\pm$0.002 inches (6.25 mm $\pm$0.05 mm);

(b) whether the tolerance could be reduced to:
$\pm$0.0012 inches ($\pm$0.03 mm) or

(c) whether another proposal would be preferable;

2. that the results of these inquiries be communicated before 31 December 1956, to the Chairman of Study Group No. X, who will then decide whether a new standard suitable for general adoption can be proposed forthwith;

3. that in the event of this not being possible, a meeting of Study Group No. X should be held at the Headquarters of the I.T.U. during the first half of 1957 if the Chairman anticipates that this would serve a useful purpose.

RESOLUTION No. 31

ORGANISATIONS QUALIFIED TO TAKE ACTION ON QUESTIONS OF SOUND RECORDING

(Study Group No. X)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that difference of opinion may exist as to which one of the organisations I.E.C., I.S.O. or C.C.I.R. is in the best position to take action in questions in the recording field;

(b) that unnecessary duplication of work and multiplicity of standards may be the result if the present situation is allowed to continue;

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* This Recommendation has been replaced by Recommendation No. 209.

UNANIMOUSLY RESOLVES

1. that the C.C.I.R. should determine the acceptability of existing standards and should collaborate with other international organisations in formulating new standards when the existing ones are unsuitable for the international exchange of programmes.

2. that the Director of the C.C.I.R. should keep in close touch with the I.E.C. and the I.S.O. with a view to avoiding unnecessary duplication of work.

RESOLUTION No. 32

TRANSMISSION OF MONOCHROME AND COLOUR TELEVISION SIGNALS OVER LONG DISTANCES

(Question No. 121 (XI))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the scope of the studies under Question No. 121 (XI) is considerable, and that it is not yet possible to give a complete and definite answer to that Question;

(b) that it seems, however, as far as the transmission of monochrome television signals is concerned, that the knowledge acquired through studies and the experience will enable a partial and provisional answer to be given to the problems listed in Question No. 121 (XI);

(c) that this answer, even though partial and provisional, will give administrations essential indications for their design projects;

(d) that, however, experience has shown that only a particularly close collaboration between the C.C.I.R. and the C.C.I.T.T. will allow an effective recognition of this possibility and the drafting of an early and complete reply;

(e) that this very collaboration is now extremely desirable in view of the problems to be solved in connection with the transmission of signals of the various colour television systems submitted for study by the C.C.I.R.;

UNANIMOUSLY RESOLVES

1. that a joint C.C.I.R.-C.C.I.T.T. Group be established to start work in the near future;

2. that this Joint Group be given the following terms of reference:

   (a) to examine the possibility of accepting for a hypothetical reference circuit of 2500 km with two intermediate video junction points, and for all monochrome television systems, the specifications laid down in Report No. 84;

   (b) if this should be the case for all or some of the specifications proposed, to draft a Recommendation to this effect, which will be submitted for approval to the Plenary Assemblies of the C.C.I.R. and C.C.I.T.T.;

   (c) to study the measures to be envisaged in order that the specifications supposed necessary for the transmission of television signals over long-distance links (coaxial cables, radio relay links, waveguides, etc.) for any one of the colour-television systems being studied, be met;

3. that the Director of the C.C.I.R. be responsible for the convening, the organisation and the secretariat of this Joint Group.

RESOLUTION No. 33 *

PUBLICATION OF SERVICE CODES IN USE IN THE INTERNATIONAL TELEGRAPH SERVICE

(Study Group No. XIII)

The C.C.I.R., (London, 1953—Warsaw, 1956)

CONSIDERING

(a) that the C.C.I.T. during its VIIth Plenary Assembly adopted the following question:

> " the study, in collaboration with the C.C.I.R., of the possibility of assembling in a separate volume, to be published by the General Secretariat of the Union, the various codes regarded as useful in the international telegraph service (line and radio) for universal use by that service ";

(b) that the C.C.I.T. has requested the C.C.I.R. to collaborate in the study of that question;

(c) that it is of importance to assemble all service codes useful in the telegraph service (such as those contained in App. I of the International Telegraph Regulations, Q-code, etc.);

UNANIMOUSLY RESOLVES

1. that the C.C.I.R. should co-operate with the C.C.I.T.T. in assembling the volume mentioned under *(a)* above, on the understanding that the C.C.I.T.T. assumes the supervision and responsibility for this work;
2. that the assembling in one volume of the various codes at present in use will be a first step towards a more unified system of service codes;
3. that administrations should consider whether there is an operational need for the unification of codes.

RESOLUTION No. 34

DEFINITIONS OF CERTAIN BASIC WORDS USED IN THE INTERNATIONAL TELECOMMUNICATION CONVENTION

(Study Group No. XIV)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

that the definitions given by the International Telecommunication Union ought to be simple and unambiguous, applicable to the activity of the Union and fit for use in national laws, regulations and recommendations and ought further to follow common parlance as far as possible,

UNANIMOUSLY RESOLVES

1. that the attention of administrations be drawn to the desirability of their studying further, with particular reference to the field of radio communication, the definitions of the words

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* This Resolution replaces Resolution No. 18.

" telecommunication " and " Hertzian waves " and of the word " radio " (as used for example in " radio waves "), with a view to the formulation of more suitable definitions at the next Plenipotentiary Conference;

2. that administrations should forward their views to the Chairman of Study Group No. XIV by July 1957, if possible;

3. that the Chairman of Study Group No. XIV should endeavour to reach agreement with the C.C.I.T.T., upon the definitions, before the next administrative conferences.

Note.—Doc. No. 451 (Warsaw) and C.C.I.T. Recommendation I.2 refer to this subject.

RESOLUTION No. 35

REDUCTION OF PREPARATORY DOCUMENTATION

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that since 1948 the C.C.I.R. has continued to develop at an ever increasing rate, as indicated by the interest shown in its work;

(b) that one result of this growing interest has been a great increase in the preliminary documentation issued before plenary assemblies, to the extent of some 500 documents, totalling 3500 pages, before the VIIIth Plenary Assembly in Warsaw;

(c) that it is desirable to reduce this large volume of documentation:
— to secure financial economy;
— to reduce the peak-load on the Secretariat;
— in the interest of the general efficiency of C.C.I.R. work;

UNANIMOUSLY RESOLVES

1. that documents submitted to the Chairman of the Study Groups should be as short as possible, and only in exceptional circumstances should be longer than *2500 words*, with approximately *3 pages of figures*, making in all *8 pages per document*;

2. that documents of theoretical interest only, which do not have a direct bearing on Questions and Study Programmes, or reports containing detailed original material, should not be submitted to the C.C.I.R. Short abstracts only of such documents should be sent to the C.C.I.R. for translation and publication. Copies of these documents, in their original language, could be distributed by the administration concerned directly to those who express their desire to receive copies;

3. that documents should contain only the minimum indispensable mathematical formulæ or numerical and experimental data;

4. that the Director should issue reminders to administrations to refrain from asking for more copies of documents than are really necessary.

RESOLUTION No. 36

ORGANISATION OF C.C.I.R. WORK

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that, although the present arrangement of work, whereby most of the activity is concentrated into one set of Study Group meetings held immediately before the Plenary Assembly, was suitable in the early years of the C.C.I.R., the increased interest in the work of the C.C.I.R. has now proved this system to have certain disadvantages;

(b) that the peak-load for the members and for the Secretariat is unreasonably high for some six months every third year;

(c) that the overall volume of paper of the preliminary documentation for the Plenary Assembly has reached a level which makes it impossible for members to study this documentation thoroughly;

(d) that the present volume of documentation, and the late date at which some of it reaches the C.C.I.R. Secretariat, has made it difficult to comply with the provisions of C.C.I.R. Recommendation No. 33;

(e) that, even when the provisions of Resolution No. 37 are complied with, difficulties will still remain, under the present arrangement of work;

UNANIMOUSLY RESOLVES

1. that Study Groups should spread their activity over the three-year period between Plenary Assemblies, rather than concentrate the whole of their activity into the final meetings which immediately precede a Plenary Assembly;

2. that Study Group Chairmen should make greater use of the provisions of paragraph 2 (2), Chapter 16, of the General Regulations (Buenos Aires, 1952) *, by which a Study Group Chairman is empowered to arrange interim meetings of his Study Group with the approval of his administration, and after consultation with the Director and the members of his Study Group;

3. that as a general rule these interim meetings of Study Groups, if held, should take place as soon as practicable before the next Plenary Assembly. In order to spread the working load, all Study Groups should not meet simultaneously. However, in order to secure economy, they should not all meet individually. The Director should make arrangements with the Study Group Chairmen concerned so as to obtain the maximum efficiency, co-ordination and economy, the places and dates of such meetings of combinations of Study Groups being chosen so as best to suit the convenience of the members;

4. that documentation for interim Study Group meetings should reach the Study Group Chairman (with copies to the Director) four months before the opening of such meetings;

5. that, as a general rule, no document prepared in connection with Study Group work will be considered which is sent directly to the Director instead of being sent to the appropriate Group Chairman;

* " Moreover, if, after a Plenary Assembly, a Group Chairman considers it necessary for his Study Group to hold a meeting not provided for by the Plenary Assembly to discuss orally questions which could not be solved by correspondence, he may, with the approval of his administration and after consultation with the Director concerned and the members of his Study Group, suggest a meeting at a convenient place bearing in mind the need to keep expenses to a minimum."

6. that all the documentation for interim Study Group meetings should be distributed only among the members of the Study Group or Study Groups concerned;

7. that documents relating to Study Group work, received by a Study Group Chairman later than stipulated in paragraph 4 above, will only in exceptional cases be approved by the Chairman for distribution to members of the Study Group and then only if they can be distributed to reach members at least one month before the Plenary Assembly;

8. that the Study Group Chairmen shall send their reports to the Director so that he receives them at least four months before the date of the opening of the Plenary Assembly;

9. that, in conformity with paragraph 4, Chapter 16, of the General Regulations (Buenos Aires, 1952), the Director shall send the final reports of the Study Group Chairmen to the participating administrations, recognised private operating agencies, etc., in time for them to be received at least one month before the date of the next Plenary Assembly;

10. that all Study Groups should hold final meetings immediately before, and at the same place as the Plenary Assembly; these Study Group meetings and the Plenary Assembly are expected to last for approximately 25 calendar days in all;

11. that preliminary documentation of a Plenary Assembly will consist only of the Chairmen's Reports of the fourteen Study Groups with annexes, and the Director's report. The Annexes to the Chairmen's Reports will consist of Draft Recommendations, Questions, Study Programmes, Reports, etc., formulated as a result of correspondence or of interim and final Study Group meetings.

RESOLUTION No. 37

WORK OF C.C.I.R. STUDY GROUPS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) Chapters 16 and 17 of the General Regulations annexed to the International Telecommunication Convention (Buenos Aires, 1952);

(b) the great increase in participation in the work of the Study Groups since the Vth Plenary Assembly of the C.C.I.R. (Stockholm, 1948);

(c) that the Chairmen of the Study Groups do not always have the necessary facilities available to translate, reproduce and distribute numerous contributions to the work of their Study Groups during the interval between successive Plenary Assemblies;

(d) that the present staff of the Specialised Secretariat is not large enough to cope with this additional work within the time limits desirable;

(e) that this additional work is likely to be irregular in volume;

(f) that it is not desirable to increase the permanent staff of the C.C.I.R. at the present time;

UNANIMOUSLY RESOLVES

1. that during the interval between Plenary Assemblies, contributions to the work of a Study Group from the participants in the work thereof be sent:
   - in one copy to the Chairman of the Study Group concerned for his consideration;

— in three copies to the Director of the C.C.I.R. for translation, reproduction and distribution to the members of the Study Group concerned;

2. that the necessary credits for the engagement, on a supernumerary basis, of the required personnel be made available from the Extraordinary Budget of the C.C.I.R. for this purpose;

3. that, as a trial, this procedure be instituted during the period between the VIIIth and IXth Plenary Assemblies of the C.C.I.R.;

4. that the Director of the C.C.I.R. report on the experience acquired and make proposals on the basis of this experience to the IXth Plenary Assembly, for a definite arrangement on this matter.

RESOLUTION No. 38

TECHNICAL ASSISTANCE

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) resolution No. 346 adopted by the 11th session of the Administrative Council reproduced in part in Document No. 491 of Warsaw;

(b) the growing importance of Technical Assistance in the sphere of telecommunications;

(c) the desirability of more effective collaboration in Technical Assistance on the part of the C.C.I.s;

(d) that additional technical information which could be given by the I.T.U. to the Technical Assistance Administration (T.A.A.) may improve ways and means of granting technical assistance;

(e) the advisability of keeping the countries concerned rapidly and fully informed of all the work carried out under the auspices of the I.T.U.;

RESOLVES

1. that a temporary joint C.C.I.R.-C.C.I.T.T. Committee be promptly established to study the present ways and means employed in granting Technical Assistance and to prepare for the Administrative Council suggestions to improve them in respect of telecommunications. The detailed terms of reference of this Committee are given in the Annex;

2. that membership in the Committee proposed in paragraph 1 above should include the Director or the Vice-director of the C.C.I.R. and the Director of the C.C.I.T.T. together with two members of the C.C.I.R. and two members of the C.C.I.T.T. of countries which are not members of the Administrative Council of the I.T.U.

3. that the Director of the C.C.I.R. should bring this Resolution to the attention of the C.C.I.T.T., the Secretary General of the I.T.U. and the Administrative Council.

ANNEX

1. Thorough study of the existing Technical Assistance procedure on the basis of the documentation supplied by U.N.O. and the I.T.U. and the answers to a Questionnaire which should be sent to the members of the I.T.U.

2. To study methods of improving and accelerating this procedure.

3. The most advantageous method whereby countries requiring Technical Assistance could obtain such assistance in the following forms, which are given as an example:

   3.1 consultations regarding plans for the development of telecommunication systems;

   3.2 expert study of telecommunication projects in various spheres (broadcasting stations, television stations, radio relay links etc.);

   3.3 expert assistance in the planning, construction, assembly, and in the final adjustment of equipment;

   3.4 exchange of specialists in the sphere of radio communication, sound broadcasting and television, so that the experience acquired may be shared;

   3.5 the sending of consultants and consulting engineers at the request of a country receiving Technical Assistance;

   3.6 assistance in the training of technical personnel of a country receiving Technical Assistance—in the country receiving such assistance—in the countries granting Technical Assistance at the request of the country receiving assistance.

4. Organisation of a more extensive information service on the work carried out by the organs of the I.T.U.

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QUESTIONS
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Questions and Study Programmes assigned to Study Group No. I

QUESTION No. 1 (I) *

REVISION OF ATLANTIC CITY RECOMMENDATION No. 4

The C.C.I.R., (Stockholm, 1948)

CONSIDERING

that to give maximum effectiveness to the studies requested by the International Radio Conference of Atlantic City (1947) in its Recommendation No. 4 to the C.C.I.R. it is expedient to rearrange this recommendation and incorporate the relevant Bucharest questions;

UNANIMOUSLY RESOLVES

A. that the text of Atlantic City Recommendation No. 4 can be rearranged and extended as follows:
in respect of the various classes of emission in use, determination of:

(a) the bandwidth strictly necessary to ensure a service of the appropriate quality, practical methods of measuring the bandwidth actually occupied by each emission;

(b) the level of radio-frequency harmonics radiated by the stations of the different services,
the level to which it is practicable to reduce such harmonics,
the methods of achieving this result,
the corresponding methods of measurement;

(c) study of improved methods of obtaining frequency stability in transmitters;

B. that the above questions ** be studied simultaneously and with the same urgency;

C. that Questions Nos. 1, 4, 11, 14, 16 and 17 of the C.C.I.R. of Bucharest be removed from the list of questions to be studied by the C.C.I.R.

AND UNANIMOUSLY DECIDES

to carry on permanently the study of the above-mentioned questions and to publish its recommendations and possible revisions as soon as practicable.

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* Study Programmes Nos. 2 (I), 3 (I), 40 (I) and 82 (I) arise from this Question.

** Concern Questions No. 1 (I), No. 2 (which no longer remains for study) and No. 3 (III).

STUDY PROGRAMME No. 2 (I) *

HARMONICS AND PARASITIC EMISSIONS

(Question No. 1.b (I))

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that in the case of wave propagation at frequencies where ionospheric reflection plays an important part, the harmonics may propagate differently from the fundamental in different directions due to the wide difference in frequencies; this effect is in addition to that caused by the antenna directivity not being the same for the fundamental and harmonic frequencies;

(b) that the harmonics of a transmitter provided for one class of service may interfere with other classes of service in other parts of the spectrum;

(c) that the relationships between fundamental and harmonic field intensities and between radiated harmonic power and harmonic field intensity measured at a distance from the transmitter differ markedly in the cases:

- where both the fundamental emission and the harmonic involve ionospheric propagation,
- where only the harmonic involves ionospheric propagation,
- where only the fundamental emission involves ionospheric propagation,
- where neither the fundamental emission nor the harmonic involves ionospheric propagation;

(d) that a more definite evaluation of the effects of the limiting values specified in App. 4 of the Radio Regulations, 1947, should be determined;

(e) that, in order to achieve or maintain a good standard of practice for transmitters with respect to the suppression of harmonics, it is essential to have readily applicable methods of specifying and testing equipments;

(f) that, since many existing high power transmitters have a fundamental to harmonic power ratio of 70 db or greater, it is desirable to consider further:

- the need for revised limits for harmonic power output for such cases,
- reduction of harmonic radiation from conductors with non-linear characteristics located within the high intensity fundamental field of the transmitter which might act as subsidiary generators;

(g) that different relationships exist between the signal-to-noise ratios appropriate for the several services in the various frequency bands and interferences caused by harmonic radiations. For example, in view of the susceptibility of television to interference, the particular harmonics falling within television channels ** which are in use in the vicinity of the interfering station are of paramount importance. The attenuation of these particular harmonics may in some cases need to be substantially greater than limits which may be applicable for some other services. Other services may also have special requirements peculiar to their own needs;

* This Study Programme arises from Question No. 1 (I).

** Television channels may be set up in certain cases in the following broadcasting bands: Band I, 41 to 68 Mc/s; II, 87.5 to 100 Mc/s; III, 174 to 216 Mc/s; and IV, 470 to 960 Mc/s.
For additional details see the Atlantic City Frequency Allocation Table, Chap. 3, Art. 5 of the Radio Regulations.

DECIDES that the following studies shall be carried out:

1. App. 4 of the Radio Regulations, 1947, should be re-evaluated, for which purpose the various administrations should submit data on harmonic power and field intensity measurements to enable a more definite evaluation to be made of the relationships between them. Such evaluation should take into account the signal-to-noise ratio aspects as related to the different services with regard to the harmonic interference problem;

2. to secure further data on methods of measurement of harmonic power by the substitution method and on the equipment to be used, particularly with regard to correctly connecting the auxiliary generator to the antenna feeder;

3. to secure further data on alternative methods of measuring harmonic power;

4. study of the elements of antenna and antenna feeder design useful in reducing harmonic radiations;

5. determination of the special conditions which may apply to certain high power transmitters (for example 100 kW or greater) which in many cases at present have a fundamental to harmonic power ratio of 70 db or greater. In this connection consideration should be given to radiation from conductors with non-linear characteristics which such transmitters may excite.

STUDY PROGRAMME No. 3 (I) *

FREQUENCY STABILISATION OF TRANSMITTERS

(Question No. 1.c (I))

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that Question No. 1.c of the C.C.I.R. refers to frequency stability, by which is meant constancy of frequency;

(b) that improvement in the utilisation of the radio-frequency bands depends also on the accurate positioning of the mean frequency, that is, on the accuracy of the frequency-determining elements as distinct from their stability;

(c) that degrees of accuracy and stability far in excess of those required by the Radio Regulations of Atlantic City are available, but that such provision may, in certain cases, conflict with economic considerations and design considerations such as weight and volume;

(d) that advancements in technique are being made in obtaining high accuracy and stability, whilst still meeting economic and design requirements;

UNANIMOUSLY DECIDES that the following study shall be carried out:

study of improved methods of attaining high accuracy and stability of the frequency of radio emissions, consistent with economic and design requirements.

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* This Study Programme arises from Question No 1 (I).

STUDY PROGRAMME No. 40 (I) *

METHODS OF MEASURING EMITTED SPECTRA IN ACTUAL TRAFFIC

(Question No. 1.a (I))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that it is of the highest importance to be able to determine with accuracy the bandwidth occupied and the spectrum of emissions in actual traffic;

(b) that the documentary material at present available does not give a full idea of the value of the results obtained in actual traffic with the apparatus used for measuring the spectrum of a periodic signal;

UNANIMOUSLY DECIDES that the following study should be carried out:

1. for a given type of measuring equipment, comparison of the results obtained on periodic signals and on actual traffic signals of comparable characteristics and of the same telegraph speed;
2. comparison of the results obtained with different methods such as those described in Recommendation No. 88;
3. continuation of experimental and mathematical studies in an attempt to bring out the physical meaning of the results obtained in actual traffic, considering various forms of energy distribution within the spectrum, especially those resulting from the use of privacy systems;
4. examination of the results obtained when using the method 1.1 of Recommendation No. 88 in cases where the bandwidth of the filter is inadequate to provide sufficient discrimination against adjacent components;
5. determination of the degree of accuracy obtainable with different methods such as those described in Recommendation No. 88.

STUDY PROGRAMME No. 82 (I) *

BANDWIDTH OF EMISSIONS

(Question No. 1.a (I) — Recommendation No. 87 **)

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) Question No. 1.a (I);

(b) that Recommendation No. 145 which contains partial answers to Question No. 1.a (I) was based on theoretical considerations as well as on results of measurements made under conditions which do not always represent those of actual traffic;

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* This Study Programme arises from Question No. 1 (I).

* This Study Programme replaces Study Programme No. 39. It arises from Question No. 1 (I).

** This Recommendation has been replaced by Recommendation No. 145.

(c) that it is therefore necessary to extend the theoretical and the experimental studies on the spectra appropriate to the various classes of emission;

(d) that the definition of the bandwidth occupied in the Radio Regulations of Atlantic City is such that measurements of the bandwidth occupied are difficult even at a short distance from the transmitter;

UNANIMOUSLY DECIDES that the following studies should be carried out:

continuation of the studies of bandwidths and spectra under actual traffic conditions in the different cases met with in practice and for all classes of emission in accordance with the following provisions:

1. the studies should be carried out simultaneously by theoretical and experimental methods and a detailed comparison should be made of the results obtained by both methods.

   The experimental studies should make use of the methods of measurement set out in Recommendation No. 88 as well as methods of measurement in actual traffic, which might be developed along the lines of Study Programme No. 40 (I);

2. the studies should be conducted along the following lines for the various classes of emission, and applied to different types of transmitters in service or under development:

2.1 *Class A1, A2 and F1 emissions.*

a sufficiently large number of measurements of spectra and of signal shape should be carried out with different types of transmitters at present in use.

The appropriate means for limiting the spectra of these transmitters as well as of new transmitters to be constructed, should be studied, with the aim, on the one hand, of determining the requisite filters and, on the other hand, of achieving a sufficient linearity of the amplifying stages or the frequency modulators.

The transmitters so improved should be put in service so that final conclusions on their behaviour may be established for various operating conditions;

2.2 *Class A3 emissions.*

measurements of radiation outside the necessary band should be made with transmitters of different types using this class of emission, and particularly with independent-sideband transmitters.

These measurements should be made with narrow bandwidth measuring apparatus such as is described in Recommendation No. 88 and the results should be compared with those obtained with wide-band apparatus, as mentioned in Recommendation No. 145, § 2.4.

It would be useful to obtain these measurements when the transmitter is modulated by an artificial voice or by white noise; these two modulations approximately reproducing the two practical cases where the transmitter is used without a privacy equipment or with a band-splitting privacy device.

Methods for still further reducing out-of-band radiation should be investigated;

2.3 *Other classes of emission.*

comparable studies should be undertaken for the other classes of emission used in international telecommunications, in particular for the classes of emission used in the HF (decametric) band such as:

— Multiplex emissions of various types;
— Class A4 and F4 emissions.

These studies should then be extended to the classes of emission used in the VHF (metric) and UHF (decimetric) bands;

3. other studies based on new principles should be undertaken as suggested in report No. 38 with a view to their possible application to new equipments;

3.1 the reduction of out-of-band radiation could be obtained through the determination of the best statistical distribution of the signal amplitudes which would permit a sufficient filtering of the signal without undue distortion, and the determination of the practical coding processes to produce such a statistical distribution;

3.2 to reduce the occupied bandwidth, the most favourable shape of a practical elementary signal should be sought theoretically and the practical shaping circuits to produce such a shape should be developed;

3.3 a delay of the signal, which is justified theoretically when a reduction of interference is to be obtained, will be introduced by the filtering and coding envisaged in the two preceding studies. The maximum acceptable delay should be determined for the various classes of emission and different services and taken into account in assessing the number of filtering cells to be used;

4. a new definition should be sought of occupied bandwidth, which will facilitate bandwidth measurements while still permitting their theoretical determination.

This new definition should not lead, for the classes of emission already studied, to results very different from those given by the definition contained in the Atlantic City Radio Regulations.

In this connection consideration should be given to suggestions that the out-of-band radiation might be defined:

— by a fixed maximum level for the corresponding components of the spectrum;
— by a fixed maximum value for the corresponding radiation per unit of bandwidth.

QUESTION No. 18 (I)

TELEGRAPHIC DISTORTION

The C.C.I.R., (Stockholm, 1948)

UNANIMOUSLY DECIDES

that it is advantageous that a joint study should be made by the C.C.I.T. and the C.C.I.R. of the following question:

establishment of a general definition of telegraphic distortion, capable of being usefully applied to the case of radiotelegraphy.

QUESTION No. 20 (I) *

FREQUENCY-SHIFT KEYING

The C.C.I.R., (Stockholm, 1948)

CONSIDERING

(a) that frequency-shift keying is employed in radiotelegraphy on fixed services and its use may be extended to the mobile services;

* Study Programmes Nos. 41 (I) and 83 (I) arise from this Question.

(b) that it is desirable to standardise the main operating characteristics of systems employing frequency-shift keying;

(c) that various technical factors influence the choice of operating characteristics in such systems, in particular:

1. the overlap of marking and spacing signals due to multipath propagation (in this respect a small deviation is preferable);
2. the possible advantage of frequency diversity for reception (an advantage which increases with deviation);
3. the economy of bandwidth and the consequent necessity for controlling the shape of the transmitted signals;
4. instability of frequency, which is one reason for the relatively large deviation employed in many existing equipments;
5. the choice of receiving systems, whether with separate filters or with frequency discriminator.

UNANIMOUSLY DECIDES that the following question be studied:

1. fixation of one or more standard values of deviation for fixed and mobile services in the various frequency bands, having regard to the various factors, in particular:
   (a) the frequency spectrum resulting from the keying operation,
   (b) the degree of frequency diversity desired,
   (c) economy of bandwidth,
   (d) instability of frequencies;
2. standardisation of the relative position of the marking frequency and the spacing frequency (is it desirable to utilise the upper frequency for mark and the lower frequency for space or vice versa?);
3. compilation of a standard terminology regarding the characteristics of systems employing frequency-shift keying.

STUDY PROGRAMME No. 41 (I) *

FREQUENCY-SHIFT KEYING

(Question No. 20 (I))

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that frequency-shift keying is employed in radio telegraphy on the fixed service and its use may be extended to the mobile service;

(b) that it is desirable to standardise the main operating characteristics of systems employing frequency-shift keying;

UNANIMOUSLY DECIDES that the following study should be carried out:

1. the determination in each particular case of recommended values of frequency shift for emissions using frequencies between 2000 and 27 000 kc/s;
2. the determination in each particular case of recommended values of frequency shift for emissions using frequencies below 2000 kc/s.

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* This Study Programme replaces Study Programme No. 4 and arises from Question No. 20 (I).

STUDY PROGRAMME No. 83 (I) *

FOUR-FREQUENCY DIPLEX SYSTEMS

(Question No. 20 (I))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that there are in use in the fixed radiotelegraph services, operating between 2 Mc/s and 27 Mc/s, four-frequency diplex (or twinplex) systems in which each of four frequencies is used to transmit one of the four possible combinations of mark and space signals corresponding to two telegraph channels; it being understood that either or both of the two telegraph channels may be sub-channelled by time-division methods and that the use of such systems may be extended;

(b) that it is desirable to standardise the main characteristics of four-frequency diplex systems;

(c) that it may sometimes be necessary to employ the same radio transmitter to work with more than one receiving station;

(d) that various technical factors influence the choice of operating characteristics in such systems, in particular;

(i) the economy of bandwidth and the consequent need to control the shape of the transmitted signals;

(ii) a relatively wide spacing between adjacent frequencies may be necessary for high telegraph speeds;

(iii) the signal distortion due to propagation conditions;

(iv) the instability of the characteristics of certain receiver and transmitter elements such as oscillators, filters or discriminators;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the study of the merits of the different coding arrangements determining the relation between the four signalling conditions and the four frequencies, with a view to reducing the number of coding arrangements to be provided on transmitting and receiving equipment and simplifying four-frequency diplex circuit operation;

2. the determination of the relation between the minimum frequency spacing and the telegraph speed over the range of telegraph speeds in practical use. This should be determined for both synchronous and non-synchronous operation.

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* This Study Programme arises from Question No. 20 (I).

QUESTION No. 74 (I) *

ARRANGEMENT OF CHANNELS IN MULTI-CHANNEL TELEGRAPH SYSTEMS FOR LONG-RANGE RADIO CIRCUITS OPERATING ON FREQUENCIES BELOW ABOUT 30 Mc/s

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that lack of uniformity in the arrangement and designation of the channels in multi-channel telegraph systems for long-range radio circuits operating on frequencies below about 30 Mc/s may give rise to certain difficulties when one transmitting station has to work with more than one receiving station;

(b) that many such systems are in use besides the multi-channel voice-frequency telegraph systems referred to in Question No. 43 (III);

UNANIMOUSLY DECIDES that the following question should be studied:

what is the best way of arranging and designating the channels in multi-channel telegraph systems for long-range radio circuits operating on frequencies below about 30 Mc/s ?

QUESTION No. 75 (I) **

LIMITATION OF UNWANTED RADIATION FROM INDUSTRIAL INSTALLATIONS

(Question No. 3 (III))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that Resolution No. 5 annexed to the International Telecommunication Convention, Buenos Aires, 1952, requires the study of the influence of intentional or parasitic oscillations on radio services, especially broadcasting and mobile services, with a view to the possible establishment of standards permitting a harmonious co-existence of radio services with industrial installations producing radio oscillations;

(b) that the harmonious co-existence of radio services with industrial installations producing radio oscillations involves close collaboration between organisations representing the manufacturers and users of these installations on the one hand, and the radio services on the other, for which the existing collaboration between the C.C.I.R. and the Special International Committee on Radio Interference (C.I.S.P.R.) provides;

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* This Question replaces Question No. 46.

** Study Programme No. 84 (I) arises from this Question. See Question No. 84 (III).

(c) that the C.I.S.P.R. has already extensively studied and continues to study the permissible signal-to-interference ratios for sound and television broadcasting, but has not yet made equivalent studies for other radio services;

UNANIMOUSLY DECIDES that the following question should be studied:

1. study of the most appropriate means of determining the level of intentional or parasitic oscillations produced by industrial, scientific or medical apparatus;

2. determination of the level to which it should be practicable to reduce such oscillations.

Note. — In this study the C.C.I.R. should keep itself informed on the results of the studies of the C.I.S.P.R. on the same subject, in order to avoid duplication of work.

STUDY PROGRAMME No. 84 (I) *

LIMITATION OF UNWANTED RADIATION FROM INDUSTRIAL INSTALLATIONS

(Question No. 75 (I))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that for the measurement of unwanted radiation no standard measuring method can yet be recommended;

(b) that the effect of interference is dependent on the particular type of service and on the waveform of the unwanted radiation;

(c) that it is desirable to compare measurements made on various test sites and possibly using different methods;

(d) that the effect of interference depends on the transmission coefficient between the source of interference and the receiver affected;

(e) that the C.I.S.P.R. has already studied and continues to study extensively the measuring methods for determining the level of interference from industrial, scientific and medical apparatus to sound and television broadcasting;

(f) that due regard should be given to the special requirements of radiocommunication services other than broadcasting;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of which parameters of the interfering field should be measured. The polarisation and the relation between the magnetic and electric field should be considered;

2. the effects of the relative positions of the industrial, scientific and medical equipment or groups of equipments and the measuring set, the number of measurements at different distances and the number of directions in which measurements should be made;

3. the effect of different open sites on the measured field;

4. the methods that can be used to measure the radiation from industrial, scientific and medical equipment which is situated indoors and the relationship between measurements made indoors and those made on outside sites;

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* This Study Programme arises from Question No. 75 (I).

5. the importance of interference due to the presence of radio-frequency voltages in the mains leads of the industrial, scientific and medical equipment and the methods of measurement;

6. the effect of the working conditions of the apparatus to be measured during the measurements;

7. the wave collectors to be used for measurements in the different frequency bands;

8. the characteristics of the equipment to be used for the measurements, particularly its bandwidth;

9. the way in which interference with various radio services depends upon the waveform of the disturbing field;

10. the statistical distribution and the representative values for the transmission coefficient between the interference sources and the receiving antenna in the service concerned.

Note : In this study the C.C.I.R. should keep itself informed of the results of the studies of the C.I.S.P.R. on the same subject in order to avoid duplication of work.

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Questions and Study Programmes assigned to Study Group No. II

QUESTION No. 78 (II)

CHOICE OF INTERMEDIATE FREQUENCY AND PROTECTION AGAINST UNDESIRED RESPONSES OF SUPER-HETERODYNE RECEIVERS

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that super-heterodyne receivers may respond to signals of frequency other than that to which the receiver is tuned;

(b) that the frequencies of undesired responses may coincide with the frequencies of other services, generally operating in nearby localities, thus producing interference;

(c) that super-heterodyne receivers may also have undesired responses due, for example, to harmonics of the signal to which the receiver is tuned and which are caused by non-linearity in the early stages of the receiver;

(d) that the value chosen for the intermediate frequency influences both the frequencies and the amplitudes of the undesired responses;

(e) that technical and economic reasons limit the radio-frequency selectivity and linearity that it is possible to provide in broadcast receivers for sound and television services, and that interference arising from these limitations is already appreciable *;

(f) that other services, e.g. maritime mobile, may be subject to interference when operating in the vicinity of powerful transmitters **;

(g) that it may not be practicable, because of the need to use all available frequency allocations, to prevent interference due to undesired responses in receivers by the prohibition of transmissions on the intermediate or other frequencies;

(h) that the susceptibility of receivers to undesired responses may need to be taken into account when preparing frequency assignment plans for the various services;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the factors that determine the frequencies and amplitudes of the undesired responses of receivers and what are typical values for receivers of the various classes, e.g. sound broadcasting, television, maritime mobile;

2. what methods, not requiring an undue increase in cost, e.g. the choice of the intermediate frequency or other means, may be employed to achieve a useful improvement in the performance of receivers with regard to undesired responses, and what is the extent of this improvement ?

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* The European Broadcasting Union has drawn attention to these problems; see Doc. Nos. 323 and 324 (London).

** The International Radio Maritime Committee has drawn attention to this problem, see Docs. No. 102, § 6 (London).

QUESTION No. 123 (II) *

SENSITIVITY AND NOISE FACTOR

The C.C.I.R., (Stockholm, 1948 — Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that with regard to the information contained in the tables of Recommendation No. 154, it is desirable to have available recent data on receiver sensitivity and noise factor;

(b) that in the case of telegraphy receivers it is desirable to have data on the maximum usable sensitivity limited by signal distortion or mutilation;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the representative values for reference sensitivity and noise factor for the various types of apparatus used for the reception of different classes of emission in the different services; **

2. in the case of telegraphy receivers: **

   (a) what method should be used for measuring the maximum usable sensitivity limited by signal distortion or mutilation;

   (b) what values should be inserted in the terms contained in the definitions of these types of sensitivity ?

QUESTION No. 124 (II) ***

FREQUENCY STABILITY OF RECEIVERS

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that in accordance with Question No. 77 and Recommendation No. 96 information has been collected on the frequency stability of some receivers and the means to improve it, and that this information has been summarised in Recommendation No. 156;

(b) that nevertheless the collection of information should be continued in order to collect more data on certain types of receiver, particularly FM broadcast and television receivers;

(c) that, in certain receivers, e.g., those in which the frequency-change oscillators are crystal controlled or which incorporate automatic frequency control, the stability of the filters may be a deciding factor in determining the overall stability;

(d) that, in some cases the figures given in the tables in the Annex to Recommendation No. 156 show that there are wide variations in the frequency stability of receivers of the same type;

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* This Question replaces Question No. 76.

** See Recommendation No. 154.

*** This Question replaces Question No. 77.

(e) that in practice the passband of a receiver often has to be increased beyond that essential for the service required in order to allow for the frequency instability of the receiver;

(f) that it is desirable to define acceptable values for frequency instability of receivers designed for different purposes;

(g) that there is insufficient information on the effect of frequency stability of the different influences measured separately, e.g. humidity, large temperature range, etc.;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the extent of the improvement obtained with respect to the frequency stability of receivers, by the application of the methods described in Recommendation No. 156 and which of these methods are the most effective;

2. what methods are most effective in improving the frequency stability of the filters and what are representative values for the frequency stability achieved;

3. what are the most representative data on frequency instability due to humidity changes and large temperature variations;

4. what are the maximum acceptable values of the frequency instability of receivers designed for various purposes taking into account typical frequency response curves * for the receivers used ?

QUESTION No. 125 (II) **

USABLE SENSITIVITY OF RADIO RECEIVERS IN THE PRESENCE OF QUASI-IMPULSIVE INTERFERENCE

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that many types of interference—e.g. from atmospheric phenomena, ignition systems and electrical equipment—cannot be considered as either random noise or as simple isolated impulses but may be regarded as " quasi-impulsive ";

(b) that while the usable sensitivity of a receiver may be limited in some cases by the internal noise of the receiver (cf. noise-limited maximum usable sensitivity—Rec. No. 94), in other cases it may be limited by external quasi-impulsive interference and that it is desirable to have a standard method of measurement for this sensitivity;

(c) that this type of maximum usable sensitivity should be determined as the minimum input signal (expressed as the e.m.f. of the unmodulated carrier) which must be applied in series with the specified source impedance to the input of the receiver in order to obtain, at the output, the signal level and the signal to quasi-impulsive interference ratio necessary for normal operation when the normal degree of modulation is applied to the carrier (this should be done for stated values of quasi-impulsive interference applied to the input) and that the maximum usable sensitivity as defined above should be described as " impulse-limited ".

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* In accordance with information obtained in reply to Question No. 128 (II).

** This Question replaces Question No. 79.

(d) that means for expressing mathematically the essential characteristics of quasi-impulsive interference and the development of pulse generators representing the effects of quasi-impulsive interference may be desirable, e.g. for facilitating theoretical as well as practical studies of the response of receivers to such interference;

(e) that representative values for the response of receivers to quasi-impulsive interference are necessary for system planning purposes, and that data on the values of quasi-impulsive interference permissible in normal operation are required;

UNANIMOUSLY DECIDES that the following question should be studied:

1. in what radio services, other than sound broadcast and television, is the usable sensitivity of receivers limited by quasi-impulsive interference;

2. is it possible to calculate approximately the response of receivers to quasi-impulsive interference from a simple mathematical model; if so, what parameters of quasi-impulsive interference are of the greatest importance for this calculation;

3. is it possible to substitute a pulse generator (e.g. generating a Poisson distribution of pulses of equal form at a controllable average rate and with a controllable amplitude distribution) at the input of the receiver, for a source of interference, and in this way to simulate with good approximation the effect of quasi-impulsive interference;

4. what are the methods of measuring and the most useful definitions of the response of receivers to quasi-impulsive interference, taking into account any non-linear effects that may occur in practice;

5. what is the amount of quasi-impulsive interference permissible in normal operation for a given signal level;

6. what are representative figures for the impulse-limited sensitivity of receivers ?

Note :

1. The above question should be brought to the attention of the U.R.S.I. by the Director of C.C.I.R. with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of this study.

2. It is considered that the information obtained as an answer to paragraphs 1, 5 and 6 should be communicated as soon as possible to the C.I.S.P.R.

QUESTION No. 126 (II) *

SPURIOUS EMISSIONS FROM RECEIVERS EXCLUDING SOUND-BROADCAST AND TELEVISION

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that many receivers produce undesired emissions which may cause interference to different services;

* This Question replaces Question No. 80.

(b) that the I.E.C. is establishing methods of measurement only for emissions from sound-broadcast and from television receivers;

(c) that the C.I.S.P.R. is firstly establishing limits for the emissions from sound-broadcast and from television receivers which affect other similar receivers;

UNANIMOUSLY DECIDES that the following question should be studied:

1. to what extent is it necessary for the C.C.I.R. to establish methods of measurement and limits for undesired emissions from types of receivers other than sound-broadcast and television;
2. are the methods established by the I.E.C. for measuring emissions from broadcast and television receivers also suitable for measuring the emissions from other classes of receivers; if not, what methods should be used;
3. what are the typical values for maximum fields in the different bands and, possibly, for different types of services, that should not be exceeded by these undesired emissions; *
4. what are the best techniques to reduce these fields ?

QUESTION No. 127 (II)

DISTORTION IN FREQUENCY-MODULATION RECEIVERS DUE TO MULTIPATH PROPAGATION

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that experience with VHF (metric) frequency-modulation broadcasting and other services has shown that secondary, delayed signals may be received in addition to the primary signal;

(b) that both the phase and the amplitude of the composite signal will thereby be affected;

(c) that not all receivers have directional aerials discriminating effectively against reception of the secondary, delayed signal;

(d) that efficient limiter circuits in the receiver will remove the amplitude variations but some receivers may not have such circuits;

(e) that consequently the subjective effect of residual amplitude modulation of the composite signal may be much more serious than that associated only with phase distortion, particularly if the path difference between the primary and secondary signals is large, for example, 8 km or greater;

(f) that the use of wide-band limiters and discriminators has been studied with a view to reducing the distortion due to multipath propagation; **

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the best method of measuring the amplitude-modulation suppression ratio of frequency-modulation receivers;
2. at what carrier levels and degree of modulation should measurements be made;

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* The answers to this Question should be given by Study Group No. III.

** ARGUIMBAU and GRANLUND, Electronics, Dec. 1949, p. 101.
PAANANEN, TV and Radio Engineering, Vol. 23, Nos. 2, 3 and 4, 1953.

3. should the C.C.I.R. adopt, for broadcast receivers, the definitions and methods of measurement established by the I.E.C. for the corresponding type of receiver;

4. what is the minimum amplitude-modulation suppression ratio necessary to eliminate substantially the avoidable distortion of the received signal for typical values of path difference and amplitude ratio between direct and indirect signals;

5. would the methods effective for suppressing amplitude modulation conflict with those employed for suppressing impulsive interference ?

QUESTION No. 128 (II) *

SELECTIVITY OF RECEIVERS

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that selectivity measurements so far produced have been limited primarily to receivers suitable for A1, A2 and A3 classes of emission, little information being available for other types of receiver (e.g. F1, F2, F3, F4, pulse-modulation, television, etc.);

(b) that such measurements as are available have been chiefly made by the single-signal method, little information being available on measurements made by the two-signal method;

(c) that, in determining the selectivity of the receiver, that is to say, its ability to separate the desired signal from undesired signals, there are cases where the determination of the usual selectivity curve (amplitude/frequency characteristic) is insufficient;

(d) that, if the amplitude/frequency characteristic is such that the attenuation slope in the vicinity of the edges of the pass-band is very high, then the phase/frequency and group-delay/frequency characteristics within the pass-band may consequently be non-linear and non-uniform respectively;

(e) that cases, already numerous, where this is particularly true are those where the signal shape is of great importance (e.g. telegraphy, facsimile, pulse modulation, television);

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are representative figures for the single-signal selectivity of types of receivers designed to receive classes of emission other than A1, A2, and A3;

2. what are representative figures for the two-signal selectivity on the various types of receivers, including those designed to receive classes of emission A1, A2, and A3;

3. for which types of receivers are the phase/frequency or group-delay/frequency characteristics important as additional information to the amplitude/frequency characteristics;

4. what are appropriate methods of measuring the phase/frequency or group-delay/frequency characteristics; **

5. what are the representative figures of the phase/frequency or group-delay/frequency characteristics in cases such as are indicated in *(e)* ?

* This Question replaces Study Programme No. 42.

** Some measuring methods and apparatus for the measurement of the group-delay/frequency characteristics of television receivers are given in Docs. Nos. 257 and 488 (Warsaw).

STUDY PROGRAMME No. 43 (II) *

PROTECTION AGAINST KEYED INTERFERING SIGNALS

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that the reduction of interference between adjacent channels is a very important problem, the solution of which should be sought with great care by all possible means;

(b) that for keyed telegraph transmissions a partial solution has already been reached by considering separately:

- the transmitter, by reducing the extent and amplitude of the spectrum (Recommendation No. 36),**
- the receiver, by increasing the selectivity in regular operation (reduction of bandwidth and increase of slope on each side of the pass-band) (Recommendation No. 42).***

These measures are quite effective when applied simultaneously and have already led to important improvements, but do not fully solve the problem;

(c) that, in practice, telegraphic emissions involve, outside the band necessarily occupied, components of levels in excess of that indicated in Recommendation No. 36 **; while even with the rounding of the keyed signals at present in use, the spectrum often still encroaches on the necessary band of an adjacent channel, thus preventing full advantage being realised from the high selectivity possible in receivers;

(d) that, on the other hand, the envelope of the components of the emitted spectrum and the selectivity curve of the receiver obtained in normal or non-keyed operation are not the only factors involved;

(e) that, for instance, Recommendation No. 36 ** indicates the limit-contour within which the amplitudes of the different components should be restricted; but that the amplitude and phase of each individual component can vary in accordance with the manner in which the restriction is achieved; the resulting distortion of the shape of the signal being able thus to vary also;

(f) that the selectivity curve of receivers is not perfectly rectangular but there is some irregularity in the pass-band response and a limited slope on the sides of the pass-band so that each component of the signal suffers some change in amplitude; furthermore, they suffer a phase change, usually of an indeterminate amount, but increasing with increasing slope of the sides of the pass-band. In recombining these components the resultant output signal differs in shape from the input signal; this may result in amplitude distortion effects. Further distortion may be caused by non-linearity in other parts of the receiver;

(g) that it is difficult to calculate the distortions mentioned in *(e)* and *(f)* or the total distortion which results over the complete transmission system; in particular, if the total distortion is fixed, that is, if the quality of the transmission is fixed at a predetermined level, it may be that the division of distortion between receiver and transmitter could modify the interference produced in adjacent channels; in this case the division should be chosen so as to produce minimum interference. The theoretical optimum division might of course have to be modified in the light of technical difficulties or economic factors (relative costs of filter circuits at transmitter and receiver, etc.) and of propagation effects;

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* This Study Programme replaces Study Programme No. 7. It does not refer to any Question under study.

** This Recommendation has been replaced by Recommendation No. 145.

*** This Recommendation has been replaced by Recommendation No. 155.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. interference produced in receivers by keyed transmissions having such degrees of rounding as, for instance, are implied in Recommendation No. 36 *, including the investigation of the resulting transient effects in the receiver, which are influenced not only by the usual selectivity curve (amplitude/frequency characteristic), but also by the phase/frequency characteristic;

2. investigation of the receiver characteristics which will add the least possible distortion to that produced by the rounding of the dot at the transmitter, bearing in mind that the pass-band should be kept as small as possible;

3. investigation of the total permissible rounding of dots from the transmitter input to the output of the receiving apparatus on a system basis, in order to reduce interference to a minimum while retaining a maximum of intelligibility, with special attention to the best compromise on the fraction of the rounding to be assigned to the effects of the transmitter, of propagation and of the receiver respectively;

4. investigation of the relative degrees of protection provided by the various classes of emission (e.g. A1, A2, F1);

5. methods of measurement most suitable for these investigations.

Note. — These studies may be extended in the future in connection with protection against other interfering signals of substantially square wave form, e.g. pulse-modulated signals.

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* This Recommendation has been replaced by Recommendation No. 145.

Questions and Study Programmes assigned to Study Group No. III

QUESTION No. 3 (III) *

REVISION OF ATLANTIC CITY RECOMMENDATION No. 4

The C.C.I.R., (Stockholm, 1948)

CONSIDERING

that to give maximum effectiveness to the studies requested by the International Radio Conference of Atlantic City (1947) in its Recommendation No. 4 to the C.C.I.R., it is expedient to rearrange this recommendation and incorporate the relevant Bucharest questions;

UNANIMOUSLY DECIDES:

A. that the text of Atlantic City Recommendation No. 4 can be rearranged and extended as follows:

(a) consideration of the desirable conditions to be fulfilled by the complete systems employed by the different services in order to determine the required technical performance of the equipment (including the station terminal apparatus and the antennae) and of the measuring apparatus used, to ascertain whether the equipment satisfies the recommendations of the C.C.I.R.;

(b) consideration of the field-strength intensity necessary for the reception of different classes of emission in the different services;

(c) consideration of the effect of frequency stability of transmitters on the minimum practicable spacing between stations;

(d) consideration of the minimum practicable spacing between the frequencies of stations operating in adjacent channels for different classes of emission in the different services;

B. that the above questions ** be studied simultaneously and with the same urgency;

C. that Questions Nos. 1, 4, 11, 14, 16 and 17 of the C.C.I.R. of Bucharest be removed from the list of questions to be studied by the C.C.I.R.;

AND UNANIMOUSLY DECIDES:

to carry on permanently the study of the above-mentioned questions and to publish its recommendations and possible revisions as soon as practicable.

* Study Programmes Nos. 44 (III) and 45 (III) arise from this Question.

** Questions Nos. 1 (I), 2 (no longer under study) and 3 (III).

STUDY PROGRAMME No. 44 (III) *

EFFECT OF INTERFERENCE AND NOISE ON QUALITY OF SERVICE IN THE PRESENCE OF FADING

(Question No. 3 (III))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that a full and precise answer cannot yet be given to Question No. 3 (III);

(b) that the effect of interference and noise on the quality of service is one of the factors to be determined;

(c) that the percentage of time for which the signal-to-interference or signal-to-noise ratios can be less than the required value for stable conditions, is a factor to be determined for each type of service;

(d) that there is an urgent need to determine the minimum permissible values for signal-to-noise and signal-to-interference protection ratios which are required for the various types of service indicated in Study Programme No. 45 (III);

UNANIMOUSLY DECIDES that the following studies should be carried out:

Experimental determination of the values of minimum permissible ratios of hourly median values of field strengths of the wanted signal to the field strength of:

— unwanted signal subject to fading, and without any appreciable noise;
— steady noise;
— steady interference.

Note. — These studies should be carried out in conjunction with the tests specified in Recommendation No. 104.** Question No. 82 (III), Study Programme No. 49 (III) and administrations should submit the results to the Director of the C.C.I.R. for publication as early as possible.

STUDY PROGRAMME No. 45 (III) ***

BANDWIDTHS AND SIGNAL-TO-NOISE RATIOS IN COMPLETE SYSTEMS

(Question No. 3 (III))

The C.C.I.R., (Geneva, 1951 — London, 1953)

UNANIMOUSLY DECIDES that the following studies should be carried out, possibly with the help of the C.C.I.F.:

1. Minimum conditions required for satisfactory services.

1.1 TELEPHONY

1.1.1 What are the minimum values of:
— bandwidth;
— signal-to-noise ratio (assumed to be stable) necessary at the output of the receiver for excellent service?

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* This Study Programme arises from Question No. 3 (III).

** This Recommendation has been replaced by Recommendation No. 163.

*** This Study Programme replaces Study Programme No. 8. It arises from Question No. 3 (III).

1.1.2 What is the value of the same elements at the output of the receiver for just usable service ?

1.1.3 For what maximum duration and percentage of time can the signal-to-noise ratio at the output of the receiver be inferior to the value indicated by the reply to the question of point 1.1.2 above, assuming unstable conditions ?

1.1.4 To what extent can the radiation outside the necessary bandwidth be reduced for transmitters now in use; can a stricter limitation be imposed on transmitters installed in the future ?

1.1.5 Bearing in mind the replies to the preceding four questions, and the need for each transmission to occupy as narrow a spectrum as possible, what regulations should be proposed to the Administrative Radio Conference concerning:

— the limits to be imposed on the radiated spectrum of existing transmitters;
— the limits to be imposed on the radiated spectrum of future transmitters;
— the minimum selectivity characteristics to be provided for receivers ?

1.1.6 In the absence of interference, what minimum field (assumed to be stable) is necessary to obtain excellent reception ?

1.1.7 To what extent and for what percentage of time can the field be less than the value referred to in point 1.1.6, the circuit still being regarded as just usable ?

1.1.8 What allowance must be made for fading ?

1.1.9 To what extent can reception be improved by the use of:

— directional antennae;
— diversity reception;
— noise reducers ?

1.1.10 Bearing in mind the replies to points 1.1.6, 1.1.7, 1.1.8 and 1.1.9 what is the median field required for just satisfactory reception ?

Note. — All the studies advocated above should be made for all classes of emission and in particular for the classes mentioned below operating in the range of 10 kc/s to 30 000 kc/s:

Telephony, double-sideband, full-carrier (A3)

Low grade
Commercial
High fidelity

Telephony, single-sideband, reduced-carrier

A3a: single channel (commercial)
A3b: more than one channel (commercial)

Broadcasting

1.2 TELEGRAPHY

1.2.1 In the absence of noise and multipath effects, but with an input signal varying in amplitude between specified limits, what is the minimum bandwidth necessary at the output of the receiver in order that the distortion will not exceed a specified amount ?

1.2.2 For the bandwidths determined in point 1.2.1 above, what are the minimum signal-to-noise ratios (assumed to be stable) necessary at the output of the receiver for error-free reception ?

1.2.3 For what minimum duration and percentage of time can the signal-to-noise ratios be inferior to those specified in point 1.2.2 for the circuits still to be just usable ?

1.2.4 To what extent can the radiation outside the necessary bandwidth be reduced for transmitters now in use; can a stricter limitation be imposed on transmitters installed in the future ?

1.2.5 Bearing in mind the replies to the preceding four questions, and the need for each transmission to occupy as narrow a spectrum as possible, what regulations should be proposed to the Administrative Radio Conference concerning:

— the limits to be imposed on the radiated spectrum of existing transmitters;
— the limits to be imposed on the radiated spectrum of future transmitters;
— the minimum selectivity characteristics to be provided for receivers?

1.2.6 In the absence of interference, what minimum field (assumed to be stable) is necessary to obtain error-free reception ?

1.2.7 To what extent and for what percentage of time can the field be less than the value referred to in 1.2.6, the circuit still being regarded as just usable ?

1.2.8 What allowance must be made for:

— fading;
— multipath effects ?

1.2.9 To what extent can reception be improved by the use of:

— directional antennae;
— diversity reception ?

1.2.10 Bearing in mind the replies to points 1.2.6, 1.2.7, 1.2.8 and 1.2.9 what is the median field required for just satisfactory reception ?

Note. — All the studies advocated above should be made for all classes of emission and in particular for the classes mentioned below operating in the range of 10 kc/s to 30 000 kc/s:

Telegraphy A1

Hand speed	8 bauds
,, ,,	24 ,,
Machine speed	50 ,,
,, ,,	120 ,,

Telegraphy A2

Hand speed	8 bauds
,, ,,	24 ,,
Machine speed	50 ,,
,, ,,	120 ,,

Telegraphy F1

Speed	50 bauds
,,	120 ,,

Facsimile A4

Hellschreiber

Multitone telegraphy

2. Separation between frequencies of adjacent channels (telegraphy and telephony)

2.1 What are the different factors to be taken into account in determining the minimum separation between frequencies of stations operating in adjacent channels ?

2.2* How is the effect of interference at the receiver output to be expressed?

2.2.1 Some of the factors which should be taken into account are:

— the possibility that the effect of peaks of interference may involve the use of a factor based on experience as a correction to the signal-to-interference power ratio;
— the fact that some types of interference occur as discrete elements in narrow bands of frequency within the radio spectrum;
— the fact that specific parts of the audio-frequency spectrum are more susceptible to interference;
— that it may be necessary to make a distinction between " intelligible interference " and " unintelligible interference ".

Nevertheless, in the case of telephony, the effect of interference may be expressed, as a first approximation, as the ratio of signal-to-interference powers as in the case of noise.

2.2.2 In the case of machine telegraphy the effect of interference can be expressed as either:

— the percentage of faulty telegraph characters, or
— the percentage of signal elements which suffer distortion in excess of a given value.

The effect of interference can be measured in terms of the ratio (in db) by which the wanted signal in the presence of interference should be increased to obtain the same quality of service.

2.2.3 In the case of telephony the effect of interference can be expressed as either:

— the percentage loss of intelligibility of related words, or
— the percentage loss of intelligibility of unrelated words.

The effect of interference can be measured in terms of the ratio (in db) by which the wanted signal in the presence of interference should be increased to obtain the same quality of service.

2.2.4 All the foregoing methods of expression can be used for assessing the effects of noise, fading and adjacent channel interference.

2.3 When the wanted signal and the interference are both stable, what is the minimum signal-to-interference ratio for excellent reception ?

2.4 To what extent, for given values of the percentage of time of occurrence, can the signal-to-interference ratio be lower than that mentioned in 2.3 for the circuit still to be usable ?

2.5 How is the signal-to-interference ratio at the receiver output affected by the selectivity of the receiver and the separation between the frequency of the interfering signal and the frequency to which the receiver is tuned ?

2.6 How should the instability of transmitter and receivers be expressed and allowed for in determining the channel separation ?

2.7 To what extent would the use of directional antennae at the transmitter and the receiver improve the signal-to-interference ratio ?

* See Note 2, p. 516.

2.8 Bearing in mind the replies to the questions in the preceding seven paragraphs and those in points 1.1.1 to 1.2.10, what is the minimum separation required between the frequencies of stations operating in adjacent channels ?

Notes :

1. All the studies advocated above should be made for all the types of service mentioned in the comments following points 1.1.10 and 1.2.10.
2. The factors enumerated are equally relevant to the study of co-channel and adjacent-channel interference.

QUESTION No. 43 (III) *

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(Study Group No. III)

(Geneva, 1951)

The VIth Plenary Assembly of the C.C.I.T., Brussels (May, 1948),

SUBMITTED the following question for study by the C.C.I.R.:

what are the conditions which should be imposed on VF telegraph plant employing double-current technique used on modulated radio transmission channels ?

Note. — To be studied in collaboration with the International Telegraph Consultative Committee (C.C.I.T. Study Group No. II ** : establishment, operation and maintenance of telegraph channels).

STUDY PROGRAMME No. 46 (III) ***

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(Question No. 43 (III))

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that different methods are now in use for voice-frequency telegraphy on radio circuits subject to fading:
— either using equipment normally designed for land-line working and suitably adapted for radio;
— or using equipment especially designed for radio working;
(See Docs. Nos. 29, 195 of Geneva, and 5, 205, 273 of London);

(b) that studies carried out so far show that it is impossible to compare transmission systems in which marking and spacing are obtained by the two-tone method and by the method of frequency-shift keying of a single oscillator without taking into account all the factors of the equipment (see more particularly Doc. No. 273 of London);

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* Study Programme No. 46 (III) arises from this Question.

** This Study Group has now become the 9th Study Group of the C.C.I.T.T.

*** This Study Programme replaces Study Programme No. 9. It arises from Question No. 43 (III).

(c) that the study of Question No. 43 (III) is to be continued in conjunction with the C.C.I.T. to obtain, if possible, unification of at least some of the component elements of voice-frequency equipment used on wire and radio;

UNANIMOUSLY DECIDES that the following study should be carried out:

comparison of the different systems used to transmit voice-frequency telegraphyon radio circuits subject to the effects of fading, particularly of the two methods:

— frequency-shift keying of one oscillator;

— transmitting mark and space by the two-tone method;

taking into account all the factors of the equipment.

QUESTION No. 81 (III) *

DIRECTIVITY OF ANTENNAE AT GREAT DISTANCES

The C.C.I.R., (Stockholm, 1948 — Geneva, 1951 — London, 1953)

DECIDES to study the following question:

experimental study, by administrations and various organisations, of the directivity of antennae realised at great distances (taking full advantage of existing transmissions) by any suitable method, for example, by use of mechanically or electrically steered antennae.

STUDY PROGRAMME No. 85 (III) **

IMPROVEMENT OBTAINABLE FROM THE USE OF DIRECTIONAL ANTENNAE

(Recommendation No. 102 — Question No. 81 (III) — Study Programme No. 45 (III))

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the study in Study Programme No. 45 (III) requires knowledge of the improvement in the signal-to-interference ratio that can be obtained by the use of directional antennae on long-distance circuits;

(b) that the Annex to Recommendation No. 162 shows the median values of discrimination in the form of gains in various arcs relative to the optimum gain for a half-wave dipole at the same height and on the correct azimuth when the wanted and unwanted emissions are in the range 3000-10 000 km;

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* This Question replaces Question No. 48. Study Programme No. 85 (III) arises from this Question.

** This Study Programme replaces Study Programme No. 48. It arises from Question No. 81 (III).

(c) that it is important to know the discrimination given by the aerial when the wanted station is in this range and the interfering station is at a much shorter range (or vice-versa);

UNANIMOUSLY DECIDES that the following studies should be carried out:

determination of:

1. the median value of the signal power gain provided by practical directional antennae relative to a half-wave horizontal dipole at the same height;

2. the median value of the discrimination provided by the aerial between the wanted and interfering signals. The data should include the variations in time and direction in the appropriate arcs as shown in Fig. 1 in Recommendation No. 162.

QUESTION No. 82 (III) *

INTERFERENCE EFFECTS OF ATMOSPHERIC NOISE ON RADIO RECEPTION

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that the results of measurements of atmospheric radio noise show the intensity of noise in a given experimental equipment and that it is necessary to transform these results in order to ascertain to what extent the noise affects various services and various types of receiving equipment used;

(b) that the r.m.s. value of atmospheric noise intensity, averaged over a period of several minutes, is not entirely adequate for the determination of the effect on radio reception;

UNANIMOUSLY DECIDES that the following question should be studied:

determination of the interfering effects of atmospheric noise on reception, as a function of the wave form and the amplitude distribution of instantaneous values of atmospheric noise over a period of several minutes.

STUDY PROGRAMME No. 49 (III) **

INTERFERENCE EFFECTS OF ATMOSPHERIC NOISE ON RADIO RECEPTION

(Question No. 82 (III))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that the C.C.I.R. curves giving seasonal median values of r.m.s. field intensity in a 1 kc/s bandwidth of atmospheric noise averaged over a period of a few minutes are expected to be prepared during the interval between the VIIth and VIIIth Plenary Assemblies;

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* Study Programme No. 49 (III) arises from this Question.

** This Study Programme arises from Question No. 82 (III).

(b) that the waveform and amplitude distribution of instantaneous values of atmospheric noise over a period of a few minutes must also be considered in determining the effects of noise on various classes of service;

(c) that, while awaiting the results of studies being carried out by scientific research organisations, it will be useful to have experimental data on the points referred to in § *(b)* above;

UNANIMOUSLY DECIDES that the following studies should be carried out:

experimental studies on the influence of atmospheric radio noise on the general operation of radio communication and, in particular, on receiving equipment, bearing in mind the intended revision of existing documents relating to this problem.

These studies should be particularly concerned with the following service applications:

A. aural services:
- — A1 telegraphy (24 bauds);
- — A2 telegraphy modulated at 1000 c/s (24 bauds);
- — A3 double-sideband full-carrier commercial telephony;
- — A3 high-fidelity double-sideband full-carrier commercial telephony;
- — A3 commercial telephony with reduced carrier and having independent sidebands (from 1 to 4 telephone channels);
- — A3 broadcasting;

B. telegraph services with automatic recording (undulator or machine telegraphy) with or without automatic repetition:
- — A1 telegraphy (120 to 180 bauds);
- — A2 telegraphy, modulated at 1000 c/s (120 bauds);
- — F1 frequency-shift telegraphy (120 to 480 bauds);

C. other services:
- — facsimile;
- — hellschreiber;
- — voice-frequency telegraphy;

these studies should also be concerned with the following characteristics of receiving equipment and the results should be submitted in the form of tables or nomograms making it possible for each particular case to be considered, viz:
- — antenna;
- — bandwidth of RF, IF and AF stages;
- — time constant of automatic gain control;
- — method of detection.

QUESTION No. 84 (III) *

DETERMINATION OF THE MAXIMUM INTERFERENCE LEVELS TOLERABLE IN COMPLETE SYSTEMS

(Question No. 3 (III))

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that Resolution No. 5 annexed to the International Telecommunication Convention, Buenos Aires, 1952, requires the study of the influence of intentional or parasitic oscillations on

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* See Question No. 75 (I).

radio services, especially broadcasting and mobile services, with a view to the possible establishment of standards permitting a harmonious co-existence of radio services with industrial installations producing radio oscillations;

(b) that the harmonious co-existence of radio services with industrial installations producing radio oscillations involves close collaboration between organisations representing the manufacturers and users of these installations on the one hand, and the radio services on the other, for which the existing collaboration between the C.C.I.R. and the Special International Committee on Radio Interference (C.I.S.P.R.) provides;

(c) that the C.I.S.P.R. has already extensively studied and continues to study the permissible signal-to-interference ratios for sound and television broadcasting, but has not yet made equivalent studies for other radio services;

UNANIMOUSLY DECIDES that the following question should be studied:

determination of the maximum level of interference caused by radiations from industrial, scientific and medical equipment producing radio oscillations, that can be tolerated in various frequency ranges by the types of system employed by radio services especially by the mobile services.

Note. — In this study the C.C.I.R. should keep itself informed on the results of the studies of the C.I.S.P.R. on the same subject, in order to avoid duplication of work.

QUESTION No. 94 (III)

FACSIMILE TRANSMISSION OF DOCUMENTARY MATTER OVER COMBINED RADIO AND METALLIC CIRCUITS

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that increasing use is being made of facsimile telegraphy for the transmission of documentary matter;

(b) that it is desirable to standardise the characteristics of the facsimile apparatus employed for this purpose;

(c) that the C.C.I.T. has already undertaken the study of this matter (Question No. 46 - Arnhem refers);

UNANIMOUSLY DECIDES that the following question should be studied by the Joint Study Group of the C.C.I.T. and the C.C.I.R. in so far as radio transmission problems are concerned:

what should be the characteristics of apparatus for the transmission by facsimile of :

— telegrams in the public telegraph service;
— business documents;
— documents of large size such as, for example, meteorological charts ?

QUESTION No. 95 (III)

TRANSMISSION OF HALF-TONE PICTURES OVER RADIO CIRCUITS

The C.C.I.R., (London, 1953)

CONSIDERING

that, in the transmission of half-tone pictures over radio circuits, the direct frequency modulation of the radio carrier by the picture modulation frequencies would result in a greater signal-to-noise ratio than if the method of sub-carrier frequency modulation were used;

UNANIMOUSLY DECIDES that the following question should be studied:

what are the desirable characteristics for a system transmitting half-tone pictures over radio circuits, in which direct frequency modulation of the radio-frequency carrier is used ?

QUESTION No. 129 (III) *

USE OF RADIO CIRCUITS IN ASSOCIATION WITH 5-UNIT START-STOP TELEGRAPH APPARATUS

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) That Art. 34, § 3 of the Telegraph Regulations (Paris Revision, 1949) recommends, except in special circumstances, the use of a 5-unit code in accordance with International Telegraph Alphabet No. 2, this being in the interest of speed and efficiency in the movement of telegraph traffic and furthering the development of a world-wide telecommunication network;

(b) that nevertheless the need to reduce the number of errors due to the nature of the radio circuits is leading to the introduction of various methods such as the use of synchronous systems, error detecting and/or correcting codes and special signalling arrangements;

(c) that the Recommendation No. 167 recommends the use of an error-detecting code with automatic repetition when the circuit comprises a return channel;

UNANIMOUSLY DECIDES that the following question should be studied:

1. the effects of varying conditions of propagation (including multi-path propagation), atmospheric noise and interference on radiotelegraph circuits used to interconnect terminal apparatus employing the International Telegraph Alhabet No. 2;

2. the signal distortion and error rate that may be expected having regard to signal-to-noise ratio, the nature of the noise, amount and nature of the interference, propagation effects, type of transmission, etc;

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* This Question replaces Question No. 83. Study Programme No. 50 (III) arises from this Question.

3. the need for and the practical value of codes permitting the correction of errors on radiotelegraph channels not associated with a return channel;

4. the procedure and equipment that should be used to permit interconnection of circuits using special codes with metallic circuits using the International Telegraph Alphabet No. 2. This Question is to be studied in collaboration with the C.C.I.T.T.

STUDY PROGRAMME No. 50 (III) *

USE OF RADIO CIRCUITS IN ASSOCIATION WITH 5-UNIT START-STOP TELEGRAPH APPARATUS

(Question No. 83 **)

The C.C.I.R., (Geneva, 1951 — London, 1953)

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the comparison of the effects of varying radio propagation conditions, atmospheric noise and other interference, upon circuits employing:
   - 5-unit start-stop systems,
   - 5-unit synchronous systems,
   - synchronous error-detecting or error-correcting systems using two-condition signalling codes other than the International Alphabet No. 2,
   - other systems using more than two signalling conditions;

2. an assessment of the relative merits of systems that sample at critical instants the envelope of the impulses forming the character and of systems that integrate this envelope;

3. the comparison of systems should be made in terms of the ratio of the undetected, or uncorrected, error rates achieved by the systems to the error rate of a 5-unit synchronous system using the same power and signalling speed, in words per minute, and operating under the same conditions. A 5-unit start-stop system may also be used as the reference system by regarding each mutilated signal as one error only. It is provisionally suggested that the ratio of the error rates should be expressed for two circuit conditions only, namely, when the improved system is subject to an average of one undetected, or uncorrected, error per 10 000 characters, and when it is subject to one such error per 1000 characters.

QUESTION No. 130 (III)

TRANSMISSION OF METEOROLOGICAL CHARTS OVER RADIO CIRCUITS BY DIRECT FREQUENCY-MODULATION OF THE CARRIER

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that meteorological charts are being transmitted extensively over radio circuits by direct frequency-modulation of the carrier;

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* This Study Programme replaces Study Programme No. 27. It arises from Question No. 129 (III).

** This Question has been replaced by Question No. 129 (III).

(b) that for high-frequency (decametric) transmissions a deviation of 800 c/s is widely used, while for low-frequency (kilometric) transmissions a deviation of 300 c/s is used;

UNANIMOUSLY DECIDES that the following question should be studied by the Joint Study Group of the C.C.I.T.T. and the C.C.I.R. in so far as radio transmission problems are concerned:

1. what frequency deviations should be used in different radio-frequency bands for the transmission of meteorological charts by direct frequency-modulation of the carrier;

2. should the higher or the lower limit of the carrier-frequency deviation correspond to documentary black ?

QUESTION No. 131 (III) *

DETERMINATION OF THE REQUIRED INTERFERENCE PROTECTION RATIOS BETWEEN VARIOUS CLASSES OF EMISSION

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that Recommendation No. 14 of the E.A.R.C. Agreement (Geneva, 1951) advocates the reduction to a minimum of the spacings between frequency assignments in the HF (decametric) band, and also urges the application of sharing to a maximum, in order to make better use of the spectrum;

(b) that interference between assignments causes one of the major problems in present day radio communication in the HF (decametric) band;

(c) that it is essential to have sufficient data to determine the limiting values of signal-to-interference ratio or frequency separation below which harmful interference occurs when two transmitters are working on the same or neighbouring frequencies;

(d) that in the cases under consideration, the pass-band of the receivers shall be no wider than is necessary for the transmission, without significant distortion, of the desired signal due allowance being made for the unavoidable instabilities of the frequencies of the transmitter and of the receiver;

UNANIMOUSLY DECIDES that the following question should be given priority of study:

1. what are the limiting values of signal-to-interference ratio or frequency separation below which harmful interference occurs for the following classes of emission:

A1	telegraphy,
F1	telegraphy,
F4	phototelegraphy,
A3a	single-sideband telephony,
A3	double-sideband telephony,
A3	broadcasting ?

The data concerning the threshold of harmful interference for a steady state condition should be collected and presented in the form indicated in the Annex.

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* This Question defines more specifically part of Question No. 3 (III). Warsaw documents Nos. 2, 174 and 319 should be taken into account in the study of this Question.

ANNEX

Minimum protection ratios and frequency separation under stable conditions

Wanted signal		Interfering signal																							
Class of emission		A1 100 bauds				F1 2 D=400 c/s				F4				A3a				A3				Broadcast			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		db	kc/s			db	kc/s			db	kc/s			db	kc/s			db	kc/s			db	kc/s		
A1	24 bauds aural																								
	50 bauds (printer)																								
	120 bauds (recorder)																								
F1	50 bauds (printer)																								
	120 bauds (recorder)																								
	200 bauds (printer ARQ)																								
F4	phototelegraphy																								
A3a	SSB																								
A3	DSB (commercial)																								

Note : Columns numbered 1 give in db the limiting values of signal-to-interference ratio in the cases when the occupied band of the interfering emission either falls entirely within the passband of the receiver, or covers it completely. Columns numbered 2, 3 and 4 indicate the frequency separation necessary between a wanted and an interfering signal when the latter is 0 or 6 or 30 db higher than the wanted signal.

QUESTION No. 132 (III)

RADIO RELAY SYSTEMS EMPLOYING IONOSPHERIC SCATTER PROPAGATION

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that experiments have already shown the possibility of utilising frequencies above 27.5 Mc/s for transmission by ionospheric scatter propagation to distances well beyond the horizon;

(b) that systems using this mode of propagation are already in service;

(c) that it is desirable to determine the preferred characteristics of such systems needed to facilitate their international connection;

(d) that the frequency bands that might be used for such systems are already intensively used by other services;

UNANIMOUSLY DECIDES that the following question should be studied:

1. how do the propagation characteristics relevant to the exploitation of systems employing ionospheric scatter propagation vary with frequency;

2. to what extent are systems employing this mode of propagation and operating on the same or neighbouring frequencies liable to interfere with each other and with other services;

3. what are the radio-frequency and baseband characteristics of such systems which it is essential to specify for the transmission of telephony or telegraphy in order to enable two systems to be interconnected, and what values should be specified ?

QUESTION No. 133 (III) *

COMMUNICATION THEORY

The C.C.I.R., (Geneva, 1951—Warsaw, 1956)

CONSIDERING

(a) that for the transmission of a given volume of information through a given telecommunication channel with a given power, either in a given time using a minimum bandwidth, or with a given bandwidth in a minimum time, the theoretical formulae suggest the use of pulse-code modulation;

(b) that the theoretical coding method for improving on this involves a long delay;

* This Question replaces Question No. 44. Study Programme No. 86 (III) arises from this Question.

(c) that the theoretical coding methods usually do not take into account the presence of a return channel, which in practice has led to efficient transmission systems with a low error rate;

(d) that the U.R.S.I. in Doc. No. 14 (Warsaw) has suggested further study;

UNANIMOUSLY RECOMMENDS the study of the following question:

1. the relation between permissible delay and residual uncertainty and its dependence on bandwidth utilisation;

2. the improvement practicably possible in existing systems with regard to the transmission of information, in particular for those systems where a go and a return channel are available.

STUDY PROGRAMME No. 86 (III) *

COMMUNICATION THEORY

(Question No. 133 (III))

The C.C.I.R., (Geneva, 1951—London, 1953—Warsaw, 1956)

CONSIDERING

(a) that in view of the increasing congestion of the radio spectrum and telecommunication circuits, it would be advantageous to discover technical methods of decreasing the bandwidth, the transmission time of a given quantity of information, or the transmitted power;

(b) that present studies seek mainly to perfect established systems whereas recent theories seem to show that these systems occupy several times the bandwidths strictly necessary for the transmission of the required information at the required speed;

(c) that even with existing systems, it is not possible to reduce the bandwidth to that strictly necessary because of unpredictable noise, natural and man-made interference, and complex propagation conditions; a margin of bandwidth is necessary to decrease distortion and the frequency of errors due to these phenomena;

(d) that it is not certain that existing codes, at least some of which were not designed in the light of phenomena peculiar to radio propagation, are making the best use of the occupied bandwidth;

(e) that a systematic study of methods such as referred to in para. *(a)*, can be made by generalising the procedures in use for certain transmission systems or by applying the results of the general theory of communication to specific practical cases;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the review of the various codes in use and the study of new codes leading to an economy of bandwidth or transmission time for a given quantity of information preserving a given quality of transmission, taking into account the phenomena peculiar to radio propagation and the

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* This Study Programme replaces Study Programme No. 47. It arises from Question No. 133 (III).

comparison of the various existing systems of modulation from the point of view of the bandwidth occupied versus the amount of information transmitted in a given time for a given power *;

2. the study in conjunction with the U.R.S.I. of the methods of communication theory, that are best suited for practical application.

QUESTION No. 139 (III) **

INFLUENCE OF DOPPLER SHIFTS ON LONG-DISTANCE HIGH-FREQUENCY COMMUNICATION USING FREQUENCY-SHIFT KEYING

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that Recommendation No. 150, point 3, recommends that for frequency-shift systems working on two conditions only and operating between 3 Mc/s and 30 Mc/s the values of frequency shift should be 200, 400 and 500 c/s;

(b) that study of the Doppler effect brought about by changes in the path of the ionospheric waves has shown that the resultant frequency variations may reach values of a few c/s, while instantaneous deviations may reach much higher values (see Documents of the VIth Plenary Assembly, Geneva 1951, Vol. II, page 79 and Warsaw Document No. 213).

UNANIMOUSLY DECIDES that the following question should be studied:

what minimum frequency-shift value is required for frequency-shift systems operating over long distances by high-frequency ionospheric propagation to take into account any possible influence of the Doppler effect?

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* Relative to this study, it is useful to consider, in the case of radio telephony, the determination of the relation between intelligibility and the shape and width of the passband of the receiver for signal-to-noise ratios, consistent with:

— just usable quality, operator to operator,

— marginally commercial quality,

— good commercial quality,

taking into account that:

1. in many cases the noise power is distributed uniformly over the audio-frequency spectrum, while speech power is distributed unevenly in the spectrum;

2. when high noise levels are present in the communication system, and the signal-to-noise ratio is constant, the intelligibility might show a maximum as a function of the bandwidth and the distribution of the power corresponding to the frequencies it contains. This distribution of the power may vary with fading.

** Following an exchange of letters between the Director and the respective study group chairmen, it has been decided to allocate the study of this Question to Study Group No. III instead of Study Group No. VI.

QUESTION No. 167 (III)

FREQUENCY STABILITY REQUIRED FOR SINGLE-SIDEBAND, INDEPENDENT SIDEBAND AND TELEGRAPH SYSTEMS, TO MAKE THE USE OF AUTOMATIC FREQUENCY CONTROL SUPERFLUOUS

The C.C.I.R.,

CONSIDERING:

(a) that it is the practice with suppressed or reduced carrier SSB (single sideband) and ISB (independent sideband) telephone systems, and with many telegraph systems, to employ AFC (automatic frequency control) to adjust the receiver oscillator frequency in sympathy with frequency variations of the transmitted signal;

(b) that such AFC systems are complex and give rise to difficulty under poor propagation conditions;

(c) that the frequency stability which can now be achieved is much higher than that laid down in C.C.I.R. Recommendation No. 148, and is approaching a value which could provide sufficient inherent stability to enable AFC to be dispensed with;

DECIDES that the following question be studied:

What frequency stabilities are necessary for SSB, ISB and telegraph operation in Fixed HF Systems, range 4,000-30,000 kc/s, to make AFC unnecessary, and how can these be achieved ?

Questions and Study Programmes assigned to Study Group No. IV

QUESTION No. 134 (IV) *

GROUND-WAVE PROPAGATION

The C.C.I.R., (Stockholm, 1948 - Warsaw, 1956)

CONSIDERING

the continuing importance of the effect of the characteristics of the earth on the propagation of waves used for all types of radio communication and location, including directional transmission and direction finding;

UNANIMOUSLY DECIDES that the following question be studied:

what should be taken into consideration to determine the ground-wave characteristics in a correct way to cover the entire radio-frequency spectrum now in practical use, giving particular attention to:

1. transmission over mixed paths, e.g., partly over land and partly over sea;
2. the effect of hills and other obstacles in diffracting the waves in either the horizontal or the vertical plane;
3. the siting of aerials for frequencies above 30 Mc/s;
4. the relative effects obtained with horizontal and vertical polarisation;
5. the variations in the phase of radio waves in transmission over the ground?

STUDY PROGRAMME No. 87 (IV) **

EFFECTS OF STANDARD TROPOSPHERIC REFRACTION ON FREQUENCIES BELOW 10 Mc/s

(Question No. 6) ***

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the ground-wave propagation curves for frequencies below 10 Mc/s submitted with Recommendation No. 52, make no allowance for normal tropospheric refraction;

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* This Question replaces Question No. 6. Study Programmes Nos. 87 (IV), 88 (IV), and 89 (IV) arise from this Question.

** This Study Programme replaces Study Programme No. 51. It arises from Question No. 134 (IV).

*** This Question has been replaced by Question No. 134 (IV).

(b) that allowance is sometimes made for normal refraction by the assumption of an effective earth's radius of 4/3 times the actual value;

(c) that the effect of normal tropospheric refraction is likely to decrease with decreasing frequency;

(d) that some mathematical analyses relating to this subject have been completed and published *

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. further measurements of ground-wave field strengths over a sufficiently long path of uniform conductivity, such as a sea path, to determine experimentally the modification of the ground-wave curves required to include the effects of tropospheric refraction at frequencies below 10 Mc/s;

2. interpretation of the mathematical analysis relating to ground-wave propagation to include the effects of tropospheric refraction on all frequencies below 10 Mc/s.

3. Investigation of the possible influence of tropospheric refraction on the phase of the ground wave.

STUDY PROGRAMME No. 88 (IV) **

GROUND-WAVE PROPAGATION OVER MIXED PATHS

(Question No. 134 (IV))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the problem of amplitude and phase variations in ground-wave propagation resulting from the non-uniformity of the electrical constants along the path is of great importance in connection with:

- the determination of the service areas of radio transmitters,
- the use of medium and low frequencies for navigational aids,
- the study of coastal refraction;

(b) that, although the rigorous mathematical analysis has now been largely extended to include the effect of:

- several boundaries,
- curvature of the earth,
- propagation obliquely to a boundary,
- variations of the electrical constants of the ground in the vertical direction,

the general problem has not been formally solved;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the obtaining of further experimental results for amplitude and phase of ground waves over mixed paths under as wide a range of conditions as possible;

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* See for example: H. BREMMER, *Terrestrial Radio Waves, Theory of Propagation*, Part II, p. 145, Formula 31.

** This Study Programme replaces Study Programme No. 53. It arises from Question No. 134 (IV).

2. the interpretation of these results in terms of the methods referred to in Recommendation No. 169;

3. the detailed examination of conditions in the neighbourhood of a boundary, especially of phase changes in various directions across a coastline;

4. the further development of the mathematical analysis and its adaptation for engineering application to replace, if possible, the existing empirical methods;

5. the extension of the experimental and theoretical work to take account of changes in the electrical constants of the ground in the vertical direction, e.g. where there is shallow water of variable depth;

6. the possibility of using amplitude and phase measurements to detect and estimate changes in the electrical constants along a land path.

STUDY PROGRAMME No. 89 (IV) *

GROUND-WAVE PROPAGATION OVER IRREGULAR TERRAIN

(Questions Nos. 6 ** and 7)

The C.C.I.R., (Geneva, 1951—London, 1953—Warsaw, 1956)

CONSIDERING

(a) that it is of great importance to pursue the studies concerning propagation over irregular terrain;
(b) that the phenomenon known as obstacle gain is proving to be of great practical significance;

UNANIMOUSLY DECIDES that the following study should be carried out:

propagation of radio waves over irregular terrain, with consideration of the following aspects:

1. propagation over a specific path between fixed points, with particular reference to:
   — propagation along valleys between mountains,
   — propagation across valleys,
   — propagation in urban areas,
   — propagation over single obstacles of definite shape,
   — propagation across hills and mountains and observation of the phenomenon known as obstacle gain;

2. the possibility of obtaining increased field strength by achieving the reduction of the strength of reflected rays reaching the receiving point;

3. propagation over a specific area surrounding a transmitter, using statistical methods, with particular reference to propagation over very irregular terrain;

4. the influence of irregular terrain on the best choice of site and the appropriate polarisation of antennae for a desired type of service;

5. the experimental study of the phase variations with distance produced by irregularities of the terrain;

6. the further development of the mathematical analysis and its practical applications.

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* This Study Programme replaces Study Programme No. 54, it arises from Question No. 134 (IV).
** This Question has been replaced by Question No. 134 (IV).

QUESTION No. 135 (IV)

DETERMINATION OF THE ELECTRICAL CHARACTERISTICS OF THE SURFACE OF THE EARTH

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that for calculations of radio propagation and particularly of propagation along the surface of the earth, it is of great importance that the equivalent values of ϵ (dielectric constant) and σ (conductivity) for the surface of the earth be known;

(b) that, although the question of the radio field in the vicinity of the earth's surface has been extensively studied from the theoretical point of view (in determining ϵ and σ knowledge of the field pattern would appear to play an important part), there is no sufficiently simple and reliable practical method in current use for determining these values;

(c) that Report No. 20, Question No. 6 * (point 5) and Study Programme No. 88 (IV) (point 6) deal only with certain aspects of these problems;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the most practical method for radiocommunication services of determining equivalent values of ϵ (dielectric constant) and σ (conductivity) for the surface of the earth;
2. how can changes in these values be deduced from the corresponding changes in the field characteristics along the path;
3. what types of apparatus can be recommended for such measurements and what degree of accuracy can be expected;
4. how do the measured values depend on frequency;
5. what physical factors, e.g. vegetation and weather, affect the accuracy and the interpretation of the measurements and to what extent ?

Note. — In connection with the above studies the following point should also be borne in mind, that in propagation over an inhomogenous earth the field characteristics may depend upon the distribution of ϵ and σ in both the horizontal and vertical directions in the ground; for example, in the neighbourhood of a boundary between two sections of markedly different ϵ and σ, the measurement of the field characteristics may lead to a negative equivalent conductivity.

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* This Question has been replaced by Question No. 134 (IV).

Questions and Study Programmes assigned to Study Group No. V

QUESTION No. 101 (V) *

ADVANTAGES TO BE OBTAINED FROM CONSIDERATION OF POLARISATION IN THE PLANNING OF BROADCASTING SERVICES IN THE VHF (METRIC) AND UHF (DECIMETRIC) BANDS

(Television and sound)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that a receiving aerial designed for reception of horizontally polarised waves will in general discriminate against vertically polarised waves and vice versa;

(b) that in the planning of broadcasting services in the VHF (metric) and UHF (decimetric) bands (television and sound) there may be occasions when it is important to take full advantage of this discrimination;

(c) that tropospherically propagated waves in the VHF (metric) and UHF (decimetric) bands, particularly at great distances from the transmitter or after propagation over irregular terrain or re-radiating structures, may no longer retain their original polarisation;

UNANIMOUSLY DECIDES that the following question should be studied:

in planning television and sound broadcasting services in the VHF (metric) and UHF (decimetric) bands, what allowance, if any, can be made for the decrease in the minimum tolerable ratio of wanted to unwanted field strengths at the receiving aerial when one transmission uses vertical polarisation and the other horizontal polarisation, as compared with the case in which both transmissions use the same polarisation? All the pertinent factors, including the following, should be taken into account:

— frequency,
— type of terrain,
— type and height of transmitting and receiving aerials,
— distances between transmitters and receivers,
— variations in tropospheric propagation conditions with time and climate.

* This Question, which was originally allocated to Study Group No. XI and gave rise to Report No. 82, was allocated to Study Group No. V at the VIIIth Plenary Assembly, Warsaw.

QUESTION No. 136 (V) *

PROPAGATION DATA REQUIRED FOR WIDE-BAND RADIO SYSTEMS

The C.C.I.R., (London, 1953—Warsaw, 1956)

CONSIDERING

(a) that in the planning of a communication network it is necessary to define the overall system performance achieved for given percentages of time;

(b) that designers of radio systems in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands require to know, from the point of view of sustained satisfactory operation, the tropospheric propagation characteristics and the resulting path attenuation that is exceeded for a low percentage of the time for each particular frequency band over the working range, which may extend from well within the optical range in line-of-sight systems to several times the optical range in tropospheric scatter systems;

(c) that the planning of systems requires a knowledge of the seasonal distribution curves of such propagation characteristics;

(d) that from the point of view of interference beyond the normal range it is necessary to know the value of path attenuation likely to be exceeded for a large percentage of time, at distances up to several times the working range;

(e) that the system bandwidth may be limited by multipath propagation effects;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the distribution with time of the values of path attenuation in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands, and particularly the values likely to be exceeded for 99.9%, 99%, 50%, 1%, 0.1% and 0.01% of each month of the year;

2. to what extent are these distributions dependent upon the length of path, the geographical region and the type of terrain over which the path passes, and in the case of optical paths, the terrain clearance;

3. what limitations on the bandwidth of transmission are imposed by the propagation medium?

STUDY PROGRAMME No. 79 (V) ***

TROPOSPHERIC PROPAGATION ACROSS MOUNTAIN RIDGES

(Question No. 85) **

The C.C.I.R., (Approved by correspondence, 1955)

CONSIDERING

(a) that Question No. 85 *** para. 3 seeks information on, amongst other things, the influence on the time distribution of the values of path attenuation, caused by the type of terrain over which the signal passes;

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* This Question replaces Question No. 85. Study Programme No. 79 (V) arises from this Question.

* This Study Programme arises from Question No. 136 (V).

*** This Question has been replaced by Question No. 136 (V).

(b) that it would be of interest to study a particular type of path crossing a high mountain ridge, so situated that it is in optical range of both the transmitter and the receiver;

(c) that there is already some evidence that signals reaching the receiver over such a ridge may, under certain conditions, be stronger than they would be in the absence of the ridge, and that, at the same time, they may show a reduced range of fading;

DECIDES that the following studies should be carried out:

1. the time distribution of the values of path attenuation (as mentioned in Sections 2 and 3 of Question No. 85 * for a signal path as described in (*b*) above;

2. the manner in which the reduction in path attenuation depends upon the directional and other properties (e.g. height) of the transmitting and receiving antenna systems.

QUESTION No. 137 (V) **

MEASUREMENT OF FIELD STRENGTH IN THE NEIGHBOURHOOD OF OBSTACLES

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the electromagnetic field in the neighbourhood of obstacles may differ considerably from that which would be present in the absence of such obstacles;

(b) that a knowledge of the value of the undisturbed field is of importance in theoretical and practical investigations;

(c) that, however, at present there are no general methods for predicting the exact quantitative effect of obstacles on this undisturbed field;

UNANIMOUSLY DECIDES that the following question should be studied:

what general criteria must be satisfied so that the effect of obstacles may be neglected, these criteria being expressed in terms of the physical properties of the obstacle, the distance of these obstacles from the measuring point, the wavelength or any other relevant parameter ?

Note.—The above Question should be brought to the attention of the U.R.S.I. by the Director of the C.C.I.R.

QUESTION No. 138 (V)

MEASUREMENT OF FIELD STRENGTH FOR VHF (METRIC) AND UHF (DECIMETRIC) BROADCAST SERVICES, INCLUDING TELEVISION

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that at many receiving sites for VHF (metric) and UHF (decimetric) broadcast services there may be many obstacles, such as buildings and trees, which impair reception, and these sites may also be in shadow areas;

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* This Question has been replaced by Question No. 136 (V).

** This Question replaces Question No. 86.

(b) that under these conditions field strengths vary widely from location to location and are difficult to measure and to predict in detail;

(c) that the available field strengths may also vary with time;

(d) that for these reasons available field strengths have been expressed on a statistical basis in terms of the percentage of time and of locations for which a specified grade of service is obtainable;

(e) that there are in use at present several methods of measuring the field strengths available, including

— continuous mobile measurements with a low, non-directional antenna,

— short periods of mobile measurements at regular intervals with the antenna elevated to about 10 meters,

— single-location measurements with a similarly elevated antenna;

(f) that it is desirable to correlate the field strengths measured by the above and other methods with the field strengths which would have prevailed at the broadcast receiving locations in the absence of obstacles;

(g) that it is desirable to analyse and to present the measurements in such a manner that they may assist in predicting the available field strengths which may be expected under various conditions of terrain, including buildings and vegetation, at the receiving locations in the service area;

UNANIMOUSLY DECIDES that the following question should be studied:

what are the methods by which the field strengths available for VHF (metric) and UHF (decimetric) broadcast services may be measured, analysed and presented so that the quality of these services may be assessed or predicted under varying conditions ?

STUDY PROGRAMME No. 55 (V) *

TROPOSPHERIC PROPAGATION CURVES FOR DISTANCES WELL BEYOND THE HORIZON

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that the curves given in Recommendation No. 111 are restricted to the frequency range 30 to 200 Mc/s, and that they give only a broad representation of the data on which they are based;

(b) that they refer only to the average meteorological conditions for the specific areas stated in the text accompanying the curves;

(c) that they specifically refer to transmission over land while conditions causing abnormal long-distance tropospheric propagation may arise more frequently over sea;

(d) that they refer only to median values with respect to geographical location;

(e) that they take no account of the height of the transmitting aerial, nor of the directivity of the transmitting and receiving aerials;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. continuous recording, for distances well beyond the horizon, of transmissions in the frequency range 30 to 4000 Mc/s in as many parts of the world as possible over a period of at least two years;

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* This Study Programme replaces Study Programme No. 17. It does not refer to any Question under study.

2. particular investigation of the problem of oversea paths;
3. the statistical analysis of the results of such experiments along the lines adopted in the production of the curves given in Recommendation No. 111;
4. deduction from this analysis of the modification to those curves to allow for the different average meteorological conditions existing in different parts of the world;
5. study of the variation of field strength at various distances from the transmitter;
6. investigation over various transmission distances of the effect of changing the height of the transmitting aerial;
7. investigation over various transmission distances of the effect of using directive aerials both for transmission and reception.

STUDY PROGRAMME No. 57 (V) *

INVESTIGATION OF MULTIPATH TRANSMISSION THROUGH THE TROPOSPHERE

The C.C.I.R., (London, 1953)

CONSIDERING

that in systems using frequencies above 30 Mc/s, radio waves may travel from a transmitter to a receiver along several paths;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. investigation of time and phase differences occurring in multipath transmissions;
2. determination of the percentage of time for which given time and phase differences occur, respectively;
3. statistical analysis of the relative strengths of signals occurring in multipath transmissions;
4. investigation of the manner in which the quantities measured vary with frequency over bands of the order of those used in television and wide-band radio and television systems;
5. investigation of the manner in which the same quantities are affected by the use of space-diversity systems.

* This Study Programme does not refer to any Question under study

STUDY PROGRAMME No. 90 (V) *

TROPOSPHERIC-WAVE PROPAGATION

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that widespread developments have taken place in the practical application of radio waves at frequencies above 30 Mc/s;

(b) that the propagation of such waves is known to be a function of the thermodynamic conditions prevalent in the troposphere and that numerous relevant measurements have been made;

(c) that, nevertheless, the detailed structure of the field in time and space is still insufficiently known;

(d) that the propagation studies required for the establishment of a radio circuit necessitate a statistical knowledge of the propagation medium, that is, of the atmosphere;

(e) that the lack of appropriate measurements makes it impossible as yet to verify the various theories put forward in explanation of radio-wave propagation;

(f) that progress in the investigation of such propagation has already led to Recommendation No. 111;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. efforts should be made to establish the correlation between the variations in the radio field strength and the thermodynamic parameters of the atmosphere;

2. study of rapid variations in the radio field strength in time and space with a view to defining the different types of propagation; the establishment of a correlation between these types of propagation and the different meteorological conditions. The presentation of the results obtained should be on the lines described in Recommendation No. 170 and the relevant annex;

3. the variations in the refractive index of air with space and time, whatever their cause, should be investigated in detail; in particular, to facilitate calculation of this index, accurate thermodynamic and radio measurements, the latter by means of a refractometer or a similar device, should be made whenever possible (see Annex, para. 1.);

4. the improvements in the instruments for measuring the small and rapid variations of the refractive index of the atmosphere, with special reference to the refractometer and a sensitive hygrometer with a low time constant;

5. world-wide radio climatology should be studied, and as a first step in this important work, the national telecommunication services, in agreement with the meteorological services concerned, should calculate for each season the mean gradient of the refractive index of the air, both for day and night, between ground and a height of 1000 metres, with a view to establishing world-wide isogradient charts (see Annex, para. 2);

6. administrations and private operating agencies should be encouraged to verify, by means of a large number of accurate measurements, the various theories put forward in explanation of propagation beyond the radio horizon.

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* This Study Programme replaces Study Programme No. 56. It does not refer to any Question under study.

Notes :

1. National administrations, the U.R.S.I. and other international organisations should be encouraged to pursue as a matter of great urgency the theoretical and experimental study of the propagation of radio waves through the troposphere.

2. The above Study Programme should be brought to the attention of the W.M.O. by the Director of the C.C.I.R., with particular reference to paragraphs 4 and 5.

ANNEX

1. The thermodynamic measurements intended for the calculation of the refractive index of the air and its gradient should, if possible, be made with an accuracy of:
   Distance between 2 consecutive points of measurement: 10 metres.
   Temperature: $\pm 0.2°$ C
   Humidity (mixing ratio) ± 0.1 g.
   Continuous measurement equipment should be used for preference.

2. To facilitate the preparation of results, the refractive index gradient for air should be calculated by the difference between N measured at 1000 metres and at ground level,

   with $$N = (n-1)\ 10^6 = \frac{77.6}{T}\left(p + 4810\frac{e}{T}\right)$$

   n = refractive index of air,
   T = absolute temperature in degrees Kelvin,
   e = water vapour pressure in mb,
   p = atmospheric pressure in mb.

It is desirable that a description of the apparatus used and the method of operation should be provided.

The calculation should cover a period of 5 years, i.e. 1951-1955.

The numerous data furnished by the national meteorological services during the International Geophysical Year should be published separately in so far as they are likely to provide additional information as compared with those for other years.

It should be assumed that the seasons can be represented by the months of February-May-August-November, and that the hours of measurement will be 0200 and 1400 U.T.

STUDY PROGRAMME No. 91 (V) *

RADIO TRANSMISSION UTILISING INHOMOGENEITIES IN THE TROPOSPHERE (COMMONLY TERMED "SCATTERING")

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that, in various countries, recent experiments, characterised by the use of transmitting and receiving antennae directed towards the same part of the troposphere, have shown that radio signals in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands can be

* This Study Programme does not refer to any Question under study.

propagated consistently through the troposphere over unexpectedly great distances, and that, beyond the line of sight, fields are found to be much greater than diffraction theory for a standard radio atmosphere would predict;

(b) that useful signals can in this manner be obtained at distances greater than was formerly expected;

(c) that tropospheric inhomogeneities play an important role in this phenomenon;

(d) that little is known about geographical and topographical influences;

UNANIMOUSLY DECIDES that the following studies should be carried out:

investigation of this new tropospheric propagation phenomenon, in its widest sense, with a view to the extension of knowledge of:

1. the variation of signal strength, including depth and rate of fading, with distance and frequency;
2. the influence of meteorological conditions, including water vapour, rain and snow on signal strength;
3. the character of signals, fading rates, time delays and bandwidths and their dependence on frequency and the propagation medium;
4. the efficiency of antennae in relation to size and design;
5. the use of spaced antennae for diversity transmission and reception;

QUESTION No. 168 (V) *

PROTECTION OF FREQUENCIES USED BY ARTIFICIAL EARTH SATELLITES OR OTHER SPACE VEHICLES FOR COMMUNICATION AND POSITIONAL OBSERVATION

The C.C.I.R.,

CONSIDERING:

(a) that transmission of radio signals between the earth and artificial satellites in extraterrestrial positions in space is now an established fact;

(b) that such extraterrestrial objects may well be consecutively above different countries of the world, thus necessitating international collaboration;

(c) that radiocommunication between extraterrestrial objects and the earth will be of importance;

(d) that no provision for such communications was made in the Atlantic City frequency allocation tables;

DECIDES that the following question should be studied:

1. what frequencies are specially suitable for penetration of the lower layers of the earth's atmosphere ?

2. what are the influences on these frequencies of the meteorological conditions which are dependent on the hour of the day, the season and the geographical location ?

3. what changes in propagation, for example in direction, can be expected by the penetration of the troposphere ?

4. what, if any, will be the differences in propagation between in-going and out-going signals relative to the earth ?

* For the corresponding Question relating to propagation through the ionosphere see Question No. 169 (VI).

Questions and Study Programmes assigned to Study Group No. VI

STUDY PROGRAMME No. 60 (VI) *

BASIC PREDICTION INFORMATION FOR IONOSPHERIC PROPAGATION

(Question No. 50)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that Question No. 50 cannot yet be fully answered;

(b) that, nevertheless, extensive practical use is made of basic prediction information by radio operating services and administrations (see Report No. 23);

(c) that the application to specific operational problems, of basic prediction information, as supplied by various administrations and centres, has revealed occasional large discrepancies between basic prediction information and operational results, even though the solar activity may have been correctly forecast; these may be attributed to such causes as the following:

— different interpretations placed upon the basic ionospheric observations;

— different methods of converting basic ionospheric observational material into world prediction charts;

— over-simplification of the prediction material resulting from the continuing use of the three-zone method of allowing for longitude effects in the characteristics of the F2 layer;

— inadequate understanding and research for suitable allowance to be made for the role played by layers other than F2, notably the E layer, for the actual modes of propagation, and for the effects of ground scatter;

— in the preparation of world prediction charts the necessity to adapt existing propagation data to extensive regions (oceans, etc.) from which no such data are available;

— differences in the statistical significance of the operational data sampled, and in the methods of assessing the circuit performance of the various classes of service;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the suitability of present methods for predicting oblique incidence MUF from vertical incidence data for both short and long paths;

2. the extent to which basic prediction material now in use could be improved by the use of:

— two separate intermediate-zone (I-zone) world charts, possibly with modified zone boundaries, or,

— a set of world charts for every hour or two hours, U.T.;

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* This Study Programme does not refer to any Question under study.

3. the role played by the E region in the determination of operational MUF for short and long paths both in summer and in winter;

4. practical means of introducing into prediction data, propagation modes and the related subject of angles of arrival and departure;

5. practical methods of introducing into monthly predictions the anticipated day-to-day spread of MUF.

Note. — The above study programme should be brought to the attention of the U.R.S.I. by the Director of the C.C.I.R. with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of its study.

STUDY PROGRAMME No. 63 (VI) *

RADIO PROPAGATION AT FREQUENCIES BELOW 1500 kc/s

The C.C.I.R., (Geneva, 1951 — London, 1953)

CONSIDERING

(a) that a large amount of work has now been done on the ionospheric propagation of waves at frequencies below 1500 kc/s **;

(b) that, nevertheless, the propagation of radio waves on frequencies below 1500 kc/s under conditions in which it is controlled by the ionosphere is not yet fully understood;

(c) that the mathematical analysis of this problem has been largely confined to ideal cases that are not sufficiently representative of practical conditions especially where long-distance propagation is concerned;

(d) that it is of interest to the I.F.R.B. to have available reliable curves of night-time propagation on these frequencies especially at the comparatively short distances for which the ground-wave predominates in daytime;

DECIDES that the following studies should be carried out:

1. the continuation of measurements at vertical and oblique incidence on frequencies below 1500 kc/s of the type described in the documents referred to;

2. with the participation of administrations and laboratories having suitable facilities, obtain results over as large a range of frequencies and geographical areas as possible;

3. carry out measurements at very great distances and very low frequencies in an effort to determine the manner of propagation of these waves to great distances;

4. the effect, on the propagation of these waves, of disturbed conditions in the ionosphere, such as those associated with sudden phase anomalies and with magnetic storms;

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* This Study Programme replaces Study Programme No. 21. It does not refer to any Question under study.

** See Doc. No. 141 of Washington 1950, Docs Nos. 69, 154 and 186 of Geneva 1951, Docs Nos. 37 and 332 of London 1953 and in the review given in *Proc. I.E.E.* 100, Part III, 64, 1953, p. 100.

5. the influence of the earth's magnetic field;

6. the development of the mathematical analysis to make it apply more closely to the general conditions of long-distance propagation in which both the ionisation and the direction of the earth's magnetic field vary along the propagation path;

7. the possibility of revising the C.C.I.R. night-time curves (presented at Cairo, 1938) in the light of present knowledge, in view of the need of the I.F.R.B. to have available reliable curves, as expressed in § *(c)* of the Annex to Report No. 24.

Note. — The above Study Programme should be brought to the attention of the U.R.S.I. by the Director of C.C.I.R., with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of its study.

STUDY PROGRAMME No. 66 (VI) *

STUDY OF FADING

(Questions Nos. 51 and 52 — Study Programme No. 24)

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that the practical requirements of radio communication necessitate not only information on the median received field strength of radio transmissions, but also:

— data on the amplitude distribution and rapidity of field strength variations (with respect to the speed of transmission),

— effects of equipment time constants,

— selective fading,

and that this information is essential to Study Groups Nos. III, X and XII in assessing the allowances for fading;

(b) that field strength variation involves phenomena of focusing, of variation in direction of arrival, of interference by components of a single mode, between different modes, and between the various magneto-ionic components, as well as of variations of ionospheric absorption and of scattering phenomena;

(c) that variations of field strength may, as a first approximation, be divided into three types:

— irregular short period variations, assumed in general to result from interference and focusing, with an apparent period of occasionally as much as several minutes and dependent to a certain degree on the frequency. These variations should be allowed for in the assessment of a *fading safety factor*;

— irregular variations of periodicity large compared with the case above, i.e. hourly, daily or from one day to another, which may be due to fluctuating absorption or to prolonged large scale focusing or which may result from variations of arrival angle and polarisation. Allowance for them should be made in the assessment of an *intensity fluctuation factor*;

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* This Study Programme does not refer to any Question under study.

— regular variations with time of day, season and solar activity, to which are added the variations of the two above types;

(d) that it is important to have as much information as possible concerning the effects of fading on time, space, frequency and polarisation diversity reception;

UNANIMOUSLY DECIDES that the following studies should be carried out for the various frequency bands used in radio communication by means of the ionosphere;

1. the rapidity, severity and time distribution (for example, Rayleigh, normal and log-normal) of short-period field-strength variations i.e. of the order of 10^{-4} second, or occasionally even shorter, to several seconds or, sometimes, to as much as several minutes;

2. the severity of day-to-day variations of hourly median field strengths i.e. for time intervals of one hour;

3. the extent to which the above variations are dependent upon season, solar activity and geographical location;

4. the effects produced by field-strength variations on different receiving systems, such as time, space, frequency and polarisation diversity systems;

5. the mechanisms which produce field-strength variations;

6. the extent to which any of the above studies are affected under modulation conditions.

Notes :

1. The above studies should be undertaken both from a theoretical and experimental viewpoint. When appropriate, consideration should be given to the time constants and other characteristics of the measuring equipment.

2. The above Study Programme should be brought to the attention of the U.R.S.I. by the Director of C.C.I.R. with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of its study.

STUDY PROGRAMME No. 92 (VI) *

CHOICE OF A BASIC INDEX FOR IONOSPHERIC PROPAGATION

(Question No. 53)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the sun is generally accepted as the primary cause of many geophysical phenomena and in particular of the formation of the ionosphere and of most of its variations;

(b) that when suitable smoothed averages are used the Wolf sunspot numbers provide an index of solar activity which shows a fairly good correlation with similarly smoothed ionospheric

* This Study Programme does not refer to any Question under study.

propagation data, but that these numbers are nevertheless subjective and empirical since they are obtained from an arbitrary formula based on the number of spots and of groups of spots observed on the sun's disc;

(c) that determination of the Wolf numbers depends, moreover, on visual observations of the sun which can therefore be made only under favourable meteorological conditions;

(d) that it has recently been shown that the intensity of solar radiation in the VHF (metric) and UHF (decimetric) bands is closely correlated with visible solar phenomena;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the relationship between solar phenomena, other than sunspots expressed in Wolf numbers which can be observed objectively, and ionospheric propagation conditions;

2. the relationship between the intensity of solar radiation at radio frequencies and ionospheric propagation conditions;

3. the possibility of establishing an index of solar activity, based upon optical or radio observations, which can be usefully employed as a basic index for ionospheric propagation;

4. the possibility of utilising, perhaps temporarily, some observations of terrestrial phenomena, such as of a geomagnetic or of an ionospheric character, so as to provide a suitable index of solar influence on ionospheric phenomena, for use in connection with ionospheric propagation studies.

Note. — The above Study Programme should be brought to the attention of the U.R.S.I. by the Director of the C.C.I.R. with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of its study.

STUDY PROGRAMME No. 93 (VI) *

IDENTIFICATION OF PRECURSORS INDICATIVE OF SHORT-TERM VARIATIONS OF IONOSPHERIC PROPAGATION CONDITIONS

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that it is desirable to have an index or indices suitable for short-term forecasts of ionospheric disturbances;

(b) that long-term indices for ionospheric propagation may not be satisfactory for indicating short-term variations in the ionosphere;

(c) that ionospheric propagation disturbances may result from either corpuscular or electromagnetic radiation from the sun;

(d) that a correlation has been found ** between short-term variations of ionospheric propagation conditions and certain indices of both magnetic phenomena and solar eruptions;

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* This Study Programme replaces Study Programme No. 59. It does not refer to any Question under study.

** See Docs. Nos. 78, 79, 123, 124 and 347 (Warsaw, 1956).

UNANIMOUSLY DECIDES that the following study should be carried out:

the possibility of selecting particular kinds of solar observations, or observations of other phenomena, which can be made objectively, and which may be usefully employed for short-term predictions of ionospheric propagation conditions.

Note. — The above Study Programme should be brought to the attention of the U.R.S.I. by the Director of the C.C.I.R., with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of its study.

STUDY PROGRAMME No. 94 (VI) *

USE OF SPECIAL MODULATION ON THE STANDARD FREQUENCY TRANSMISSIONS FOR ASSESSING THE RELIABILITY OF PROPAGATION FORECASTS

(Question No. 50)

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that radio operating agencies are quite willing to take periodical note of the quality of the propagation observed on certain paths during their normal traffic;

(b) that the data thus obtained are nevertheless inadequate for clear conclusions to be drawn concerning the actual propagation conditions and the accuracy of available forecasts;

(c) that the method of continuously recording the field set up by continuously operating transmitters or by transmitters with transmissions evenly spaced in time seems at present to be a more efficient way of comparing forecasts with actual propagation conditions;

(d) that it would be extremely difficult, if not impossible, to obtain assignments of sufficiently clear frequency channels, and of necessary transmitting facilities, for the specific purpose of obtaining more useful data for such comparisons;

(e) that transmitters of standard frequencies and time signals were quite satisfactory for this purpose so long as they were few enough in number not to cause mutual interference, but that this is no longer the case;

(f) that the study of propagation conditions using experimental transmitters does not always require permanent transmissions but merely transmissions of short duration repeated every few minutes;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the possibility of providing special tone modulation on the various standard-frequency transmitters, suitable for radio propagation measurements. Such modulation ought to provide, for example, one or more distinct sidebands spaced far enough from the carrier and from the other modulation sidebands to allow the recording receiver to receive only the wanted sideband. The overall standard-frequency transmission, however, must not fall outside the bands allocated to this service by the Radio Regulations, Atlantic City, 1947. This study should be

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* This Study Programme replaces Study Programme No. 62. It does not refer to any Question under study.

effected in such a way that the same degree of precision is maintained for each frequency emitted and that the radiated power of each station, and on each frequency, is kept constant;

2. the feasibility of applying such additional modulation for a short interval of time repeated every few minutes, to each transmitter successively, on a given frequency, and according to a pre-arranged sequence.

STUDY PROGRAMME No. 95 (VI) *

IONOSPHERIC SCATTER PROPAGATION

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that ionospheric scatter propagation is now an established means of long-distance communication in the lower part of the VHF (metric) band over distances from approximately 1000 to 2000 kilometres;

(b) that communication systems employing this mode of propagation have been confined largely to arctic and sub-arctic regions and have been developed during a period of low solar activity;

(c) that while much study has already been given to this subject (see Report No. 64), many factors require further investigation;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the delineation of the physical mechanisms involved with reference to the design and operation of communication systems;

2. the diurnal and seasonal variation of median received signal intensity for a given system with:
   — geographical location,
   — path orientation,
   — solar and geomagnetic activity indices;

3. the influence of the plane-wave gain and directivity of the antennae on the median received-signal intensity;

4. the short-term variations of received-signal intensity in relation to the use of diversity methods;

5. the most suitable modulation techniques to take account of such unusual characteristics of the received signals as the Doppler shifts associated with meteors and certain polar aurorae;

6. the multipath characteristics of the received signal in relation to
   — antenna directivity,
   — path length,

   with a view to establishing the maximum useful information rates (bandwidths);

7. the problems arising from the occurrence, at the frequencies employed, of regular reflection from the Es and F2 layers.

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* This Study Programme replaces Study Programme No. 64. It does not refer to any Question under study.

STUDY PROGRAMME No. 96 (VI) *

MEASUREMENT OF ATMOSPHERIC RADIO NOISE

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that there is a continuing need for more information regarding atmospheric noise and its influence on radio systems, particularly to provide data for further revisions of the noise curves and charts which have been prepared for the C.C.I.R.;

(b) that there is still no generally adopted objective method of measuring atmospheric noise;

(c) that the aims of Study Programme No. 65 have only partly been achieved;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the setting up of a world-wide network of stations for measuring atmospheric noise and for locating its sources;

2. the establishment of a direct comparison between objective and subjective methods of noise measurement (including the Thomas method) for the various classes of emission so as to choose the most suitable methods of measurement for the future;

3. extension of facilities (e.g. narrow-sector and cathode-ray direction finders) for locating thunderstorm centres and for the comparison of the results of observations at various frequencies within the spectrum of atmospherics;

4. the experimental and theoretical determination of the characteristics of atmospheric noise, and in particular, its statistical properties;

5. the choice of a method of statistical presentation of atmospheric noise data that can be subsequently recommended;

6. the investigation of the relative importance of atmospheric noise as compared with other types of noise as a limiting factor in radio communication.

Notes :

1. The studies mentioned in this programme should be carried out in close collaboration with the World Meteorological Organisation.

2. The above Study Programme should be brought to the attention of the U.R.S.I. by the Director of the C.C.I.R. with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of its study.

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* This Study Programme replaces Study Programme No. 65. It does not refer to any Question under study.

STUDY PROGRAMME No. 97 (VI) *

PULSE-TRANSMISSION TESTS AT OBLIQUE INCIDENCE

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the study of many problems in ionospheric propagation of direct concern to the C.C.I.R. can be greatly aided by the use of fixed-frequency pulse transmissions;

(b) that these problems include:

- the nature of fading,
- the assessment of ionospheric absorption,
- the investigation of transmission modes,
- the measurement of group delay times,
- the polarisation and direction of arrival in azimuth and elevation of ionospherically reflected waves,
- the consequences of magneto-ionic double refraction,
- the relation of the vertical-incidence critical frequencies to the oblique-incidence classical MUF,
- the causes of propagation above the classical MUF.

(c) that where high power is needed for such pulse transmissions, use might be made of commercial transmitters;

(d) that, at least for short and medium distances where the individual modes can be separated, much additional information can be obtained by using sweep-frequency pulse transmissions;

(e) that such transmissions involve difficult technical problems of synchronisation and display at the receiver;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the characteristics of long-distance ionospheric propagation by the use of fixed-frequency and sweep-frequency pulse transmissions, using commercial transmitters, if practicable, where high power is needed on fixed frequencies;

2. the making of ionospheric vertical-incidence soundings at points along the transmission path, in particular, as near to the terminal points and the mid-point as possible;

3. the continued development of the techniques required in connection with the display used at the receiver and its synchronisation with the transmitter;

Note. — The above Study Programme should be brought to the attention of the U.R.S.I. by the Director of C.C.I.R. with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of its study.

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* This Study Programme partly replaces Study Programme No. 67. It does not refer to any Question under study.

STUDY PROGRAMME No. 98 (VI) *

BACK-SCATTERING

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that back-scatter phenomena yield direct information at the transmitting station of the performance of the frequency used;

(b) that back-scatter phenomena reveal an increase of the MUF above the value calculated from vertical incidence tests and produce signals within the classical skip-distance;

(c) that back-scatter measurements can partly replace oblique-incidence pulse tests (Compare Study Programme 97(VI));

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. Discrimination between various back-scatter modes (ground-scatter, E-scatter etc.);
2. the use of back-scattering to supplement the information obtainable by oblique-incidence pulse transmissions;
3. field-strength measurements to determine the back-scattering coefficient as a function of frequency, the nature of the scattering surface and the angle of incidence at the scattering surface;
4. determination of the incident field at the scattering zone from the back-scattering coefficient as derived from the field-strength measurements made near the transmitting site;
5. study, by back-scattering, of sporadic-E formation and movement;
6. determination from back-scattering measurements of actual propagation conditions;
7. determination of effective antenna diagrams at large distances by means of back-scattering.

Note. — The above Study Programme should be brought to the notice of U.R.S.I. by the Director of the C.C.I.R. with a view to encouraging that organisation to expedite its work bearing on these studies, requesting the U.R.S.I. to inform the C.C.I.R. of the results of its studies.

* This Study Programme partly replaces Study Programme No. 67. It does not refer to any Question under study.

STUDY PROGRAMME No. 99 (VI) *

THE ESTIMATION OF SKY-WAVE FIELD STRENGTHS ON FREQUENCIES ABOVE 1500 kc/s

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the estimation of sky-wave field strengths on frequencies above 1500 kc/s is of great importance in the planning of high-frequency long-distance radio communication;

(b) that the similar problem for short distances up to 800 km is of special importance in tropical broadcasting;

(c) that such estimates depend upon a knowledge of ionospheric absorption;

(d) that this absorption is a more complicated function of local time, season and geomagnetic latitude than is usually assumed in making such field-strength estimates;

(e) that in this connection the E layer often has a complicated structure and there is considerable night-time absorption in certain tropical regions;

(f) that the mechanism of long-distance ionospheric propagation is not yet fully understood;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the making of absorption measurements in as many parts of the world as possible with a view to improving the basic data embodied in methods for estimating sky-wave field strengths on frequencies above 1500 kc/s;
2. the improvement of such methods to take more account of the earth's magnetic field especially near the magnetic equator and in regions of abnormally high absorption;
3. the possibility of deciding on the method most adapted to the needs of tropical broadcasting and taking into account the special conditions existing in low geomagnetic latitudes;
4. the further examination of the theoretical basis of long-distance ionospheric propagation with regard to the possible modification of the methods of field-strength estimation.

Note. — All organisations participating in these studies should collaborate and exchange information among themselves and with the U.R.S.I.

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* This Study Programme replaces Recommendation No. 115. It does not refer to any Question under study.

STUDY PROGRAMME No. 100 (VI) *

PREDICTION OF SOLAR INDEX

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the sun is the primary cause of many geophysical phenomena, in particular, of the formation of the ionosphere and of most of its variations;

(b) that the gradual waxing and waning of solar activity, with intervals of approximately eleven years between maxima, corresponds closely with many slowly varying geophysical activity indices;

(c) that the slowly varying component of solar and geophysical activity can be estimated from many solar activity indices based on optical and radio measurements and by geomagnetic and ionospheric sounding measurements;

(d) that reliable prediction of such parameters is of the utmost importance to radio propagation work;

(e) that autocorrelation techniques have been studied in various countries;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. predictions by all published autocorrelation or quasi-autocorrelation methods should be compared with each other and with the results of subsequent observations for recent years; these comparisons should be continued on a current basis;

2. further attention should be given to the combination of autocorrelation and empirical methods which may yield more nearly optimum predictions.

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* This Study Programme does not refer to any Question under study.

QUESTION No. 169 (VI) *

PROTECTION OF FREQUENCIES USED BY ARTIFICIAL EARTH SATELLITES OR OTHER SPACE VEHICLES FOR COMMUNICATION AND POSITIONAL OBSERVATION

The C.C.I.R.,

CONSIDERING:

(a) that communication between the earth and artificial earth satellites is now a practical reality;

(b) that, while VHF and UHF emissions are likely to be used for many such communication purposes, the ionosphere nevertheless will have some influence on the character of the received signals and on apparent positions as observed by radio methods;

(c) that the study of the effects of the ionosphere on such communications may be facilitated by comparison of HF signals with VHF or UHF signals since the ionospheric effects are larger on the lower frequencies;

(d) that, in particular, the ionosphere above the F2-layer peak, which cannot normally be studied with radio waves of terrestrial origin, will have some influence on such communications;

(e) that there is no provision for communications of this kind in the table of frequency allocations of the Atlantic City Conference;

DECIDES that the following question should be studied:

1. what are the optimum frequency bands for intercommunication between any two points in space, with particular reference to the earth and to rockets, satellites and space vehicles launched therefrom ?

2. what special practicable measures can be taken in particular in the HF and the lower part of the VHF band to provide protection from interference to signals passing to or from artificial earth satellites or other kinds of space vehicles and also from the interference arising from satellite signals.

* For the corresponding Question relating to propagation through the troposphere see Question No. 168 (V).

Questions and Study Programmes assigned to Study Group No. VII

QUESTION No. 140 (VII) *

STANDARD-FREQUENCY TRANSMISSIONS AND TIME SIGNALS

The C.C.I.R., (Stockholm, 1948 — Geneva, 1951 London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the Atlantic City Radio Conference called for the study of the establishment and operation of a world-wide standard-frequency and time-signal service;

(b) that a number of stations are now regularly transmitting standard frequencies and time signals in the bands allocated by the Atlantic City Conference;

(c) that some areas of the world are not yet adequately served;

(d) that the use of more stations than are technically necessary would, by producing harmful interference, diminish the utility of the service;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what measures can be recommended for increasing the effectiveness of the existing standard-frequency and time-signal service in the bands allocated by the Atlantic City Conference;
2. what measures can be recommended for the reduction of mutual interference between standard-frequency and time-signal stations operating on the same frequency and whose service areas overlap?

STUDY PROGRAMME No. 101 (VII) **

STANDARD-FREQUENCY TRANSMISSIONS AND TIME SIGNALS

(Question No. 140 (VII))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that Question No. 140 (VII) calls for information on methods for improving the utility of the existing standard-frequency transmission and time-signal service;

* This Question replaces Question No. 87. Study Programme No. 101 (VII) arises from this Question.
** This Study Programme replaces Study Programme No. 68. It arises from Question No. 140 (VII).

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

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. an investigation of the possibility of arranging the programme of tone modulation and of announcements in telegraphy and telephony to avoid harmful interference between standard-frequency transmissions;
2. an investigation of the possibility of reducing interference between standard-frequency transmissions by using special types of transmissions such as single-sideband with carrier or double-sideband suppressed carrier;
3. an investigation of the possibility of using an improved type of modulation for the time signal.

QUESTION No. 141 (VII)

STABILITY OF STANDARD-FREQUENCY TRANSMISSIONS AND TIME SIGNALS AS RECEIVED

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that standard-frequency transmissions and time signals when received are less stable than at the source;

(b) that some phenomena occurring in the propagation of radio waves, e.g. the Doppler effect or multipath interference, reduce the accuracy with which the standard-frequency transmissions and time signals can be utilised;

(c) that errors which occur during propagation depend on the nature and conditions of the medium and are generally different in different regions of the radio spectrum;

(d) that special forms of time signals may improve the accuracy with which they can be received;

(e) that the accuracy with which time signals can be received may depend upon the design of the receiving equipment;

(f) that standard-frequency transmissions and time signals as received are insufficiently stable for some uses;

(g) that a statistical knowledge of the figure of accuracy to be expected would be very useful and would increase the utility of existing and future standard-frequency transmissions and time signals.

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the causes of the reduction in the stability and accuracy of the standard frequencies and time signals as received by the users;
2. what is the magnitude in statistical terms of the instability introduced by these causes;
3. what is the best form of time pulse and receiving equipment for obtaining the maximum accuracy in the reception of time signals?

QUESTION No. 142 (VII)

STANDARD-FREQUENCY TRANSMISSIONS AND TIME SIGNALS IN ADDITIONAL FREQUENCY BANDS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that Question No. 140 (VII) refers only to the transmission of standard frequencies and time signals in the bands allocated by the Radio Regulations Atlantic City 1947, centred on the frequencies of 2,5, 5, 10, 15, 20, and 25 Mc/s;

(b) that in certain regions, particularly in industrial centres, it is not always possible to obtain an adequate ratio of the wanted signal to the noise level with the existing standard-frequency and time-signal transmission system;

(c) that it seems advisable to ensure distribution of standard frequencies and time signals on a local basis;

(d) that the bands allocated for standard-frequency transmissions and time signals are at times made inoperable by ionospheric storms, which may last for a day or more;

(e) that frequency comparisons to within 1 part in 10^9 against standard-frequency transmissions operating in the allocated bands usually require a measurement period of 1 to 10 days ;

(f) that in communications, research, and industry there is an increasing need for high measurement accuracy in a shorter measurement time;

(g) that frequency comparisons to within 1 part in 10^9 against standard-frequency transmissions operating at 16 kc/s or 60 kc/s require a measurement period of about 10 minutes;

UNANIMOUSLY DECIDES that the following question should be studied:

what can be recommended for the distribution of standard frequencies and time signals above 30 Mc/s and below 100 kc/s ?

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Questions and Study Programmes assigned to Study Group No. VIII

QUESTION No. 104 (VIII)*

IDENTIFICATION OF RADIO STATIONS

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that, in order to carry out an efficient monitoring service of radio stations, it is necessary for these stations to be identified as regularly as possible during their transmissions;

(b) that in many types of radio systems, the identification procedure used at present is satisfactory to both the operating agencies and the regulating administrations, as is the case for single-channel low-speed telegraphy;

(c) that the Atlantic City Radio Regulations (Chap. V, Art. 13, Section V, § 10) set forth requirements for transmissions of radio call signs, and state that each radio station provided with a call sign from the international series must, unless the Atlantic City Radio Regulations provide otherwise, transmit this call sign during the course of their transmission as frequently as is practicable and reasonable;

(d) that certain types of radio stations are exempted from the necessity of having an international call sign, for example, stations which are easily identified by other means and whose signals of identification, or characteristics of emission, are published in international documents;

(e) that the problem of accomplishing identification of multi-channel telephone and telegraph transmissions, except for single-sideband systems, is particularly difficult without the use of costly special apparatus ;

(f) that the requirements of frequently transmitting a call sign may impose a difficult and costly hardship on the operating agencies, particularly where heavily loaded multi-channel or high-speed machine operation is employed;

DECIDES that the following question should be studied:

the possibility of ensuring the convenient identification of stations utilising multi-channel synchronised systems, high-speed machine systems, facsimile systems, or other special systems of transmission, in the most effective manner without the necessity of interrupting the transmissions of such stations, or of increasing the transmissions of such stations, or of increasing the bandwidth of the emissions. The increased costs to the monitoring and transmitting stations which would be incurred by the recommended solutions should be borne in mind.

Note. — This study should be carried out urgently.

* This Question replaces Question No. 17. Study Programme No. 115 (VIII) refers to this Question.

This Question was allocated to Study Group No. XIII in London. Following an exchange of letters after the VIIIth Plenary Assembly, the Director, in agreement with the respective study group chairmen, has allocated it to Study Group No. VIII.

STUDY PROGRAMME No. 115 (VIII) *

IDENTIFICATION OF RADIO STATIONS

(Question No. 104 (VIII))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that Recommendation No. 220 does not cover all aspects of the problem;

(b) that the development and general use of satisfactory means for the identification of radio stations is required as a matter of urgency by international monitoring stations, and would be of assistance to the I.F.R.B.;

(c) the desirability of not interrupting the flow of traffic, nor appreciably increasing the bandwidth of the emissions, nor increasing the costs which would be incurred by the monitoring and transmitting stations as a result of adopting the recommended solutions;

DECIDES that the following studies should be carried out:

1. the problem of applying low-power amplitude modulation or developing other methods of superimposing an acceptable identification signal on frequency-shift transmissions;

2. the problem of transmitting call signals in multi-channel synchronous, and other special telegraph systems, not using single-sideband transmission.

Notes :

1. These studies are to be carried out urgently.
2. Report No. 91 on the " Identification of radio stations " refers to this Study Programme.

QUESTION No. 143 (VIII) **

AUTOMATIC MONITORING OF OCCUPANCY OF THE RADIO-FREQUENCY SPECTRUM

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the rapidly increasing demand for radio services continues to require the most efficient use of the radio-frequency spectrum;

(b) that the most efficient use of the spectrum can be made only when its occupancy is know;

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* This Study Programme replaces Study Programme No. 78. The Bielorussian S.S.R., the P.R. of Bulgaria, the Ukrainian S.S.R. and the U.S.S.R. reserved their opinion on this Study Programme.

This Study Programme was allocated to Study Group No. XIII in Warsaw. Following an exchange of letters after the VIIIth Plenary Assembly, the Director, in agreement with the respective study group chairmen, has allocated it to Study Group No. VIII.

** This Question replaces Question No. 88.

(c) that automatic monitoring is recommended as a valuable aid to determining the occupancy of the spectrum; and the desirable characteristics of such equipment have been recommended (see Recommendation No. 182);

(d) that it is desirable to make further studies of equipment characteristics and to determine the means whereby the greatest benefit may be derived from automatic monitoring records;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the accuracy of automatic monitoring equipment in determining bandwidth and field intensity;

2. what is the capability of automatic monitoring equipment in determining signal-to-noise ratios;

3. what are the best means of analysing and evaluating automatic monitoring records, both singly and collectively;

4. is it possible to analyse present records by automatic means and, if not, what modifications are necessary to enable this to be done?

QUESTION No. 144 (VIII)

MEASUREMENTS AT MOBILE MONITORING STATIONS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the number of transmitting stations especially in the VHF (metric) range is increasing;

(b) that many of these transmitters can be monitored only at mobile monitoring stations;

(c) that information regarding the capability of mobile monitoring stations is needed;

UNANIMOUSLY DECIDES that the following questions should be studied:

1. what measurements of radio-frequency emissions can be made at mobile monitoring stations;

2. what are the desirable types and characteristics of equipments for making such measurements;

3. what are the limitations and accuracies of such measurements?

QUESTION No. 145 (VIII)

FREQUENCY MEASUREMENTS AT MONITORING STATIONS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that it is possible to reduce the ratio between the error of measurement at monitoring stations and the specified tolerance of an emission as stated in the consideration *(c)* of Recommendation No. 180;

(b) that it is desirable to simplify frequency measurements;

(c) that it may be desirable to use a stable transfer oscillator and an electronic frequency counter in conjunction with a spectrum analyser for frequency measurements under conditions of fading, interference, carrier instability, suppressed carrier and interruption of the carrier by keying;

(d) that the accuracy of frequencies of emissions and frequency tolerances are being improved and that in particular the measurement of the frequencies of television emissions in offset operation requires a high degree of absolute accuracy;

(e) that in general the frequency range of amplitude modulated emissions under effective observation at fixed monitoring stations is approximately from 10 kc/s to 50 Mc/s;

(f) that the number of frequency-modulated emissions, especially in the frequency range above 50 Mc/s, is increasing;

(g) that it is believed that the accuracy of the secondary standards for frequency measurements is capable of being improved;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the ratio of the error of frequency measurement to the permissible tolerance of emissions that is necessary and desirable for frequency measurements at monitoring stations and particularly when the permissible tolerances are small, when statistical methods are used for evaluation purposes;

2. what is the accuracy of frequency measurements which can be accomplished at monitoring stations, especially under the conditions contained in consideration *(c)*;

3. bearing in mind the high degree of accuracy required for the measurements of certain emissions (e.g. television emissions where offset carrier operation is used), what equipments and methods are preferred for frequency measurements at monitoring stations with regard to :

(a) frequency-modulated emissions,

(b) amplitude-modulated emissions;

4. what is the accuracy required for measurements of frequencies (Recommendation No. 180):

(a) of frequency-modulated emissions of stations operating

— in the band 4000 kc/s-50 Mc/s,

— in the band 50 Mc/s-500 Mc/s,

— above 500 Mc/s;

(b) of amplitude-modulated emissions

— of stations, except broadcasting stations, operating in the band 10 kc/s-4000 kc/s,

— of broadcasting stations operating in the band 10 kc/s-4000 kc/s;
— of stations, except television broadcasting stations, operating in the band 4000 kc/s-500 Mc/s,
— of stations, except television broadcasting stations, operating above 500 Mc/s,
— of television broadcasting stations operating in the band 30 Mc/s-3000 Mc/s?

STUDY PROGRAMME No. 102 (VIII) *

FIELD-STRENGTH MEASUREMENTS AT MONITORING STATIONS

The C.C.I.R., (London, 1953—Warsaw, 1956)

CONSIDERING

(a) that Recommendation No. 181: " Accuracy of field-strength measurements by monitoring stations " does not cover all aspects of the problem, and that it recommends that studies relating to methods and equipment for use at monitoring stations should be continued;

(b) that the importance of collecting comparable field-strength data for the purpose of making propagation studies is increasing;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. taking into account the previous work of the C.C.I.R. in this field, what are the preferred equipment and the preferred methods for measuring the field strength of emissions for propagation studies at monitoring stations;

among other factors the following should be studied:
— the methods for measuring the field strength,
— the measuring and recording equipment,
— the total frequency range,
— the calibrating equipment,
— the methods for analysing the records,
— the most effective form of presentation and distribution of these data for the benefit of various bodies, for example the I.F.R.B. (See Recommendation No. 22);

2. what are the most useful programmes of propagation studies in the different frequency ranges that can be carried out at monitoring stations bearing in mind

(a) the needs of the I.F.R.B., study groups of the C.C.I.R. and other bodies,

(b) the various distances and the particular paths over which propagation data are required;

3. what are the equipment and methods to be preferred for measuring the field strength of emissions

(a) with interrupted carrier,

(b) with reduced carrier,

(c) with other types of signals, including television signals;

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* This Study Programme replaces Study Programme No. 69. It does not refer to any Question under study.

4. what are the equipment and methods to be preferred for measuring the field strength of emissions of the types given in paragraph 3 in the presence of noise and interference;

5. to what extent the determination of the relative levels of the field strength of the fundamental and of the harmonic frequencies of an emission measured at a distance can give usable data about the relative levels measured at the transmitter itself?

STUDY PROGRAMME No. 103 (VIII) *

SPECTRUM MEASUREMENT BY MONITORING STATIONS

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that it is desirable that international monitoring stations should be able to measure the spectrum of emissions;

(b) that Recommendation No. 88 is concerned only with measurements of spectrum made near the transmitter;

(c) that although the methods of measurement and equipment used at monitoring stations for spectrum measurement may be generally similar to those used near the transmitter, nevertheless, additional factors will need to be considered (e.g., the effects of fading, noise and interference on the received signal and the necessity for making measurements on traffic rather than on periodic signals);

(d) that the accuracy possible or necessary at monitoring stations may differ from that possible for measurements made near the transmitter;

UNANIMOUSLY DECIDES that the following studies should be carried out:

determination of the most suitable equipment and methods for the measurement of spectrum of emissions by monitoring stations, taking into account:

1. the work of the C.C.I.R. concerning measurements of spectrum made near the transmitter;

2. the necessity for monitoring stations to examine various classes of emission and to make measurements of a fading signal in the presence of noise and interference;

3. the possible or necessary accuracy of measurements by monitoring stations.

Note.—In order to determine the possible accuracy of measurements at monitoring stations in comparison with the accuracy obtainable near the transmitter, it would be desirable to make comparisons of the spectra of various types of emission using identical equipments:

— at the transmitter itself,

— at a monitoring station distant from the transmitter, under favourable conditions as well as under various conditions of fading, noise and interference.

In order to assist monitoring stations to identify various classes of emissions, particularly more complex types of machine telegraphy, it would be useful to study the spectra of these emissions

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* This Study Programme replaces Study Programme No. 70. It does not refer to any Question under study.

both for the purpose of identification and of classification of such emissions in the presence and absence of fading and interference.

Present studies have largely been confined to measurement of the spectra of emissions using frequencies below 30 Mc/s and with bandwidths not exceeding 25 kc/s. It would be useful to extend the studies to emissions above 30 Mc/s where bandwidths up to about 10 Mc/s are often employed. It is recognised that this may entail the development of new equipment.

It is known that the spectrum of an emission is closely related to the form of the envelope of the emission and it is believed that it may, in certain cases, be more useful to have information on the waveform than on the spectrum or the bandwidth, e.g. in the case of television emissions. It is suggested that preliminary consideration might be given to the subject of measurement of waveform characteristics at monitoring stations.

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Questions and Study Programmes assigned to Study Group No. IX

STUDY PROGRAMME No. 28 (IX) *

WIDE-BAND RADIO RELAY SYSTEMS OPERATING IN THE VHF (METRIC), UHF (DECIMETRIC) AND SHF (CENTIMETRIC) BANDS

(Questions Nos. 29 and 41)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that wide-band radio relay systems suitable for operation in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands and for incorporation in networks carrying telephone, broadcast programmes, telegraph and television signals, present technical problems of concern to the C.C.I.F., the C.C.I.R. and the C.C.I.T. and in particular to the C.C.I.F. and the C.C.I.R.;

(b) that Recommendation No. 40 ** approved by the VIth Plenary Assembly of the C.C.I.R. concerning radiotelephone systems operating in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands is in terms of an objective to be attained and that consequently it is necessary to study many technical problems in detail, in order that suitable recommendations may be given to enable this objective to be achieved in specific cases;

(c) that the best method of cooperation between the two C.C.I.s appears to be based on the broad principle that those aspects of a given problem concerning only one C.C.I. are dealt with solely by that C.C.I. while those aspects which concern both C.C.I.s are the responsibility of the C.C.I. most concerned, the other C.C.I. being adequately represented at all discussions and meetings;

(d) that, as described in C.C.I.R. Doc. No. 188 of Geneva, some studies have already been carried out by the C.C.I.F.;

UNANIMOUSLY DECIDES that the following studies shall be carried out and that the appropriate steps be taken to coordinate the work with the C.C.I.F. on the lines indicated below:

1. Questions for study by the C.C.I.F.

the overall transmission characteristics for the transmission of multi-channel telephone, broadcast-programme, telegraph and television signals over land-line systems and over integrated systems including line and radio;

2. Questions for study by the C.C.I.R.

the studies referred to in this section should be carried out for the VHF (metric), UHF (decimetric) and SHF (centimetric) bands, and should include consideration of the trans-

* This Study Programme does not refer to any Question under study.

** Concerning Questions Nos. 29 and 41, see Doc. No. 423 of Geneva.

mission of telephone, broadcast programme, telegraph and television signals. These studies may include consideration of the following items:

2.1 transmission characteristics of radio systems;

2.2 radio propagation, fading, diversity reception, noise and interference;

2.3 considerations involved in choice of sites for radio stations;

2.4 modulation processes and methods of multiplexing;
consideration should be given to amplitude, frequency and pulse modulation and to frequency-division and time-division systems;

2.5 radio equipment (transmitters, receivers, relays, aerials and transmission lines);

2.6 methods of measurement on the radio system;

3. Questions for study by the C.C.I.F. with C.C.I.R. representatives.

3.1 the equipment at the radio terminals to provide for connection to the land-line network;

3.2 the merits of the several possible systems of modulation and multiplexing in respect of the effective integration of line and radio systems;

3.3 the addition to, and withdrawal of, channels from a relay system at intermediate stations;

3.4 transmission characteristics required for the transmission of multi-channel telephone, broadcast programme, and television signals;

3.5 the provision of land-lines for the supervision and monitoring of radio systems;

3.6 monitoring and basic principles of maintenance and reliability of radio relay links integrated into the general network;

3.7 methods of measurement on overall line and radio systems;

4. Questions for study by the C.C.I.R. with C.C.I.F. representatives.

4.1 supervisory and monitoring facilities on radio systems;

4.2 the percentage of time during which the required transmission characteristics can be expected to be met for telephone, broadcast programme, telegraph and television signals.

Note. — In the above Study Programme an attempt has been made to outline the overall studies required, and while it is appreciated that these studies are a matter of some urgency, it must be understood that in several respects the proposed studies are of the long-term type and that only with advances in the development of radio relay systems in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands and with measurements of their performances will the necessary information become available.

QUESTION No. 92 (IX)

[STANDARDISATION OF MULTI-CHANNEL RADIOTELEPHONE SYSTEMS USING TIME-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that a variety of types of multi-channel radiotelephone systems using time-division multiplex and operating at frequencies above about 30 Mc/s have been developed;

(b) that in certain cases it is desirable to be able also to interconnect systems of different manufacture, particularly on international circuits;

(c) that the lack of uniformity in the types and characteristics of modulation (for example, number of channels, pulse repetition frequency, synchronising methods, signalling and supervisory arrangements, etc.) in many cases makes direct interconnection impossible;

(d) that direct interconnection would provide the most economical and, from a technical point of view, the most satisfactory solution;

UNANIMOUSLY DECIDES that the following question shall be studied:

1. what are the technical characteristics of time-division multiplex radiotelephone systems operating on frequencies above about 30 Mc/s which should be specified in order to be able to interconnect any two such systems;

2. what specifications should be drawn up for such characteristics and should be recommended as standards for radiotelephone systems using time-division multiplex for use on international circuits?

QUESTION No. 93 (IX) *

STANDARDISATION OF MULTI-CHANNEL RADIO RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that a variety of types of multi-channel radio relay systems operating at frequencies above about 30 Mc/s use frequency-division multiplex;

(b) that in certain cases it is desirable to be able to interconnect systems of different types particularly on international circuits;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the radio or intermediate-frequency characteristics of frequency-division multiplex radio systems operating at frequencies above about 30 Mc/s which it is essential to specify in order to enable two such systems to be interconnected;

2. what specifications should be drawn up for such characteristics and should be recommended as standards for radio systems carrying frequency-division multiplex for use on international circuits and operating at frequencies above about 30 Mc/s?

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* Study Programme No. 104 (IX) arises from this Question.

STUDY PROGRAMME No. 104 (IX) *

STANDARDISATION OF MULTI-CHANNEL RADIO RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

(Question No. 93 (IX))

(Warsaw, 1956)

The C.C.I.R.,

CONSIDERING

(a) that the principal characteristic of frequency division multiplex radio systems with 60 and 120 telephone channels using frequency modulation are recommended with a view to their international interconnection;

(b) that plans have been prepared for the arrangement of the radio-frequency channels in 240 and 600 telephone-channel systems, and for television systems of 625 lines or less and of 819 lines, whereas no such plans exist for radio systems transmitting 60 and 120 telephone channels per radio-frequency channel;

(c) that in certain countries 60 and 120 channel systems have been introduced and that these systems will also be used in the future in countries where the telephone traffic is not so intense;

(d) that it is possible to use several of these systems in parallel on the same antenna, which is a considerable contribution to economy in radio installations;

UNANIMOUSLY DECIDES that the following study should be carried out:

the preparation of plans for the most suitable radio-frequency channel arrangement for systems with 60 and 120 telephone channels working in the frequency band between 1700 and 2300 Mc/s, on the assumption that these systems will be connected to the same antenna adapted for a frequency band of 200 Mc/s at the maximum.

Note. — When the above plans are being prepared, the following points must be taken into account:

1. The values of the mid-frequencies of the radio-frequency channels should be the same for 60 and for 120 channel systems.
2. The spacing between the RF mid-frequencies should be such that the systems can work with the maximum frequency deviation (200 kc/s) given in Recommendation No. 191.

QUESTION No. 96 (IX)

MAINTENANCE PROCEDURE FOR WIDE-BAND RADIO RELAY SYSTEMS

The C.C.I.R., (London, 1953)

CONSIDERING

that the operation of wide-band radio relay systems would be facilitated by co-ordinated maintenance procedures, similar to those in existence for line networks;

* This Study Programme arises from Question No. 93 (IX).

UNANIMOUSLY DECIDES that the following question should be studied, as a first stage in the preparation of maintenance procedures:

what are the quantities that must be measured in order to maintain the quality of overall performance of radio links used in international networks, bearing in mind the accepted line practice ?

QUESTION No. 97 (IX) *

HYPOTHETICAL REFERENCE CIRCUIT FOR WIDE-BAND RADIO RELAY SYSTEMS

The C.C.I.R., (London, 1953)

CONSIDERING

that the noise permissible in a radio relay system may be expected to depend to some extent on the length of the system, and that it may, therefore, be desirable for design purposes to specify a hypothetical reference circuit for radio relay systems analogous to that specified by the C.C.I.F. for coaxial systems (C.C.I.F. Yellow Book, Part IV, Paris 1949, pp. 39-40);

UNANIMOUSLY DECIDES that the following question should be studied:

the determination of a hypothetical reference circuit for the design and specification of radio relay systems, the elements appropriate to such a circuit and the proportions of the noise power appropriate to the complete circuit in the various circuit elements.

STUDY PROGRAMME No. 105 (IX) **

WIDE-BAND RADIO RELAY SYSTEMS

Noise tolerable during very short periods of time

(Question No. 97 (IX))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that for radio relay links, it is necessary to clarify how high noise levels occurring for short periods of time should be taken into consideration;

(b) that consideration must be given not only to the percentage of time during which high noise levels occur but also to the duration of each burst of noise;

(c) that account should be taken of the fact that in radio relay systems high noise often occurs at night when the traffic is particularly light;

(d) that examples of the distribution of noise with time in radio relay systems are given in the Annexes to Recommendation No. 200 and that these Annexes also contain examples of the values of noise power likely to be experienced for short periods of time;

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* Study Programme No. 105 (IX) arises from this Question.

** This Study Programme arises from Question No. 97 (IX).

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. in what way should the maximum value of noise be specified when considering transmission on radio relay systems;
2. what should be the time constant of the noise measuring apparatus;
3. should a limit be set to the number of high noise bursts, of a duration exceeding a given value, occurring in a given time;
4. in considering this problem should account be taken of the fact that the traffic loading is greater during the day than during the night;
5. in what way can the maximum tolerable noise power for a part of a radio link be deduced from the maximum value of noise power tolerable for the complete radio link?

QUESTION No. 146 (IX) *

PREFERRED CHARACTERISTICS OF RADIO RELAY SYSTEMS FOR THE TRANSMISSION OF MONOCHROME TELEVISION

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the study of the preferred characteristics of radio relay systems for multi-channel telephony is being carried out in connection with Questions No. 92 (IX) and No. 93 (IX);

(b) that the study of the requirements for the transmission of television over long distances is being carried out in connection with Study Programme No. 32 (XI);

(c) that Study Programme No. 32 (XI) does not, however, include a consideration of the characteristics (other than at baseband frequencies) of radio relay systems designed for the transmission of television;

(d) that Recommendation No. 187 indicates that it is preferable for the major intermediate-frequency and radio-frequency characteristics of international radio relay systems to conform as far as possible with those for multi-channel telephony;

UNANIMOUSLY DECIDES that the following question should be studied:

what are the preferred characteristics of international radio relay systems for television where they differ from those for telephony?

QUESTION No. 147 (IX)

SERVICE CHANNELS FOR WIDE-BAND RADIO RELAY SYSTEMS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the question of the maintenance of wide-band radio relay systems cannot be separated from that of service channels (Report No. 72);

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* This Question replaces Question No. 91.

(*b*) that it would be desirable to define the steps to be taken for the establishment of such service channels and for facilitating their international interconnection:

UNANIMOUSLY DECIDES that the following question should be studied:

1. in what form and by what means should the service channel required for the maintenance of wide-band radio relay systems be established;

2. what are the characteristics, if any, to be specified with a view to permitting international interconnection of such service channels;

3. what are the specifications to be provided for and recommended as standards for such characteristics?

QUESTION No. 148 (IX)

RADIO RELAY SYSTEMS EMPLOYING TROPOSPHERIC SCATTER PROPAGATION

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(*a*) that experiments have already shown the possibility of utilising frequencies in the UHF (decimetric) and SHF (centimetric) bands for transmission by tropospheric scatter propagation to distances well beyond the horizon;

(*b*) that systems using this mode of propagation are already in service;

(*c*) that it is desirable to determine the preferred characteristics of such systems needed to facilitate their international interconnection;

(*d*) that some of the frequency bands that might be used for such systems are already used by other services;

UNANIMOUSLY DECIDES that the following questions should be studied:

1. how do the propagation characteristics relevant to the exploitation of wide-band systems employing tropospheric scatter vary with frequency;

2. to what extent are systems employing this mode of propagation and operating on the same or on neighbouring frequencies liable to interfere with each other and with other services;

3. what are the radio-frequency, intermediate-frequency and baseband characteristics of such systems which it is essential to specify for the transmission of frequency-division multiplex telephony, television or telegraphy in order to enable two systems to be interconnected, and what values should be specified?

QUESTION No. 165 (IX) *

TRANSMISSION INTERRUPTIONS DUE TO SWITCHING FROM NORMAL TO STANDBY EQUIPMENT IN RADIO RELAY SYSTEMS INCLUDING TROPOSPHERIC SCATTER SYSTEMS

(Continuation of Question 10 studied in 1955-1956 by S.G. 5 of the C.C.I.F.)

What is the duration of interruptions to transmission to be expected on radio links when switching from normal to standby equipment? (See Recommendation No. 196 of the C.C.I.R.).

Note : It is necessary to distinguish the duration of breaks in transmission corresponding to the three following cases:

a) failure of normal equipment,

b) fading in radio-propagation indicated by the presence of excessive noise at a switching point of the radio link,

c) changeover of the normal and standby equipment for maintenance of the radio link.

* Question No. 10 of S.G. 3 of the C.C.I.T.T. to be studied by the C.C.I.R. in cooperation with S.G. 3 and S.G. 4 of the C.C.I.T.T.

STUDY PROGRAMME No. 120 (IX) *

STANDARDISATION OF MULTI-CHANNEL RADIO-RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX AND OPERATING AT FREQUENCIES ABOVE ABOUT 30 Mc/s

Frequency plan for systems with 60/120 telephone channels within the band 5925-8500 Mc/s

(Question No. 93 (IX))

The C.C.I.R.,

CONSIDERING

(a) that plans have been prepared for the arrangement of the radio-frequency channels in 60 and 120 telephone-channel systems between 1700 and 2300 Mc/s (see Recommendation No. . . . **);

(b) that in the future, frequencies in the higher ranges of about 6000 Mc/s and more will become of increasing importance for multi-channel radio-relay systems;

(c) that Administrations may already be planning to allocate frequency bands within the band 5925-8500 Mc/s to small capacity radio-relay systems;

(d) that in the frequency range of about 2000 Mc/s it has been found practicable to formulate a frequency plan within a bandwidth of 200 Mc/s;

(e) that in the higher frequency ranges of about 6000 Mc/s and more, larger frequency bands may become available;

(f) that it is possible to use several of these systems in parallel on the same antenna;

DECIDES that the following studies should be carried out:

1. the consideration of whether a suitable radio frequency plan for 60 and 120 telephone-channel systems, operating at frequencies between 5925 and 8500 Mc/s can be accommodated in a bandwidth of 200 Mc/s, or whether some larger bandwidth would be greatly preferable;

2. having regard to the above, the preparation of suitable radio frequency channel plans for such systems;

Note :

When the above plans are being prepared, the following points must be taken into account:

1. The values of the mid-frequencies of the radio frequency channels should be the same for 60 and 120 channel systems.
2. The spacing between the mid-frequencies of the radio frequency channels should be such that the systems can work with the maximum frequency deviation (200 kc/s) given in Recommendation No. 191.
3. It would be useful to take the frequency plan for 60 and 120 telephone channels in the 2000 Mc/s range as a guide.
4. The necessity for compatibility with frequency plans for wideband radio-relay systems for multi-channel telephony and for television operating in neighbouring frequency bands, should be taken into account; these different systems should not necessarily use the same aerial.

* This Study Programme refers to Question No. 93 (IX)

** Recommendation (Geneva Doc. No. IX/105, 1958) the draft of which was approved at the last interim meeting of Study Group IX, but which will only become effective after its approval by the IXth Plenary Assembly of the C.C.I.R.

STUDY PROGRAMME No. 121 (IX) *

STANDARDISATION OF WIDE-BAND RADIO-RELAY SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX

Radio frequency interconnexion of 1800-channel telephony systems or systems transmitting television and telephony simultaneously

The C.C.I.R.,

CONSIDERING

(a) that the baseband characteristics for radio-relay systems suitable for 1800 telephone channels, or with television and telephony channels transmitted simultaneously, are being studied;

(b) that some Administrations may require to provide up to 6 go and 6 return RF-channels on a given route within a frequency band of 400 Mc/s, using frequencies near to 2000, 4000 or 6000 Mc/s;

(c) that other Administrations may require to provide more than 6 go and 6 return RF-channels on a given route, using a frequency band of more than 400 Mc/s;

(d) that there would be advantages in cost and efficient utilization of the frequency spectrum together with ease of interconnexion, if the RF-channel arrangement given in Recommendation No. . . . ** for 600 and 960 channel telephony systems could also be used for systems with a capacity of 1800 telephone channels, or television and telephony transmitted simultaneously;

(e) that systems with more than 6 go and 6 return RF-channels will require a different radio frequency channel arrangement from that given in Recommendation No. . . . **;

RECOMMENDS that the following studies should be carried out:

1. the consideration of Recommendation No. . . . ** to determine if it may apply to systems with a capacity of 1800 telephone channels, or television and telephony transmitted simultaneously, when up to 6 go and 6 return RF-channels in a 400 Mc/s band are required;

2. the preparation of a radio frequency channel arrangement for use when more than 6 go and 6 return RF-channels, each with a capacity of 1800 telephone channels, or television and telephony transmitted simultaneously, are required and a bandwidth of more than 400 Mc/s is available.

* This Study Programme refers to Question No. 93 (IX)

** Recommendation (Geneva Doc. No. IX/106, 1958) intended to replace Recommendation No. 194 and the draft of which was approved at the last interim meeting of Study Group IX, but which will only become effective after its approval by the IXth Plenary Assembly of the C.C.I.R.

STUDY PROGRAMME No. 122 (IX)*

RADIO-RELAY SYSTEMS EMPLOYING TROPOSPHERIC SCATTER PROPAGATION

Radio frequency channel arrangements

(Question No. 148 (IX))

The C.C.I.R.,

CONSIDERING

(a) that radio-relay systems using tropospheric scatter propagation are already in service and that systems of this type may come into more extensive use in the future;

(b) that such systems may use very high power (10 kW or even more, fed into aerials of high gain);

(c) that tropospheric scatter systems are capable of causing interference over wide areas and long distances, to systems of the same or of different type operating on the same or closely adjacent frequencies; and that such interference could frequently extend over national boundaries;

(d) that tropospheric scatter systems may be particularly susceptible to interference from systems of the same or of different type, because of the low field strengths available at the receiving terminal;

(e) that distances between adjacent stations may vary widely, e.g. between about 100 and 400 km;

(f) that overshoot problems are likely to be more severe than with line-of-sight systems;

(g) that interference may be caused in directions other than that of the main beam;

(h) that most tropospheric scatter systems are expected to provide not more than about 120 telephone channels; that many smaller systems may provide only 12 or 24 channels, but certain systems may transmit wideband information such as television;

(i) that the transmitting power used may differ considerably according to the distance to be covered, the number of channels to be transmitted, etc.;

(j) that at present frequency modulation of the radio frequency carrier is most generally used, but that other types of modulation, e.g. single sideband may be introduced for some systems;

(k) that simultaneous transmission on two frequencies, to assist in the provision of quadruple diversity reception or for other reasons, while strongly deprecated in areas where the radio frequency spectrum is likely to become congested, may be used in other areas;

(l) that the requirements for radio frequency channel arrangements for tropospheric scatter systems would seem from the above considerations to differ substantially from those for line-of-sight radio-relay systems or for other services;

* This Study Programme refers to Question No. 148 (IX)

DECIDES that the following studies should be carried out:

1. on what basis should radio frequency channel arrangements for tropospheric scatter systems be established;

2. what basic arrangements should be proposed ?

Note

This study should include consideration of the following points:

1. The extent to which radio frequency channel arrangements must be considered in relation to a large geographical area rather than only to individual routes.

2. The especially difficult problem of avoiding interference to and from other systems.

3. The need to accommodate systems of differing channel capacity, power, type of modulation and type of service.

4. The transmitted bandwidths appropriate to such systems.

5. The appropriate frequency spacing or spacings between go and return channels on a given section of route.

6. The appropriate frequency spacing between two or more parallel channels along the same section of route.

7. The appropriate frequency spacing between systems installed in the same station for use on different routes.

8. The distances at which frequencies can be re-used without undesirable interference effects, both in the direction of the main beam and in other directions.

9. Whether the problem of radio frequency channel arrangements might be substantially eased if intermediate frequencies (or the first intermediate frequency if a double frequency change receiver is used) differing from those given in Recommendation No. 190, were to be used.

Questions and Study Programmes assigned to Study Group No. X

QUESTION No. 23 (X) *

HIGH-FREQUENCY BROADCASTING

Directional antenna systems

(Stockholm, 1948)

For the following Question it will be appropriate to organise the compilation of statistical measured results from antennae of different types in various parts of the world, in respect of the signal laid down by the main beam and subsidiary lobes, and the amount of scattering in unwanted directions.

The C.C.I.R.,

UNANIMOUSLY DECIDES that the following question should be studied:

what are the methods by which the formation of strong subsidiary lobes can be avoided, particularly when the directional antenna systems are fed asymmetrically to produce a slew of the main beam?

ANNEX

The characteristics of directional antenna systems used in broadcasting have been very completely studied from theoretical aspects, and a number of experimental investigations have been undertaken by various bodies on the actual measured performance **.

With a suitably designed antenna the power radiated in unwanted directions can be reduced to a small proportion of the power radiated in the wanted direction. An aerial system with a reflector having an aperture of two wavelengths should have a radiation at 25° off the main beam reduced 16 db below the main radiation field. At 40° off the main beam the radiation should be reduced to 35 db below the main radiation path. Tests have been made as to the actual reception at distant points at places which are off the main radiation beam. These show, however, that the field at such reception points is often in excess of the expected field predicted from the power radiated in the given direction.

These abnormal signal strengths presumably result from a field which is a combination of a direct radiation in the given direction, and indirect radiation due to scattering of the main beam on reflection. Measurements of this phenomenon would clearly take a very considerable time,

* Study Programme No. 106 (X) arises from this Question. The reasons which justify this Question are given in the Annex.

** "The Measured Performance of Horizontal Dipole Transmitting Arrays", by H. PAGE, *J.I.E.E.*, 92, Part III, No. 18, June 1945.

Radio Engineering, by E. K. DANDEMAN, Chapman & Hall, page 674.

"The Empire Service Broadcasting Station at Daventry", by L. W. HAYES and B. N. MACLARTY, *J.I.E.E.*, 85, No. 513, September 1939.

"Aerial Characteristics", by N. WELLS, *J.I.E.E.*, 89, Part III, No. 6, June 1942.

Restricted Range Sky Wave Transmission, by J. E. HACKE Jr. and A. H. WAYNICK, Elec. Eng. Dept., Pennsylvania State College, P.A., U.S.A.

and could only be properly evaluated on a statistical basis. It appears possible, that the limitation to frequency sharing may be the scattering of the main beam of radiation.

It will, however, always be of utility to reduce the power radiated in unwanted directions and particularly in the subsidiary lobes of an antenna system.

Further study of this question is recommended, and in particular it is recommended that attention be given to the development of methods of avoiding the production of subsidiary radiation lobes when a directional antenna is asymmetrically fed in order to produce a slew of the main lobe of radiation.

STUDY PROGRAMME No. 106 (X) *

HIGH-FREQUENCY BROADCASTING

Directional Antenna Systems

(Question No. 23 (X) and Recommendation No. 80)

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) the development in the use of highly directional antenna systems in H.F. (decametric) broadcasting;

(b) the need to share frequencies wherever possible to allow the most efficient use of the broadcasting bands;

UNANIMOUSLY DECIDES to carry out the following study:

the extent to which the theoretical protection can be obtained in practice when using the usual types of directional broadcasting transmitting antennae.

Note :

1. It is suggested that actual field-strength measurements should be obtained to verify the nominal gain in the main beam and the validity of Recommendation No. 80.
2. Tests should be arranged in such a way as to eliminate to the greatest possible extent the effects of changing ionospheric conditions.

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* This Study Programme arises from Question No. 23 (X).

QUESTION No. 37 (X) *

HIGH-FREQUENCY BROADCASTING

Justification for use of more than one frequency per programme

(Geneva, 1951)

The International High Frequency Broadcasting Conference, Mexico City,

CONSIDERING

that it has not been possible to make a complete study of a number of questions mentioned in the *Report of the Committee on Technical Principles Standards* (Doc. No. 635 **);

DRAWS THE ATTENTION of the C.C.I.R. to the technical data contained therein and REQUESTS the C.C.I.R. to undertake the further study of the following question:

the technical conditions under which, because of the urgent need for economy in the use of frequencies for broadcasting, it would be possible to justify the use of more than one frequency for the transmission of one programme to one reception area. This study should be linked with a study of the question of an appropriate definition of " geometric reception area ".

STUDY PROGRAMME No. 107 (X) ***

HIGH-FREQUENCY BROADCASTING

Directional aerial systems for reception areas of unusual size or shape

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that in any given reception area it is desirable that the field strengths should be approximately uniform;

(b) that this result can sometimes be obtained only by using several frequencies with normal directive aerials if the reception area is unduly wide or deep in shape or if it is made up of several separate parts;

UNANIMOUSLY DECIDES that the following study should be carried out:

what types of aerial systems using one transmitting frequency only, will give field strengths reasonably uniform over a reception area of extensive width or depth or over an area comprising two or more separate parts? ****

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* Study Programmes Nos. 107 (X) and 108 (X) arise from this Question.

** Of Mexico.

*** This Study Programme arises from Question No. 37 (X).

**** See Warsaw Doc. No. 206.

STUDY PROGRAMME No. 108 (X) *

HIGH-FREQUENCY BROADCASTING

Use of synchronised transmitters

(Question No. 37 (X))

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

that the information contained in Study Programmes Nos. 30 and 72 and embodied in Recommendation No. 205 is incomplete;

UNANIMOUSLY DECIDES that the following studies should be carried out:

to determine experimentally whether satisfactory reception can be obtained when two HF (decametric) broadcasting transmitters carrying the same programme are at different sites. The study should include reception at all distances in areas both overlapping and non-overlapping, and should cover conditions in which:

— the transmitters are synchronised as accurately as possible (methods of achieving this and of ensuring correct phasing should be taken into consideration);

— the difference between the frequencies of the two transmitters is constant and of the order of 5 to 20 c/s, the audio-frequency phasing being correct.

QUESTION No. 39 (X)

HIGH-FREQUENCY BROADCASTING

Conditions for satisfactory reception

(Geneva, 1951)

The International High Frequency Broadcasting Conference, Mexico City,

CONSIDERING

that it has not been possible to make a complete study of a number of questions mentioned in the *Report of the Committee on Technical Principles and Standards* (Doc. No. 635 **);

DRAWS THE ATTENTION of the C.C.I.R. to the technical data contained therein and REQUESTS the C.C.I.R. to undertake the further study of the following question:

the technical and practical questions, such as the desirable modulation bandwidth, fading, and the various forms of distortion, related to the subjective aspects of quality of reception;

in making this study, particular attention should be given to the question of the corrections that should be made to take account of long and short term fading in determining:

* This Study Programme replaces Study Programme No. 72, and arises from Question No. 37 (X).

** Of Mexico.

(*a*) the average level of the signal necessary to ensure satisfactory reception in the presence of noise or other interference having a fixed level;

(*b*) the average level of the signal necessary to ensure satisfactory reception in the presence of atmospheric noise;

(*c*) the ratio required between the average levels of wanted and unwanted signals.

QUESTION No. 149 (X) *

HIGH-FREQUENCY BROADCASTING

Effects of closer spacing between carrier frequencies

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(*a*) the overcrowding of the HF (decametric) broadcasting bands;

(*b*) that frequency planning with interlaced carriers at 5 kc/s intervals is being considered;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what ratio of median wanted to unwanted signal field-strengths would give satisfactory reception ** when two transmitters use frequencies 5 kc/s apart to serve separate areas;
2. under these conditions what modifications in the design of HF (decametric) broadcast receivers would allow a reduction in this protection ratio;
3. how could modifications having the same effect be introduced into existing receivers?

QUESTION No. 150 (X) ***

FREQUENCY-MODULATION BROADCASTING IN THE VHF (METRIC) BAND

The C.C.I.R., (London, 1953 — Warsaw, 1956)

UNANIMOUSLY DECIDES that the following question should be studied:

1. what protection ratio is required for frequency-modulation sound broadcasting in the VHF (metric) band; ****
2. what advantages can be obtained from the off-setting of co-channel stations and what off-setting should be used for 2 or for 3 transmitters;
3. what is the resulting interference effect when two or more unwanted signals are present?

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* This Question replaces Question No. 98.

** Satisfactory reception should be assessed subjectively and defined as a condition when the interference from the unwanted signal is deemed tolerable.

*** This Question replaces Question No. 99.

**** See Report No. 77.

QUESTION No. 151 (X) *

MEASUREMENT OF PROGRAMME LEVEL IN SOUND BROADCASTING

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that difficulties have arisen in the exchange of programmes;

(b) that certain information has been submitted which indicates the desirability of further study; **

UNANIMOUSLY DECIDES that the following question should be studied:

by what methods and by means of what equipment should the programme level be controlled in connection with recording, reproduction and transmission over lines or radio links?

STUDY PROGRAMME No. 109 (X) ***

MEASUREMENT OF PROGRAMME LEVEL IN SOUND BROADCASTING

(Question No. 151 (X))

The C.C.I.R., (Warsaw, 1956)

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. an investigation into the errors in the indicated programme level, as measured in relation to the true peak value, arising from the use of existing equipment;
2. an investigation of improved methods of operation, new designs of equipment or modifications to existing equipment in order to minimise these errors.

STUDY PROGRAMME No. 74 (X) ****

STANDARDS OF SOUND RECORDING FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES

(Question No. 42)

The C.C.I.R., (Geneva, 1951 — London, 1953)

DECIDES that the following studies should be carried out:

1. investigation of methods for measuring wow and flutter for both disc and magnetic tape recording and reproducing, and of the values which may be allowed;

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* Study Programme No. 109 (X) arises from this Question.

** See Doc. No. 214, Warsaw.

*** This Study Programme arises from Question No. 151 (X).

**** This Study Programme replaces Study Programme No. 31. It does not refer to any Question under study.

meanwhile, any quoted values of wow and flutter should be accompanied by a statement of the method of measurement used, together with a statement of any frequency weighting that has been used, and whether the values are peak, peak to peak, mean or r.m.s.;

2. further study of disc recording, and reproducing, styli;

3.* further investigation of methods of absolute measurement of the characteristics of the signal recorded on a magnetic tape in order to define and measure, over as wide a range of wavelengths on the tape as possible, the absolute level of a recorded signal independently of the particular magnetic properties of each type of tape;

4. further investigation of the technique of sound recording to extend and improve the recommendations already made.

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* *Note by the Director:* A second paragraph in this section referred wholly to action already taken. It has therefore been deleted.

QUESTION No. 170 (X)

STEREOPHONIC BROADCASTING

The C.C.I.R.,

CONSIDERING that:

(a) stereophonic recording of sound on both disc and magnetic tape is already becoming well established in the industry and such discs and tapes are already on sale to the public in some countries;

(b) experimental transmissions of stereophonic sound programmes have already been made by broadcasting stations in a number of countries;

(c) if such transmission became generalised without any international coordination of the radio parameters serious interference could be caused to existing sound broadcasting services;

(d) by adoption of suitable techniques on an international scale such interference and indeed spectrum occupancy could be minimised;

(e) it is desirable to achieve standardisation internationally of transmission parameters so as to make possible the use of standard parameters in receivers.

DECIDES that the following question be studied:

1. by what methods should stereophonic sound be broadcast so as to ensure good reproduction with the maximum economy of spectrum space and the minimum interference to existing services;

2. what parameters should be standardised so as to ensure a " compatible " * system;

3. what values should be assigned to these parameters ?

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* " Compatible " in the sense that ordinary single channel receivers may continue to receive one channel without any special adaptation or special adjustment whatever.

Questions and Study Programmes assigned to Study Group No. XI

QUESTION No. 66 (XI)

TELEVISION RECORDING

(Question No. 64)

The C.C.I.R., (Geneva, 1953)

CONSIDERING

the desirability of perfecting methods for recording television signals for subsequent reproduction;

UNANIMOUSLY DECIDES that the following question shall be studied:

what are the desirable characteristics of equipment for recording television signals and the corresponding sound?

Note. — It is recommended that the line-broadening (spot-wobble) technique should be investigated with a view to minimising the line structure when recording on film.

QUESTION No. 117 (XI) *

SINGLE VALUE OF SIGNAL-TO-NOISE RATIO FOR DIFFERENT TELEVISION SYSTEMS

(Provisional text)

Will it be possible to recommend a single value of the signal-to-noise ratio for all types of erratic, continuous " noise " and for all television systems, by using a curve which gives a " weighting " to each narrow frequency band in the noise spectrum?

QUESTION No. 118 (XI) **

COLOUR TELEVISION STANDARDS

The C.C.I.R., *(Approved at Brussels, 1955)*

CONSIDERING

(a) that Question No. 64 does not cover all aspects of the problems arising in the standardisation of colour television;

* Question No. 20 of the C.C.I.T.T. 1st Study Group, and to be studied in collaboration with that Study Group.

** This Question replaces Question No. 64 and Study Programme No. 37. Study Programmes Nos. 80 (XI), 81 (XI) and 110 (XI) arise from this Question.

(b) that, in Europe at least, the situation in Bands I and III differs from that in Bands IV and V, and that, in deciding on colour systems for Bands I and III, individual administrations may find it convenient to use systems compatible with their monochrome systems already working in these bands;

(c) that as Bands IV and V have not yet been exploited in many countries, it is desirable and theoretically possible for these countries to achieve a common standard for these bands;

(d) that in choosing a colour system for Bands IV and V administrations may well be influenced by any colour systems which they may have adopted for Bands I and III, and that this possibility complicates the choice of common standards;

DECIDES that the following question should be studied:

what standards can be recommended for colour television for public broadcasting? Account should be taken of such points as:

— satisfactory picture (colour and monochrome) and sound quality;
— economical use of bandwidth;
— reliable receivers of reasonable cost;
— operation of studio, transmitting and relaying equipment;
— susceptibility to interference;
— compatibilities *;
— frequency planning;
— international exchange of programmes;
— scope for development;
— the differences between Bands I and III as compared with Bands IV and V.

STUDY PROGRAMME No. 80 (XI) **

STANDARDS FOR VIDEO COLOUR TELEVISION SIGNALS ***

The C.C.I.R., *(Approved at Brussels, 1955)*

DECIDES that the following studies should be carried out:

1. the preferred colorimetric parameters for representing the television picture;
2. the scanning standards that can be recommended, e.g. sequential (field, line, dot), simultaneous or mixed;
3. comparison of the various methods of coding and decoding the colour picture information;
4. the minimum acceptable bandwidths for the signal components corresponding to these parameters.

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* A compatible colour television system is one that produces acceptable monochrome versions of the colour pictures on existing monochrome receivers.

A reverse compatible colour television system is one that produces acceptable monochrome pictures on colour receivers from existing monochrome transmissions: in either case the bandwidths of the colour and monochrome systems may be the same or different.

** This Study Programme arises from Question No. 118 (XI).

*** The answers to Question No. 153 (XI) with studies and experience of colour television systems should be taken into account.

STUDY PROGRAMME No. 81 (XI) *

STANDARDS FOR RADIATED COLOUR TELEVISION SIGNALS

The C.C.I.R., *(Approved at Brussels, 1955)*

DECIDES that the following study should be carried out:

comparison of different colour television systems in terms of the criteria listed in the text of Question No. 118 (XI). These comparisons should pay particular attention to colour television systems which are either in operation, or which are, or have been, the subject of experiment.

STUDY PROGRAMME No. 110 (XI) *

DISTORTION OF TELEVISION SIGNALS DUE TO THE USE OF VESTIGIAL-SIDEBAND TRANSMISSION

(Question No. 118 (XI))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that vestigial-sideband transmission of television signals is accepted practice in broadcasting;

(b) that this method of transmission results in overall distortion which is a combination of:

— quadrature distortion inherent in the method;

— distortion caused by non-uniformity of group-delay in transmitter circuits;

— distortion caused by non-uniformity of group-delay in receiver circuits;

(c) that the importance of the individual contributions listed in (b), in respect of the overall degradation of the received picture, has not been established;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the quantitative assessment of the respective distortions introduced in a television system using vestigial-sideband transmission, due to:

   — quadrature error,

   — group-delay error at the transmitter,

   — group-delay error at the receiver;

2. suitable methods to be adopted for measuring and correcting such distortions;

3. the extent to which such corrections should be introduced at the transmitter.

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* This Study Programme arises from Question No. 118 (XI).

QUESTION No. 119 (XI) *

RATIO OF THE WANTED TO THE UNWANTED SIGNAL IN TELEVISION

The C.C.I.R., *(Approved at Brussels, 1955)*

CONSIDERING

(a) that the satisfactory operation of a television service renders it necessary to specify the maximum field-strength of interfering or unwanted signals which can be tolerated without unduly affecting the reception of television programmes;

(b) that the frequency bands allotted for television broadcasting services are so limited that it is essential for more than one transmitting station to operate in the same channel;

(c) that, on the frequencies used for television, radio waves in certain cases travel to distances far in excess of the normal service area;

(d) that the varying propagation of such waves, under different conditions, is the major factor in determining the geographical distances separating television transmitting stations to avoid mutual interference;

DECIDES that the following question should be studied:

the determination of the minimum admissible ratio of wanted to unwanted signal, when two television transmitters are operating:

— in the same channel,
— in adjacent channels,
— with dissimilar but partially overlapping bandwidths.

Note. — The reply to the question should give the protection ratios required when the transmitters are both radiating monochrome signals, both radiating colour signals, and when the one is radiating a monochrome and the other a colour signal; and it should take into account all the different signal standards that may be used and should also indicate percentage of time during which protection is desired and the proportion of the programme time for which the stated degree of interference must be avoided. Separate answers may be required for various grades of service

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STUDY PROGRAMME No. 111 (XI) **

RATIO OF THE WANTED TO THE UNWANTED SIGNAL IN TELEVISION

Use of the offset method when there are great differences between the carrier frequencies of the interfering stations

(Question No. 119 (XI))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the offset method ***, when there is partial overlapping of the interfering channels, may make it possible to reduce the protection ratios and thus facilitate the planning of television networks over territories where different television standards are used;

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* Study Programme No. 111 (XI) arises from this Question which replaces Question No. 67.

** This Study Programme arises from Question No. 119 (XI).

*** Referred to in Report No. 82, § 4.

(*b*) that the advantages to be expected from the offset method depend on the stability of the line frequency of the picture received and the type of modulation of the unwanted signal;

(*c*) that the effect of the interference on the quality of a monochrome picture may take the form of contrast distortion and irregular line synchronisation;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. conditions and frequency bands in which the use of the offset method is advantageous;
2. methods to be applied in order to render the offset method advantageous when there are great differences in the carrier frequencies of the interfering transmitters, with special reference to telecinema transmissions;
3. influence of the sidebands of the wanted and unwanted signals when the offset method is used;
4. influence of the line synchronisation system in the receiver on the reception quality, when the offset method is used.

QUESTION No. 120 (XI)

EXCHANGE OF TELEVISION PROGRAMMES

The C.C.I.R., *(Approved at Brussels, 1955)*

CONSIDERING

(*a*) that it is desirable to exchange television programmes between countries,

(*b*) that a variety of television standards is in use;

DECIDES that the following question should be studied:

what methods can be used to enable television programmes to be exchanged between countries:

1. when the nominal field frequencies are the same, but the numbers of lines are different, or vice-versa;
2. when the nominal field frequencies as well as the numbers of lines are different;
3. when the nominal field frequencies are the same and the numbers of lines are the same, but the synchronising signals are different in form?

Note. — Programme exchanges between different monochrome systems, between different colour systems, and between monochrome and colour systems should be considered.

QUESTION No. 121 (XI) *

TRANSMISSION OF MONOCHROME AND COLOUR TELEVISION SIGNALS OVER LONG DISTANCES

The C.C.I.R., *(Approved at Brussels, 1955)*

CONSIDERING

(a) that all the information required by the C.C.I.R. and the C.C.I.F. relating to the requirements for the transmission of monochrome television signals over long distances is not yet available;

(b) that it is necessary to study without delay the problems that may arise in the future concerning the transmission of colour television signals, whatever form these signals may take;

(c) that the choice of a standard colour television system must certainly take into account the possibility of transmitting the signals over existing links as well as the requirements that may be imposed on future circuits;

(d) that the adoption of a hypothetical reference circuit of 2500 km length for the presentation of the results of studies, as proposed by the C.C.I.F. for cable circuits, is acceptable and useful;

DECIDES that the following question should be studied:

for the transmission of monochrome or colour television signals over a hypothetical reference circuit (2500 km):

1. what are the characteristics of the signal and of the circuit that must be considered, what are their recommended values and what tolerances must be imposed in order to ensure satisfactory transmission;

2. how do these characteristics and their values and tolerances differ as between the requirements for the transmission of monochrome signals and of colour signals;

3. what methods of measurement and what test signals can be recommended for checking the characteristics?

STUDY PROGRAMME No. 32 (XI) **

REQUIREMENTS FOR THE TRANSMISSION OF TELEVISION OVER LONG DISTANCES

(Question No. 40)

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) that it is necessary to transmit television signals over long distances;

(b) that the C.C.I.F. needs information upon which to plan circuits;

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* Study Programmes Nos. 32 (XI), 35 (XI) and 36 (XI) arise from this Question.

** This Study Programme arises from Question No. 121 (XI).

UNANIMOUSLY DECIDES that the following study shall be carried out:

determination (see Ann. II) of the values and tolerances for the following factors for the satisfactory transmission of television signals over long distances:

A. *Input and output impedance of the transmission circuit*

value, whether balanced or unbalanced, tolerance;

B. *Polarity of signal*

polarity and whether A.C. or D.C.;

C. *Amplitude of signal*

value from peak white to tip of synchronising pulses;

D. *Picture signal to synchronising signal ratio*

value to be used for feeding into and out of transmission circuit;

E. *Non linearity*

the tolerable change of slope of the output/input amplitude characteristic;

F. *Stability of overall transmission circuit*

the tolerable change of overall gain at a reference frequency over:

(a) short periods, e.g of 1 second,

(b) medium periods, e.g. of 1 hour,

(c) long periods, e.g. of 1 month;

G. *Signal-to-noise ratio*

the tolerable signal-to-noise ratio for:

(a) random uniform noise,

(b) periodic noise,

(c) impulsive noise.

In order to simplify the comparison of the results of the tests carried out in the various countries, it is suggested that the ratios should be quoted in db and that the ratio should be:

$$\frac{\text{peak-to-peak value of the picture signal}}{\text{peak-to-peak value of the noise}}$$

and the synchronising signal should not be considered as being part of the picture signal. It should be understood that the ratio can be measured in other terms and a suitable correction factor applied; in this case the correction factor should be stated, for example the crest factor in the case of random uniform noise;

H. *Attenuation and phase characteristics*

the limits which can be allowed on:

(a) the attenuation/frequency characteristic,

(b) the phase/frequency characteristic,

(c) the transient response *.

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* For the transient response study, attention is drawn to the proposals made by the C.C.I.F. and reproduced in Annex I.

ANNEX I

C.C.I.F. Proposals for the transient tests to be made on television systems

It is proposed that the following two types of recurrent pulses should be used:

(a) *a square wave* of fundamental frequency equal to the vision field-frequency, and of unity mark/space ratio, for the purpose of indicating the waveform distortion which corresponds to attenuation/frequency and phase/frequency distortions in the lower part of the effectively transmitted frequency range;

(b) *a sine-squared (or raised sine) pulse*, of repetition frequency equal to the vision line frequency. This pulse is intended to indicate attenuation and phase distortions in the upper part of the frequency range. Its half-amplitude width should be equal to one half of the period corresponding to the nominal upper cut-off frequency of the television system.

Remark. — The line and field synchronising signals may possibly be inserted in between two such pulses, if it is desired to use the same time bases in the cathode ray oscilloscopes used for these tests and in those employed for monitoring the television transmission.

ANNEX II

General requirements for a 405-line 3000 kc/s video band system

The figures in this Annex are given merely for information and do not represent a transmission specification.

A. *Input and output impedance of the transmission circuit*

75 ohms unbalanced and a return loss of not less than 30 db at any frequency between 10 kc/s and 3000 kc/s;

B. *Polarity of signal*

the video signal for transmission to line has positive polarity; i.e. its amplitude will increase in proportion to the brillance of the corresponding point of the picture. The d.c. component is not transmitted;

C. *Signal amplitude*

about 1 volt peak-to-peak;

D. *Picture signal to synchronising signal ratio*

about 70/30;

E. *Non linearity*

for the complete signal from the tip of the synchronising pulse to peak white, the slope should not vary more than 0.9 to 1.1, relative to the ideal;

F. *Stability of overall transmission circui*

(a) ±0.3 db,

(b) ±0.5 db,

(c) ±2.0 db;

G. *Signal-to-noise ratio*

(a) 45-50 db,

(b) 40-55 db, depending upon frequency,

(c) 35-40 db, if not more than one pulse in a 10 second period;

H. *Attenuation and phase characteristics*

(a) flat to within ±1 db, and free from numerous and marked changes of slope from 20 c/s to 3000 kc/s,

(b) substantially linear and free from numerous and marked changes of slope; variation of group delay between 200 kc/s and 3000 kc/s should not exceed a value of about ±0.1 microsecond for a 100 kc/s interval,

(c) 0.16 microsecond for 10 to 90% *.

Limits for overshoot and echoes *

Time after response has reached 50% ideal amplitude	Limits of rapid variation of response % of ideal amplitude
0.2 to 0.5 microseconds	± 4
0.5 to 1.0 microseconds	± 1
1.0 microsecond or longer	± 0.5

STUDY PROGRAMME No. 35 (XI) **

REDUCTION OF THE BANDWIDTH FOR TELEVISION

(Question No. 64) ***

The C.C.I.R., (Geneva, 1951)

CONSIDERING

(a) the great technical or financial difficulty encountered in obtaining the required bandwidth in transmitting television signals, both in broadcasting and in transmission over intermediate links;

(b) the potential value of various techniques, such as dot-interlace or rapid-transition (" crispening ") circuits in improving the resolution of television images without increasing the bandwidth;

(c) the possibility of reducing flicker by the use of long-persistence phosphors;

UNANIMOUSLY DECIDES that the following studies shall be carried out:

1. the methods which can be used to reduce the bandwidth occupied by the transmission and broadcasting of a television picture without reducing the picture quality, especially its sharpness;
2. the possibility of transmitting a standard signal from point to point by converting that signal into an intermediate signal (e.g., the dot-interlace type of signal), the bandwidth of the intermediate signal being smaller than that of the terminal signal;
3. the effect of the field frequency and the use of long-persistence phosphors on inter-dot flicker and inter-dot crawl.

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* Using a square waveform with a rise time of 0.1 microsecond.

** This Study Programme arises from Question No. 121 (XI).

*** This Question has been replaced by Question No. 121 (XI).

STUDY PROGRAMME No. 36 (XI) *

CONVERSION OF A TELEVISION SIGNAL FROM ONE STANDARD TO ANOTHER

(Question No. 64) **

The C.C.I.R., (Geneva, 1951)

UNANIMOUSLY DECIDES that the following studies shall be carried out:

methods of converting a television signal from one standard to another:

— when the field frequency is identical in the two standards, but the number of lines differs;

— when both the field frequency and the number of lines are different in the two standards.

QUESTION No. 152 (XI) ***

ASSESSMENT OF THE QUALITY OF TELEVISION PICTURES

(Question No. 121 (XI))

The C.C.I.R., (Geneva, 1951—Warsaw, 1956)

CONSIDERING

(a) that appreciable discrepancies may exist between different experts' assessments of the quality of the pictures given by the television systems now in use or proposed;

(b) that these discrepancies are to be attributed to the fact that it is usually impossible to obtain simultaneous viewing of the pictures under comparison, to possible variations in quality between apparatus nominally using the same system and to alterations that may occur with time in the characteristics of the equipment used;

(c) that consequently it would be eminently desirable to have some standard method of gauging or even measuring television picture quality which would permit objective comparison of the results obtained in different places and would serve as a guide to the efficient and uniform working of the equipment in service;

UNANIMOUSLY DECIDES that the following question shall be studied:

what standardised methods and means of test, independent of the television standards which may be employed, can be used to measure accurately, and whenever possible, objectively, the deterioration introduced into monochrome and colour pictures by television, taking into account the system, the equipment and the transmission processes?

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* This Study Programme arises from Question No. 121 (XI).

** This Question has been replaced by Question No. 121 (XI).

*** This Question replaces Question No. 65.

QUESTION No. 153 (XI) *

RESOLVING POWER AND DIFFERENTIAL SENSITIVITY OF THE HUMAN EYE

The C.C.I.R., (Geneva, 1951—Warsaw, 1956)

CONSIDERING

(a) that those responsible for a regular television service must have an exact knowledge of the physiological properties of the human eye, the demands of which they are endeavouring to satisfy;

(b) that, among these properties, the most important are the resolving power by means of which regular fields and fine details are perceived, the differential sensitivity to brilliance and the differential sensitivity to a change in the shade of the same colour;

(c) that accurate and sufficient data on the resolving power of the human eye is available for still pictures but insufficient data is available for the case of animated pictures;

(d) that the results of the numerous physiological studies already undertaken on this subject cannot, a priori, be assumed to be equally valid for the observation of television pictures, because of the special nature of such pictures;

UNANIMOUSLY DECIDES that the following question shall be studied:

1. what is the resolving power of the human eye, expressed in minutes of angle, for values of contrast, luminance, colour and distance, normally encountered when observing animated pictures;

2. what is the differential sensitivity of the human eye to:

— a change of luminance,

— a change of shade in the same colour,

for values of contrast, luminance, colour, and distance normally encountered when observing television pictures?

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* This Question replaces Question No. 68.

QUESTION No. 166 (XI) *

SINGLE VALUE OF SIGNAL-TO-NOISE RATIO FOR DIFFERENT TELEVISION SYSTEMS

The C.C.I.R.,

CONSIDERING

(a) that it is desirable to devise a method for the objective assessment of the signal-to-noise ratio valid for all television systems, with the object or recommending a single value for the tolerable signal-to-random noise ratio in television and especially for the international exchange of programmes;

(b) that the relation between the peak value of the signal and the RMS or quasi-peak noise does not necessarily indicate the visibility of the noise on the pictures received;

(c) that the method of assessing the signal-to-noise ratio by means of a weighting network producing a mean objective curve of the weighting of the various frequency components leads to a more objective assessment of the ratio;

DECIDES that the following question should be studied

1. is it possible to recommend an objective mean curve for the weighting of the noise components as a function of frequency and also to recommend a weighting network to produce this curve, giving a figure for the signal-to-noise ratio indicating the visibility of the noise on the pictures;

2. is there any other measurement method producing the same result that could be recommended;

3. is it possible, using the method or methods thus recommended, to adopt a single figure for the tolerable signal-to-random noise ratio in television especially for the international exchange of programmes ?

STUDY PROGRAMME No. 116 (XI) **

SINGLE VALUE OF THE SIGNAL-TO-NOISE RATIO FOR DIFFERENT TELEVISION SYSTEMS

The C.C.I.R.,

CONSIDERING

(a) that a method of measuring the signal-to-noise ratio capable of giving a figure showing the visibility of noise on the pictures received has already been indicated and appears in the documents of the C.C.I.R., C.C.I.T.T. and C.M.T.T.;

(b) that this method implies the adoption of a weighting curve for the various noise components as a function of frequency;

(c) that this method also requires the adoption of a weighting network to transform noise in such a way that the measured signal-to-noise ratio shall give a valid indication of the visibility of the noise;

(d) that the different television systems, because of different standards, have different requirements including different frequency bands;

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* Study Programme No. 116 (XI) arises from this Question, which is intended to replace Question No. 117 (XI).

** This Study Programme arises from Question No. 166 (XI).

DECIDES that the following studies should be carried out:

1. what should be the weighting curve for the various noise components as a function of frequency if the measured value is to be representative of the visibility of noise on the pictures received;
2. what weighting network can be recommended to produce this weighting curve;
3. what should be the characteristics of the equipment* associated with the weighting network in measuring the signal-to-noise ratio;
4. is it possible to obtain a single measuring apparatus by means of interchangeable subsidiary components meeting the different requirements of the various television systems;
5. what general conditions and parameters should be standardized in the experimental determination of the form of the weighting curve and what uniform method of expressing the results should be used;
6. in the case of colour television, what should be the forms of the weighting curves for the red, green and blue colours on the screen?

STUDY PROGRAMME No. 117 (XI) **

CONSTITUTION OF A SYSTEM OF STEREOSCOPIC TELEVISION

The C.C.I.R.,

CONSIDERING

(a) the possible future development of stereoscopic television broadcasting;

(b) the great utility this form of television may have;

DECIDES that the following studies should be carried out:

1. *Monochrome stereoscopic television*
   - 1.1 investigation into the development of methods of providing stereoscopic television not requiring the use of spectacles;
   - 1.2 study of the possibility of decreasing the bandwidth of stereoscopic television broadcasting, e.g., by transmitting one picture of the stereoscopic couple with the full standardized bandwidth and the other with a reduced bandwidth on a sub-carrier within the first frequency spectrum;
   - 1.3 study of the influence of noise on stereoscopic television pictures and determination of the permissible signal-to-noise ratio;
   - 1.4 investigation of the design of receivers with direct reproduction of stereoscopic pictures, e.g., by taking the structure of receiving tube displays as a basis for the lay-out of the phosphorescent elements;
2. *Stereoscopic colour television*
   - 2.1 the carrying out of tests to assess the quality of colour reproduction with binocular mixing of its components in respect of the stability of picture detail (" field-clash ");

* One of the possible devices for measuring signal-to-noise ratio is described in Doc. XI/25 (Moscow, 1958) of the USSR.
** This Study Programme arises from Question No. 118 (XI).

2.2 study of the possibility of decreasing the frequency band for stereoscopic colour television, e.g., by transmitting the green field of the stereoscopic couple with the full standardized band, the red and blue fields being transmitted by means of a sub-carrier within the first frequency spectrum;

2.3 research into the design of receivers for the direct reproduction of stereoscopic colour television.

STUDY PROGRAMME No. 118 (XI) *

RATIO OF THE WANTED TO THE UNWANTED SIGNAL IN TELEVISION

Use of the offset method when there are great differences between the carrier frequencies of the interfering stations

The C.C.I.R.,

CONSIDERING

(a) that the offset method **, when there is partial overlapping of the interfering channels, may make it possible to reduce the protection ratios and thus facilitate the planning of television networks over territories where different television standards are used;

(b) that the advantages to be expected from the offset method depend on the stability of the line frequency of the picture received and the type of modulation of the unwanted signal;

(c) that the effect of the interference on the quality of a monochrome picture may take the form of contrast distortion and irregular line synchronisation;

DECIDES that the following studies should be carried out:

1. conditions and frequency bands in which the use of the offset method is advantageous;
2. methods to be applied in order to render the offset method advantageous when there are great differences in the carrier frequencies of the interfering transmitters, with special reference to telecinema transmissions;
3. influence of the sidebands of the wanted and unwanted signals when the offset method is used;
4. influence of the line synchronisation system in the receiver on the reception quality, when the offset method is used.

ANNEX

One useful method of carrying out these studies is given below:

Measurements are made with an interfering sinusoidal frequency varying from 5 kc/s to 10 Mc/s. The level of these frequencies is adjusted to give the same subjective interference as a reference signal of ½-line frequency with a peak-to-peak amplitude of 17 db, 20 db and 23 db

* This Study Programme, which is intended to replace Study Programme No. 111 (XI) arises from Question No. 119 (XI). The text differs from that of Study Porgramme 111(XI) only by the addition of the Annex.

** Referred to in Report No. 82, para. 4.

below the peak-to-peak value of the picture signal (excluding since pulses), which correspond to ratios of 27 db, 30 db and 33 db respectively for the radio frequency carriers.

The frequency of the interfering sinusoidal signal should be adjusted for:

1. Non-offset working
2. Offset working.

The measurement should be made with video frequencies and with radio frequency carriers. In the latter case the wanted signal should correspond to input levels at the receiver of both 1 millivolt and 0.1 millivolt.

In making these subjective tests, uniform viewing conditions are very necessary, and for guidance Doc. No. 76 (Brussels, 1955) should be consulted.

STUDY PROGRAMME No. 119 (XI) *

REDUCTION OF THE CHANNEL CAPACITY REQUIRED FOR A TELEVISION SIGNAL

The C.C.I.R.,

CONSIDERING

(a) that the large channel capacity required for the transmission of television signals introduces problems which are both technical and economic;

(b) that the need for large channel capacity limits severely the maximum distance over which television signals can be transmitted by radio;

(c) that all present day methods of transmitting and receiving television signals are wasteful in that they require a channel capacity which greatly exceeds that which is necessary to transmit the essential information contained in a television picture and which can be utilised by the human eye;

DECIDES that the following studies should be carried out:

1. the methods which can be used to reduce the required channel capacity for a television signal without reducing perceptibly the quality of the reproduced picture;
2. the way in which removal of redundancy (signal compression) can best be exploited to reduce the bandwidth required for transmission;
3. the possibility of transmitting a signal from point to point by converting it into another (intermediate) signal which has been processed to have a bandwidth smaller than that of the original signal in keeping with a reduction of channel capacity;
4. the best method of exploiting signal compression to increase the range over which television signals can be transmitted, taking into account that for a fixed rate of information it is in general possible to exchange bandwidth and signal-noise ratio;
5. the ways in which knowledge of the characteristics of the human eye can be used to reduce to a minimum the amount of information which it is required to transmit in order to reproduce a satisfactory television picture.

* This Study Programme, which is intended to replace Study Programme No. 35 (XI) arises from Question No. 121 (XI).

STUDY PROGRAMME No. 123 (XI) *

RATIO OF THE WANTED TO THE UNWANTED SIGNAL IN MONOCHROME TELEVISION

Use of frequency-offset for sound when the wanted signal is frequency-modulated

The C.C.I.R.,

CONSIDERING

(a) that, when assigning frequencies to television transmitters for sound, it is desirable to make the fullest use of the advantage derived from frequency-offset;

(b) that precision frequency-offset of the vision carriers makes it possible in some cases to obtain protection ratios (for just tolerable interference) of 20 db and that it is desirable for the protection ratios for the sound not to exceed this value;

(c) that recent tests tend to show that the protection ratio of 20 db mentioned in Report No. 82 for just tolerable interference in the case of wanted and unwanted frequency-modulated signals may be too small;

(d) that recent tests have shown that in this case an offset of about 20 kc/s may be advantageous;

(e) that Report No. 82 does not consider the case of a wanted frequency-modulated signal and an unwanted amplitude-modulated signal;

DECIDES that the following studies should be carried out:

determination of the protection ratio for the sound/signal (for just tolerable interference)

1. when the wanted and unwanted signals are frequency-modulated
- — with a frequency difference below 300 c/s;
- — with a frequency difference of about 10 kc/s;
- — with a frequency difference of about 20 kc/s;

2. when the wanted signal is frequency-modulated and the unwanted signal amplitude-modulated
- — with a frequency difference below 300 c/s;
- — with a frequency difference of about 20 kc/s.

* This Study Programme arises from Question No. 119 (XI)

Questions and Study Programmes assigned to Study Group No. XII

QUESTION No. 102 (XII) *

INTERFERENCE IN THE BANDS SHARED WITH BROADCASTING **

The C.C.I.R., (Stockholm, 1948 — Geneva, 1951 — London, 1953)

CONSIDERING

Recommendation No. 8 of the International Radio Conference (Atlantic City, 1947) and the studies pursued at the Vth, VIth and VIIth Plenary Assemblies of the C.C.I.R.,;

DECIDES that the following question should be studied:

what is the minimum permissible protection ratio for broadcasting signals, when measured at the output of a receiver fitted with a filter having an audio-frequency cut-off of 5 kc/s and to what minimum value of the wanted field should this ratio be maintained? ***

ANNEX

1. The permissible frequency tolerances for broadcasting stations would permit variations in frequency of broadcasting stations up to about 250 c/s until 1953 and up to about 150 c/s after that date. The corresponding tolerances for fixed stations would allow maximum frequency changes of about 500 c/s and 150 c/s respectively. The tolerances permitted to mobile stations would be initially about 2500 c/s and later about 1000 c/s. These tolerances are very large in relation to the possible spacing between broadcast carrier frequencies in the shared bands and, for a consideration of the problem, it is therefore necessary to assume a frequency spacing between such broadcast carriers.

2. If it is assumed that the stations of other services will be located only on frequencies centrally located between the broadcast carriers, and if it is further assumed that the broadcast carrier frequencies will be separated by not more than 10 kc/s, then the maximum frequency spacing between a fixed or mobile station and a broadcasting station would be 5 kc/s. From this consideration it will be seen that the permissible tolerances represent a very large proportion of the spectrum space between a broadcasting carrier and a sharing service carrier and that the possible heterodyne frequency will be such that a receiver giving adequate broadcasting reception would not eliminate it. At the present time, it would seem very difficult greatly to increase the stability of mobile transmitters and it is therefore suggested that a case exists

* This Question replaces Question No. 4. Study Programmes. Nos. 112 (XII), 113 (XII) and 114 (XII) refer to this Question.

** The reasons justifying this question will be found in the annex

*** Practical consideration of the frequency separation of adjacent channels requires the use of an audio-frequency cut-off of 5 kc/s in the measurement, in preference to 6.4 kc/s, appropriate corrections being applied, if considered necessary, to correspond to an audio-frequency cut-off of 6.4 kc/s.

for recommending to administrations in tropical zones that the minimum number of mobile stations should be assigned in the shared bands. For fixed stations it would seem that since by 1953 fixed stations in these bands will have to maintain the same frequency tolerances as broadcasting stations, as specified in App. 3 to the Atlantic City Radio Regulations, that it would be advisable to request administrations to expedite improvement in the frequency stability of fixed stations in bands shared with broadcasting and that the minimum number of fixed stations in tropical zones might be assigned in these shared bands, unless they do meet the requirements laid down for frequency tolerance for broadcasting stations.

3. If it is not possible entirely to eliminate mobile stations from the shared bands in the tropical zones, then it might be recommended that every effort should be made to eliminate the use of mobile stations using A3 type of transmission in these bands. As in other services, fully adequate telephony quality is maintained with a reduced audio-frequency bandwidth, it might be recommended that the audio bandwidth transmitted by mobile stations when operating in the tropical zones should be limited to 3000 c/s.

4. In Stockholm Doc. No. 110, it is recommended that power limitations should be placed on broadcasting stations operating in these bands. It is generally admitted that the field strength required for an adequate telegraph service is of the order of 10% of the field strength required for an adequate signal on a broadcasting service. There would seem, therefore, to be a logical case to put a restriction on the power to be used by other services in the shared bands. All voice transmission in this band might possibly be carried out on power limits not exceeding those laid down for broadcasting stations in Stockholm Doc. No. 110.

5. A recommendation might be made in accordance with Art. 13, § 3 of the Atlantic City Radio Regulations that the use of directive antennae be followed in all possible cases in order to reduce mutual interference between services.

6. As is pointed out in Stockholm Doc. No. 21, page 5, the permissible interference level for ordinary telephony with noise reducers is +32 db and for ordinary telephony without noise reducers is +42 db. For broadcasting use, higher signal-to-noise ratios are suggested. It is felt, however, that it would be a matter of considerable difficulty under tropical conditions to obtain a signal-to-noise ratio greater than 40 db with respect to the local noise. Such a level has been taken as a reasonable maximum in Stockholm Doc. No. 110. It is considered, therefore, that it is not justifiable to specify limits of interference more stringent than that imposed by a protection ratio of 40 db between the wanted signal and the interference. It might be suggested, therefore, that an undesired signal should be defined as causing interference to a broadcasting service only when its effective level in the output of an ordinary receiver, having an audio passband of 6.4 kc/s, is less than 40 db below the desired signal level within the defined service area of the broadcasting station.

7. To minimise the effect of interference, a recommendation might be made that spurious radiation, key-clicks, sideband spread and other forms of interference-producing radiation should be kept to a minimum in all transmitters used in tropical zones on the shared bands.

8. While it is considered that, under normal conditions, a modulation band of 6400 c/s is desirable in the interests of quality, it is recognised that, in the tropical zones, the levels of atmospheric noise in the tropical broadcasting bands and the possibilities of interference due to the difficulty of accommodating all stations in these bands are such that a modulation band of 5000 c/s may have to be accepted.

STUDY PROGRAMME No. 112 (XII) *

SHORT-DISTANCE HIGH-FREQUENCY BROADCASTING IN THE TROPICAL ZONE (TROPICAL BROADCASTING) **

(Questions Nos. 102 (XII) and 27 — Recommendation No. 215)

The C.C.I.R., (Geneva, 1951 — Warsaw, 1956)

CONSIDERING

(a) that there is little data on the determination of the power required for a given grade of tropical broadcasting service;

(b) that it would be helpful in the planning of new tropical broadcasting services to have more reliable data;

(c) that more reliable data would be helpful in the organisation of services in the bands shared with tropical broadcasting (See Art. 9, No. 244 of the Radio Regulations, 1947);

UNANIMOUSLY DECIDES that the following studies shall be carried out:

1. the experimental determination of the signal-to-noise ratio and the signal-to-interference ratio that should be adopted as representative of an acceptable tropical broadcasting service. The observations should be made with aerials and receivers that are representative of those normally used for tropical broadcasting reception. The reports on this study should indicate as fully as possible the conditions of measurement, the characteristics of the equipment and the methods used, so that the results may be correlated with those of other observers. In particular, the bandwidth of the receiver employed should be given;

2. a practical examination of whether the provisional power limits in Recommendation No. 215 are satisfactory or whether they should be changed to give an acceptable tropical broadcasting service. The reports on this study should include all the relevant factors concerned and, in particular, information on the following points:

   — the area and the day, month and year for which observations are made;
   — the distance from the transmitter to the point of observation;
   — the carrier power of the transmitter and its depth of modulation;
   — the details of the transmitting and receiving aerials;
   — the characteristics of the receiver used;

   Information on the signal-to-noise ratio and the signal-to-interference ratio (if possible in a statistical form) would also be helpful (see also § 1 above). Any conditions peculiar to the area concerned and which have an important bearing on the transmitted power required should also be stated;

3. the study of natural noise in the tropical zone, which should be continued, with particular reference to broadcasting conditions. The aim should be to provide noise data (in a statistical form if possible) which could be used in problems concerning the field strength or radiated power required to produce a given grade of broadcasting service. The method of measure-

* This Study Programme replaces Study Programme No. 38 and arises from Question No. 102 (XII).

** As this service is defined in the considerations of Question No. 27 reproduced in the Annex.

ment used should be clearly defined, particularly as concerns the bandwidth of the measuring equipment. Particular attention should be paid to those frequency bands allocated to broadcasting below 16 Mc/s which could be used for broadcasting in the tropical zone and to the normal broadcast listening hours (approximately 0600 to 2400 local time);

4. the study of the field strength produced by tropical broadcast transmitters.

Reports should, if possible, be evaluated on a statistical basis, and should give, in particular, the following information:

— method of measurement employed;
— methods of analysis;
— location of the transmitter;
— distance from the transmitter at which measurements are made;
— radiated carrier power;
— polar diagram of the transmitting aerial (or equivalent data);
— period during which measurements are made;
— radio frequency used.

It might be convenient to carry out this study in conjunction with those outlined in § 1 and 2 above. If it is possible to make measurements of the field strength produced outside the service area of the tropical broadcasting station, the resulting information would also be helpful in determining the degree of interference produced to other services which share frequency bands with tropical broadcasting.

ANNEX

Considerations of Question No. 27 (Maximum power for short-distance high-frequency broadcasting in the tropical zones):

The C.C.I.R.,

CONSIDERING

(a) *that a short-distance high-frequency broadcasting service is an indirect-ray service in which the incident ray meets the reflecting layer at a considerable angle to the horizontal and there is no appreciable skip distance between the transmitter and the service area ;*

(b) *that the outer limit of a short-distance service is considered here as being 800 km ;*

. . . .

STUDY PROGRAMME No. 113 (XII) *

INTERFERENCE IN THE BANDS SHARED WITH BROADCASTING

(Recommendation No. 216 — Question No. 102 (XII))

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that Recommendation No. 216 does not provide a final answer to Question No. 4 ** § 6, and recommends a further study to determine finally a value for the minimum permissible protection ratio for broadcasting services operating in the tropical zone in the shared bands;

* This Study Programme replaces Study Programme No. 77 and arises from Question No. 102 (XII). See Report No. 89.

** This Question has been replaced by Question No. 102 (XII).

(b) that sufficient data is at present not available in order to answer C.C.I.R. Question No. 4*, § 6;

DECIDES that the following study should be carried out:

1. experimental determination of a minimum protection ratio to be provided for a broadcasting station operating in the shared bands in the tropical zone against interference from Telegraphy A1 and A2, and Telephony A3 emissions when:
   - the interference is caused by one of these three types of emission;
   - the interference is caused by two or more types of emission at the same time;

1.1 this study should be carried out taking into account transmitter frequency variations equal to the sum of the permissible frequency tolerances of the tropical broadcasting services and the other services, as laid down in the Atlantic City Radio Regulations (App. 3);

1.2 measurements should be carried out at the output of a receiver fitted with a filter having an audio-frequency cut-off of 5 kc/s **;

2. experimental determination of the minimum field strength to which a protection ratio as defined in § 1 above should relate, taking into account the nature, intensity and distribution of noise levels in different parts of the tropical zone.

STUDY PROGRAMME No. 114 (XII) ***

INTERFERENCE IN THE FREQUENCY BANDS USED FOR TROPICAL BROADCASTING

(Question No. 102 (XII))

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the limited data available on the measured field-strength of tropical broadcasting transmitters operating in the bands 2300 kc/s to 5060 kc/s and in the high-frequency broadcasting bands above 5060 kc/s normally used for tropical broadcasting, is insufficient to arrive at the minimum signal to be protected, as required in Question No. 102 (XII);

(b) that the method of propagation affecting the field-strength values is not clearly known;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. extensive field-strength data should be collected on tropical broadcast transmissions in the bands 2300 kc/s to 5060 kc/s and in the high-frequency broadcasting bands above 5060 kc/s normally used for tropical broadcasting, at distances of:
   - the order of 50 km
   - 200 to 300 km
   - 400 to 600 km
   - 800 to 1200 km and, if possible, at appreciably greater distances from the transmitters;

2. measurements as in § 1 above shall be carried out simultaneously with experimental observation of signal-to-noise ratios.

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* This Questions has been replaced by Question No. 102 (XII).

** If considered necessary, appropriate correction to the results of measurements could be applied to correspond to an audio-frequency cut-off of 6.4 kc/s.

*** This Study Programme arises from Question No. 102 (XII).

QUESTION No. 154 (XII) *

BEST METHOD FOR CALCULATING THE FIELD STRENGTH PRODUCED BY A TROPICAL BROADCASTING TRANSMITTER **

(Question No. 27)

The C.C.I.R., (Geneva, 1951 — Warsaw, 1956)

CONSIDERING

(a) the importance of being able to calculate the power required to produce a given field strength under given conditions for tropical broadcasting;

(b) that reliable methods of calculation would assist the planning of new tropical broadcasting services and the allotment of frequencies to services in the tropical zone;

(c) that, for the tropical zone, little basic data exists concerning ionospheric absorption and its dependence upon the time of day, the season and the sunspot cycle;

(d) that the relation of ionospheric absorption at oblique incidence to that at vertical incidence is not yet fully understood;

(e) that there is no internationally agreed method of examining the nature of the multiple reflections and of calculating the resultant field strength occurring at the intermediate distances involved in tropical broadcasting;

DECIDES that the following question shall be studied:

1. what is the best method that may be used for calculating the field strength produced at the earth's surface by the indirect ray, at various distances between 0 and 800 km and between 800 and about 4000 km, by a transmitter situated in the " tropical zone " (as defined in App. 16 of the Radio Regulations, 1947) radiating a power of 1 kW from a half-wavelength dipole situated ¼ and $^7/_{16}$ths of a wavelength above ground respectively, and operating in any of the frequency bands used for tropical broadcasting (i.e. the " shared bands " listed in Art. 9, No. 244, and the general broadcasting bands below 15 450 kc/s listed in the Table of Frequency Allocations, Art. 5, Radio Regulations, 1947), at any season, and for sunspot numbers of about 5, 60 and 125, respectively, during normal listening hours (approximately 0600 to 2400 local time);

2. what is the probable error in the proposed method of calculation;

3. what basic data should be used in the proposed method of calculation;

4. what is the probable statistical distribution of the fading of the signal?

* This Question replaces Question No. 69. See Report No. 88.

** As this service is defined in the considerations of Question No. 27 reproduced in the Annex to Study Programme No. 112 (XII), page 596.

QUESTION No. 155 (XII) *

DETERMINATION OF NOISE LEVEL FOR TROPICAL BROADCASTING **

(Question No. 27)

(Geneva, 1951 — Warsaw, 1956)

The C.C.I.R.,

CONSIDERING

(a) that the determination of the transmitter power required depends upon the value of the signal-to-noise ratio regarded as being the minimum for an acceptable broadcasting service in the tropical zone and it is necessary to have as precise a knowledge as possible of atmospheric noise levels in this zone;

(b) that present knowledge of the atmospheric noise levels in the tropical zone and for tropical broadcasting frequencies has no agreed scientific significance and is insufficient for practical use;

(c) that the methods at present in use for the measurement of atmospheric noise are of a subjective nature, likely to be misinterpreted if applied to broadcasting;

(d) that it, therefore, seems desirable to develop an objective method of measuring atmospheric noise levels for possible application to broadcasting, in particular to tropical broadcasting, and to relate such a method to the subjective effect on the listener;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what parameters, characterising atmospheric noise would determine the response of a broadcast receiver to atmospheric noise and the effect of such noise on the grade of reception;

2. subsequent to the question in § 1, what characteristics of noise can be measured directly, what range of values should be covered by the measuring apparatus and how are these values related to the above-mentioned parameters;

3. what is the best method of atmospheric noise measurement for the specific conditions of tropical broadcasting, with particular regard to type of service, geographical zones, frequencies used and propagation conditions;

3.1 can a suitable objective method of noise measurement be developed in the near future;

3.2 can the subjective method, at present in use, be modified to obtain, as soon as possible, an approximate result for the type of service concerned;

3.3 is it possible and under what conditions, to correlate the results obtained by a subjective method of noise measurement and those which may be expected from the application of an objective method;

4. how should the recommended measuring apparatus be designed for the specific conditions imposed by tropical climates and how should it be used to obtain results which can be correlated for the various parts of the tropical zone?

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* This Question replaces Question No. 71.

** As this service is defined in the considerations of Question No. 27 reproduced in the Annex to Study Programme No. 112 XII), page 596.

QUESTION No. 156 (XII) *

DESIGN OF TRANSMITTING AERIALS FOR TROPICAL BROADCASTING

The C.C.I.R., (Geneva, 1951 — London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the average radius of a tropical broadcasting service area is about 800 km;

(b) the necessity for further study of the design of transmitting aerials for tropical broadcasting for the purpose of concentrating the energy transmitted by reflection from the ionosphere as much as possible into the desired service area:

(c) that the use of efficient aerials for transmission would permit the use of transmitters of lower power;

(d) the importance of reducing interference to a minimum between services which share frequency bands as provided by Nos. 244 and 253 of the Radio Regulations (Atlantic City, 1947):

(e) the provisions of No. 374 of the Radio Regulations (Atlantic City, 1947);

UNANIMOUSLY DECIDES that the following question should be studied:

1. what factors determine the best position for the transmitting aerials, with respect to the area to be served, in order to concentrate the energy received by reflection from the ionosphere within the desired service area and to reduce to a minimum the amount of energy received outside the broadcast service area;

2. what practical improvements, confirmed by measurement, can be made in the design of transmitting aerials for tropical broadcasting, in order to concentrate the energy received by reflection from the ionosphere within the desired service area and to reduce to a minimum the energy received outside the broadcast service area; in particular, what steps can be taken to reduce low-angle radiation to a minimum?

QUESTION No. 157 (XII)

FADING ALLOWANCES FOR TROPICAL BROADCAST TRANSMISSIONS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that Recommendation No. 164 and Study Programme No. 45 (III) treat the allowances for protection of fading signals for broadcasting in general only;

(b) that tropical broadcasting has special characteristics which are different from those of high-frequency broadcasting for long distances;

(c) that the nature, type and intensity of fading of broadcasting emissions under tropical conditions of propagation are peculiar and require further study;

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* This Question replaces Question No. 103. See Report No. 87.

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the different types and characteristics of fading encountered in tropical zones;
2. what is the annoyance value to reception from the point of view of listener satisfaction;
3. what allowances should be provided for planning tropical broadcasting services?

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Questions and Study Programmes assigned to Study Group No. XIII

QUESTION No. 158 (XIII) *

MARINE IDENTIFICATION DEVICES

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the use of marine radar identification devices might reduce marine casualties and make the movement of vessels safer in narrow congested waters;

(b) that the conditions of use of inter-ship radar identification and shore-based radar identification would be different;

(c) that as far as is practicable, however, it would be advantageous for the same type of ship-borne equipment to be used for both inter-ship identification and identification to a shore-based radar installation;

(d) that administrations have been advised in Recommendation No. 222 to take steps to formulate any international navigational requirements that should be met by devices for inter-ship radar identification;

(e) that work has already been carried out on this problem and is described in Doc. Nos. 53 and 71 of Warsaw and is summarised in Report No. 92;

UNANIMOUSLY DECIDES that the following question should be studied:

what devices can be recommended for international adoption for:

— identification of a ship on the radar of another ship;
— identification of a ship on the radar of a station on shore?

QUESTION No. 159 (XIII) **

BEARING AND POSITION CLASSIFICATION FOR DIRECTION FINDING IN THE VHF (METRIC), HF (DECAMETRIC) AND THE 2 Mc/s BANDS

The C.C.I.R., (London, 1953 — Warsaw, 1956)

CONSIDERING

(a) that the procedure specified in Appendix 15, Section 6 (estimate of accuracy) of the Radio Regulations, Atlantic City, 1947, applies to direction-finding bearings and positions in the 500 kc/s band;

* This Question replaces Question No. 105.

** This Question replaces Question No. 106.

(b) that the standards of classification and accuracy of bearings for the 500 kc/s band may not apply to other frequency ranges;

(c) that increasing use is being made of the 2 Mc/s band by ships;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what accuracies of determination of bearing and position are probable for direction finding in the VHF (metric), HF (decametric) and the 2 Mc/s bands;

2. how should the accuracies be classified, assuming that not more than three classes of accuracy are adopted, and what factors should be taken into account by an operator in assessing the class of bearing or position;

3. what type of signal should be sent for the purpose of VHF (metric) direction finding and what is the minimum time for which it should be sent;

4. what type of signal should be sent for the purpose of direction finding in the 2 Mc/s band?

Note. — In the study of this Question, the work that has been done, or is being done, by I.C.A.O., and the information given in Docs. Nos. 67 and 232 (Warsaw) and in Report No. 93 should be taken into account.

QUESTION No. 160 (XIII)

SELECTIVE CALLING DEVICES FOR USE IN THE INTERNATIONAL VHF (METRIC) MARITIME MOBILE SERVICE

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) Recommendation No. 223 in answer to Question No. 107 concerning VHF (metric) equipments in the maritime mobile service;

(b) that there may be advantages in the use of selective calling devices in the operation of the international VHF (metric) maritime mobile service;

(c) that a selective calling device should provide for a sufficiently large number of individual non-conflicting signalling combinations;

(d) that the frequency bandwidth required for signalling should not exceed that required for the transmission of speech;

(e) that the signalling equipment should operate reliably under poor transmission conditions, that is, when it is just possible to understand speech at the normal modulation;

(f) that the signal sending and receiving units should be capable of operating with the radio transmitting and receiving equipments commonly available on ships;

(g) that the transmission of a complete call number should be accomplished in a few seconds;

(h) that the equipment should be low in cost and capable of operation under shipboard conditions for long periods without excessive maintenance;

UNANIMOUSLY DECIDES that the following question should be studied:

1. is there a need for an international selective calling system in the VHF (metric) maritime mobile service, and to what extent, and for what purposes can selective calling be used with advantage;

2. what are the operational requirements that should be met by any selective calling system that could be used for the purposes recommended in answer to paragraph 1 of this Question;

3. what are the essential technical characteristics of selective calling devices on which international agreement is required;

4. what selective calling systems are there which fulfil the operational and technical requirements in answer to paragraphs 2, and 3;

5. is it desirable to limit selective calling at any given coast station to vessels regularly using that coast station;

6. should it be possible to adjust the code of a ship to any particular code at will, bearing in mind the additional equipment complexity which might result;

7. is it useful to prefix the call by a long dash, or other special signal, in order to attract the attention of vessels not fitted with a selective calling device?

QUESTION No. 161 (XIII)

SPURIOUS EMISSIONS FROM FREQUENCY-MODULATED VHF (METRIC) MARITIME EQUIPMENT

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that efficient operation of a VHF (metric) maritime mobile communication system could be limited by possible interference caused by spurious emissions falling within the band of frequencies used by the maritime mobile services;

(b) that it has been possible at present to recommend only provisional limits, based on equipment now in service, to such emissions;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the nature of such spurious emissions;

2. what are the tolerable limits for such spurious emissions from the point of view of interference?

QUESTION No. 162 (XIII)

TECHNICAL CHARACTERISTICS OF SINGLE-SIDEBAND AERONAUTICAL MOBILE AND MARITIME RADIOTELEPHONE EQUIPMENTS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that the use of single-sideband telephony equipments on board ships and aircraft would tend to reduce congestion of the radio-frequency spectrum;

(b) that it would be desirable to reach agreement upon the essential technical characteristics for single-sideband aeronautical and maritime radiotelephone equipments for use in international services in order to expedite the international use of such equipments;

(c) that the operational requirements of the aeronautical and maritime mobile services may be different;

(d) that there would be special problems during the interim period concerning intercommunication between single-sideband and double-sideband equipments;

(e) that early introduction and world-wide use of single-sideband equipments could contribute to safety of life by reducing interference and improving communication efficiency;

UNANIMOUSLY DECIDES that the following question should be studied:

1. to what extent, for what purposes, and in what frequency bands should single-sideband working be introduced into the aeronautical and maritime mobile services, and what are the relative advantages and disadvantages of so doing;

2. what preferred values should be assigned to the following characteristics for single-sideband equipments used, on the one hand, in the aeronautical mobile service, and on the other, in the maritime mobile service:

   - degree of carrier reduction,
   - frequency tolerance of emissions,
   - choice of the upper or lower sideband to be transmitted,
   - bandwidth of emissions,
   - position in the spectrum of the assigned and carrier frequencies, relative to the corresponding frequencies of double-sideband stations,
   - minimum frequency separation between adjacent channels occupied by the same or other classes of emissions,
   - protection ratio necessary for common-channel operation,
   - audio-frequency response characteristics,
   - factors affecting capability of intercommunication with stations using double-sideband equipments during a transition period for an orderly conversion of all such stations to single-sideband operation,
   - such other characteristics as may be necessary?

QUESTION No. 163 (XIII)

CHARACTERISTICS OF EQUIPMENTS AND PRINCIPLES GOVERNING THE ALLOCATION OF CHANNELS IN THE VHF (METRIC) AND UHF (DECIMETRIC) LAND MOBILE SERVICES

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that an interchange of information on the requirements of administrations concerning the technical characteristics of equipments used in the VHF and UHF land mobile services would be advantageous in the development of those services;

(b) that an exchange of information among different countries concerning the practices applied to the assignment of channels and the experience gained in the operation of VHF and UHF land mobile services is of value in general;

(c) that a certain measure of agreement may be desirable on the characteristics of VHF and UHF land mobile equipments that are used in the border areas of neighbouring countries in order to minimise mutual interference;

(d) that a certain measure of agreement may also be desirable on the practices governing the allocation and use of channels in the VHF and UHF land mobile services in border areas;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the technical requirements of administrations concerning equipments used in the VHF and UHF land mobile services that are of international importance in the development of such services, e.g. transmitter power, type of antenna, emission characteristics, frequency tolerance;

2. to what extent would it be desirable to standardise the performance characteristics of VHF and UHF land mobile equipments internationally;

3. what are the broad practices adopted by administrations in the allocation of channels to the various kinds of user in the VHF and UHF land mobile service, e.g. channel separation, geographical spacing of stations in the same and adjacent channels, frequency separation for duplex operation, degree of frequency sharing in a particular service area;

4. to what extent is it desirable to reach international agreement on the practices for the allocation of channels in the VHF and UHF land mobile service?

QUESTION No. 164 (XIII)

Note by the Director of the C.C.I.R..

The study of this Question was requested at the Maritime VHF Radiotelephone Conference (The Hague, 1957) by the following 13 administrations, members of the I.T.U.: Denmark, Federal German Republic, Finland, France, Ireland, Italy, Netherlands, Norway, Poland (P. R. of) Sweden, the United Kingdom of Great Britain and Northern Ireland, the United States of America and the U.S.S.R. It therefore becomes an official Question of the C.C.I.R. (see Art. 2, § 7 of the International Telecommunication Convention, Buenos Aires). The Director of the C.C.I.R. has allocated this Question to Study Group No. XIII.

INTERFERENCE DUE TO INTERMODULATION PRODUCTS IN THE VHF (METRIC) MARITIME SERVICE

(Recommendation No. 223, § 1.5)

The C.C.I.R., (Approved at the Hague, 1957)

CONSIDERING

(a) that serious interference to reception in the VHF (metric) maritime service may occur as a result of intermodulation products;

(b) that such intermodulation products may be generated by non-linear elements, for example, in stay-wires and masts, where strong fields are present;

(c) that where a strong field from the ship's carrier is present, an intermodulation product may cause interference in the ship's receiver of a duplex system provided that the frequency separation on this duplex system is the same as the frequency separation of two of the other strong fields contributing to the interference;

(d) that specifically, two of these strong fields may arise from the sound and vision carriers of a television transmission, or from two other sources;

DECIDES to study the means for minimising the interference due to intermodulation products by:

1. removing the intermodulation products at the source, for example by bonding;

2. suitable siting and design of the ship's VHF aerials;

3. suitable location of the coast station relative to the stations causing the interference;

4. other means.

Questions and Study Programmes assigned to Study Group No. XIV

QUESTION No. 72 (XIV)

DECIMAL CLASSIFICATION

The C.C.I.R., (Geneva, 1951)

CONSIDERING

that it is advisable to standardise the classification of documents and articles on radio so as to facilitate librarian's work and make it possible for anyone to find the documents required without delay;

UNANIMOUSLY DECIDES that the following question should be studied:

the classification of documents and articles on radio by means of a decimal index, to be made, if possible, within the framework of the universal decimal classification (U.D.C.) and in agreement with the International Federation of Documentation.

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QUESTIONS SUBMITTED BY THE C.C.I.R. TO THE C.C.I.T. AND THE C.C.I.F.

QUESTION No. 109

USE OF RADIO CIRCUITS IN ASSOCIATION WITH 5-UNIT START-STOP TELEGRAPH APPARATUS

Signals other than those specified in the International Telegraph Alphabet No. 2

The C.C.I.R., (London, 1953)

CONSIDERING

the problems raised in Question No. 83 *;

UNANIMOUSLY DECIDES that the following question should be submitted to the C.C.I.T.:

is it necessary, on radio circuits used in association with 5-unit start-stop apparatus, to provide for the transmission of signals other than those specified by the International Telegraph Alphabet No. 2, e.g. in the International Telex Service. If so, what are the characteristics and tolerances of such signals, which are required to be transmitted over radio circuits?

QUESTION No. 110

USE OF RADIO CIRCUITS IN ASSOCIATION WITH 5-UNIT START-STOP TELEGRAPH APPARATUS

Maximum tolerable signal error rates

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that the transmission difficulties present on certain types of radio circuits make some errors in telegraph transmission inevitable;

(b) that the type of telegraph system selected for a particular use over a radio circuit may depend upon the proportion of errors that can be tolerated:

UNANIMOUSLY DECIDES that the following question should be submitted to the C.C.I.T.:

what are the maximum tolerable signal error rates for various types of telegraph service?

* This Question has been replaced by Question No. 129 (III).

QUESTION No. 111

SIGNAL AMPLITUDES IN INDIVIDUAL CHANNELS OF MULTI-CHANNEL TELEPHONE SYSTEMS

The C.C.I.R., (London, 1953)

CONSIDERING

(a) that in multi-channel telephone systems for line or radio transmission, interference due to harmonics and intermodulation is an important limitation;

(b) that mathematical studies of various aspects of this interference have been published;

(c) that data on the statistical distribution of signal amplitudes with time are an essential basis for such studies;

(d) that studies of such data have been published in various countries;

UNANIMOUSLY DECIDES that the following question should be submitted to the C.C.I.F.:

what is the statistical distribution with time of the instantaneous signal amplitudes on individual telephone channels which can be regarded, for practical purposes, as representative of normal operating conditions at a point of zero reference level?

QUESTION No. 112

INFORMATION REQUIRED ON THE TRANSMISSION CHARACTERISTICS OF LINE SYSTEMS FOR USE IN THE DESIGN OF WIDE-BAND RADIO RELAY SYSTEMS

The C.C.I.R., (London, 1953)

UNANIMOUSLY DECIDES that the following question should be submitted to the C.C.I.F.:

1. for what percentage of the time are the specified transmission characteristics attained in existing line systems;

2. to what extent are these characteristics affected by the transmission of either multi-channel voice-frequency telegraph traffic or voice-frequency signalling tones over these line systems?

ALLOCATION OF REPORTS, RESOLUTIONS, QUESTIONS AND STUDY PROGRAMMES TO THE STUDY GROUPS OF THE C.C.I.R.

Note. — In this list, in conformity with the instructions of the VIIth Plenary Assembly, the Questions are followed by the relevant Study Programmes. The Study Programmes which are not derived from any Question at present under study are marked with an asterisk.

Reports and Resolutions arising directly from a Question or a Study Programme still under study immediately follow it; otherwise they are preceded by an asterisk.

In the list which follows, the texts are arranged in order of subject.

Resolutions which do not directly concern the Study Groups have been omitted.

STUDY GROUP No. I
(Transmitters)

Chairman : Colonel J. LOCHARD (France)
Vice-Chairman : Professor S. RYŻKO (P. R. of Poland)

Question No. 1 (I)	Revision of Atlantic City Recommendation No. 4
Report No. 38	Determination of the type of emission producing minimum interference
Study Programme No. 2 (I)	Harmonics and parasitic emissions
Report No. 17	Harmonics and parasitic emissions
Study Programme No. 3 (I)	Frequency stabilisation of transmitters
Study Programme No. 40 (I)	Methods of measuring emitted spectra in actual traffic
Study Programme No. 82 (I)	Bandwidth of emissions

Question No. 18 (I)	Telegraphic distortion

Question No. 20 (I)	Frequency-shift keying
Study Programme No. 41 (I)	Frequency-shift keying
Report No. 40	Frequency-shift keying
Study Programme No. 83 (I)	Four-frequency diplex systems

Question No. 74 (I)	Arrangement of channels in multi-channel telegraph systems for long-range radio circuits operating on frequencies below about 30 Mc/s
Report No. 39	Arrangement of channels in multi-channel radio-telegraph systems for long-range circuits operating on frequencies below about 30 Mc/s

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Question No. 75 (I)	Limitation of unwanted radiation from industrial installations
Study Programme No. 84 (I)	Limitation of unwanted radiation from industrial installations
Resolution No. 20	Measurement of unwanted radiation from industrial installations

STUDY GROUP No. II
(Receivers)

Chairman : Mr. P. DAVID (France)
Vice-Chairman : Mr. P. ABADIE (France)

Question No. 78 (II)	Choice of intermediate frequency and protection against undesired responses of super-heterodyne receivers

Report No. 41	Choice of intermediate frequency and protection against undesired responses of super-heterodyne receivers
Question No. 123 (II)	Sensitivity and noise factor
Question No. 124 (II)	Frequency stability of receivers
Question No. 125 (II)	Usable sensitivity of radio receivers in the presence of quasi-impulsive interference
Question No. 126 (II)	Spurious emissions from receivers, excluding sound-broadcast and television
Question No. 127 (II)	Distortion in frequency-modulation receivers due to multipath propagation
Question No. 128 (II)	Selectivity of receivers
*Study Programme No. 43 (II)	Protection against keyed interfering signals

STUDY GROUP No. III
(Fixed service systems)

Chairman : Dr. H. C. A. van DUUREN (Netherlands)
Vice-Chairman : Mr. A. COOK (United Kingdom)

Question No. 3 (III)	Revision of Atlantic City Recommendation No. 4
Study Programme No. 44 (III)	Effect of interference and noise on quality of service in the presence of fading
Study Programme No. 45 (III)	Bandwidth and signal-to-noise ratios in complete systems
Question No. 43 (III)	Voice-frequency telegraphy on radio circuits
Study Programme No. 46 (III)	Voice-frequency telegraphy on radio circuits
Report No. 19	Voice-frequency telegraphy on radio circuits
Question No. 81 (III)	Directivity of antennae at great distances
Study Programme No. 85 (III)	Improvement obtainable from the use of directional antennae
Question No. 82 (III)	Interference effects of atmospheric noise on radio reception
Study Programme No. 49 (III)	Interference effects of atmospheric noise on radio reception
Question No. 84 (III)	Determination of the maximum interference levels tolerable in complete systems
Question No. 94 (III)	Facsimile transmission of documentary matter over combined radio and metallic circuits
Question No. 95 (III)	Transmission of half-tone pictures over radio circuits
Question No. 129 (III)	Use of radio circuits in association with 5-unit start-stop telegraph apparatus

Study Programme No. 50 (III)	Use of radio circuits in association with 5-unit start-stop telegraph apparatus
Report No. 42	Use of radio circuits in association with 5-unit start-stop telegraph apparatus

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Question No. 130 (III)	Transmission of meteorological charts over radio circuits by direct frequency-modulation of the carrier

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Question No. 131 (III)	Determination of the required interference protection ratios between various classes of emission

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Question No. 132 (III)	Radio systems employing ionospheric scatter propagation

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Question No. 133 (III)	Communication theory
Study Programme No. 86 (III)	Communication theory

Question No. 139 (III)	Influence of Doppler shifts on long-distance high-frequency communication using frequency-shift keying
Question No. 167 (III)	Frequency stability required for single-sideband, independent sideband and telegraph systems, to make the use of automatic frequency control superfluous

STUDY GROUP No. IV
(Ground-wave propagation)

Chairman : Professor L. Sacco (Italy)
Vice-Chairman : Mr. G. Millington (United Kingdom)

*Report No. 43	Review of publications on propagation

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*Report No. 46	Temporal variations of ground-wave field-strength

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Question No. 134 (IV)	Ground-wave propagation
Study Programme No. 87 (IV)	Effects of standard tropospheric refraction on frequencies below 10 Mc/s
Report No. 45	Effects of standard tropospheric refraction on frequencies below 10 Mc/s

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Study Programme No. 88 (IV)	Ground-wave propagation over mixed paths
Report No. 47	Ground-wave propagation over mixed paths
Study Programme No. 89 (IV)	Ground-wave propagation over irregular terrain
Report No. 21	Ground-wave propagation over irregular terrain
Report No. 44	Ground-wave propagation over irregular terrain. Addendum to Report No. 21

Question No. 135 (IV)	Determination of the electrical characteristics of the surface of the earth

STUDY GROUP No. V
(Tropospheric propagation)

Chairman : Dr. R. L. Smith-Rose (United Kingdom)
Vice-Chairman : Mr. E. W. Allen (United States)

*Report No. 48	Field-strength measurement
*Report No. 49	Methods of measuring field strength
*Report No. 50	Methods of measuring field strength

Question No. 101 (V)	Advantages to be obtained from consideration of polarisation in the planning of broadcasting services in the VHF (metric) and UHF (decimetric) bands (television and sound)

Report No. 85 [1]	Advantages to be obtained from consideration of polarisation in the planning of broadcasting services in the VHF (metric) and UHF (decimetric) bands (television and sound)
Question No. 136 (V)	Propagation data required for wide-band radio systems
Report No. 53	Propagation data required for wide-band radio systems
Study Programme No. 79 (V)	Tropospheric propagation across mountain ridges
Report No. 52	Tropospheric propagation across mountain ridges
Question No. 137 (V)	Measurement of field strength in the neighbourhood of obstacles
Question No. 138 (V)	Measurement of field strength for VHF (metric) and UHF (decimetric) broadcast services, including television
*Study Programme No. 55 (V)	Tropospheric propagation curves for distances well beyond the horizon
*Study Programme No. 57 (V)	Investigation of multipath transmission through the troposphere
Report No. 51	Investigation of multipath transmission through the troposphere
*Study Programme No. 90 (V)	Tropospheric-wave propagation
*Study Programme No. 91 (V)	Radio transmission utilising inhomogeneities in the troposphere (commonly termed " scattering ")
Question No. 168 (V)	Protection of frequencies used by artificial earth satellites or other space vehicles for communication and positional observation

STUDY GROUP No. VI
(Ionospheric propagation)

Chairman : Dr. J. H. Dellinger (United States)
Vice-Chairman : Dr. D. K. Bailey (United States)

*Report No. 54	Long-distance propagation of waves of 30 to 300 Mc/s by way of ionisation in the E and F regions of the ionosphere
*Report No. 55	Practical uses and reliability of ionospheric propagation data
*Report No. 56	Questions submitted by the I.F.R.B.
*Report No. 58	Exchange of information for the preparation of short-term forecasts and the transmission of ionospheric disturbance warnings
*Report No. 60	Centralising agencies for the rapid exchange of information on propagation
*Report No. 61	Extension of the C.C.I.R. propagation curves below 300 kc/s

[1] Question No. 101 (V), formerly allocated to Study Group No. XI, was allocated to Study Group No. V by the VIIIth Plenary Assembly of the C.C.I.R., and Report No. 85, which refers to the same subject, has been allocated to the same Study Group.

*Report No. 62	Investigation of circularly polarised emitted waves propagated via the ionosphere
*Resolution No. 25	Local lightning-flash counters
*Study Programme No. 60 (VI)	Basic prediction information for ionospheric propagation
*Study Programme No. 63 (VI)	Radio propagation at frequencies below 1500 kc/s
Report No. 63	Radio propagation at frequencies below 1500 kc/s
*Study Programme No. 66 (VI)	Study of fading
Report No. 59	Fading of HF (decametric) and MF (hectometric) signals propagated by the ionosphere
*Study Programme No. 92 (VI)	Choice of a basic index for ionospheric propagation
Report No. 57	Choice of a basic index for ionospheric propagation
*Study Programme No. 93 (VI)	Identification of precursors indicative of short-term variations of ionospheric propagation conditions
*Study Programme No. 94 (VI)	Use of special modulation on the standard-frequency transmissions for assessing the reliability of propagation forecasts
*Study Programme No. 95 (VI)	Ionospheric scatter propagation
Report No. 64	Regular long-distance transmission in the VHF (metric) band by means of scattering from inhomogeneities in the lower ionosphere
*Study Programme No. 96 (VI)	Measurement of atmospheric radio noise
Report No. 65	Revision of atmospheric radio noise data
*Study Programme No. 97 (VI)	Pulse-transmission tests at oblique incidence
*Study Programme No. 98 (VI)	Back-scattering
*Study Programme No. 99 (VI)	Estimation of sky-wave field strengths on frequencies above 1500 kc/s
*Study Programme No. 100 (VI)	Prediction of solar index
Question No. 169 (VI)	Protection of frequencies used by artificial earth satellites or other space vehicles for communication and positional observation

STUDY GROUP No. VII
(Standard frequencies and time signals)

Chairman : Mr. B. Decaux (France)
Vice-Chairman : Professor M. Boella (Italy)

Question No. 140 (VII)	Standard-frequency transmissions and time signals
Report No. 66	Standard-frequency transmissions and time signals
Study Programme No. 101 (VII)	Standard-frequency transmissions and time signals
Question No. 141 (VII)	Stability of standard-frequency transmissions and time signals as received

Question No. 142 (VII)	Standard-frequency transmissions and time signals in additional frequency bands

STUDY GROUP No. VIII
(International monitoring)

Chairman : Mr. J. Campbell (Australia)
Vice-Chairman : Mr. G. S. Turner (United States)

*Report No. 67	Frequency measurements above 50 Mc/s at monitoring stations

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Question No. 104 (VIII)	Identification of radio stations
Report No. 91	Identification of radio stations
Study Programme No. 115 (VIII)	Identification of radio stations

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Question No. 143 (VIII)	Automatic monitoring of occupancy of the radio-frequency spectrum

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Question No. 144 (VIII)	Measurements at mobile monitoring stations

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Question No. 145 (VIII)	Frequency measurements at monitoring stations

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*Study Programme No. 102 (VIII)	Field-strength measurements at monitoring stations

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*Study Programme No. 103 (VIII)	Spectrum measurement at monitoring stations
Report No. 68	Spectrum measurement at monitoring stations

STUDY GROUP No. IX
(Radio relay systems)

Chairman : Mr. H. Stanesby (United Kingdom)
Vice-Chairman : Mr. G. Pedersen (Danemark)

*Report No. 69	International wide-band radio relay systems operating on frequencies above about 30 Mc/s. Transmission of telephony and television on the same system

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*Report No.74	Methods for the computation of intermodulation noise due to non-linearity in radio relay systems

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*Study Programme No. 28 (IX)	Wide-band radio relay systems operating in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands

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Question No. 92 (IX)	Standardisation of multi-channel radiotelephone systems using time-division multiplex and operating at frequencies above about 30 Mc/s
Report No. 70	Preferred characteristics of multi-channel radiotelephone systems using time-division multiplex and operating on frequencies above about 30 Mc/s

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Question No. 93 (IX) — Standardisation of multi-channel radio relay systems using frequency-division multiplex and operating at frequencies above about 30 Mc/s

Report No. 71 — Preferred characteristics for multi-channel radio relay systems using frequency-division multiplex and operating at frequencies above about 30 Mc/s

Study Programme No. 104 (IX) — Standardisation of multi-channel radio relay systems using frequency-division multiplex and operating at frequencies above about 30 Mc/s

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Question No. 96 (IX) — Maintenance procedure for wide-band radio relay systems

Report No. 72 — Maintenance procedure for wide-band radio relay systems. Service channels

Report No. 73 — Transmission of pilot frequencies over circuits consisting of cable paths and radio relay systems

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Question No. 97 (IX) — Hypothetical reference circuit for wide-band radio relay systems

Study Programme No. 105 (IX) — Wide-band radio relay systems. Noise tolerable during very short periods of time

---

Question No. 146 (IX) — Preferred characteristics of radio relay systems for the transmission of monochrome television

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Question No. 147 (IX) — Service channels for wide-band radio relay systems

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Question No. 148 (IX) — Radio relay systems employing tropospheric scatter propagation

Question No. 165 (IX) — Transmission interruptions due to switching from normal to standby equipment in radio relay systems including tropospheric scatter systems

Study Programme No. 120 (IX) — Standardisation of multi-channel radio-relay systems using frequency-division multiplex and operating at frequencies above about 30 Mc/s

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Study Programme No. 121 (IX) — Standardisation of wide-band radio-relay systems using frequency-division multiplex

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Study Programme No. 122 (IX) — Radio-relay systems employing tropospheric scatter propogation

STUDY GROUP No. X
(Broadcasting)

Chairman : Mr. A. Prose Walker (United States)
Vice-Chairman : Mr. K. W. Miller (United States)

*Report No. 33 — Questions Nos. 14 and 15 of the C.C.I.F.

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*Report No. 81 — Sound recording on film for the international exchange of television programmes

---

Question No. 23 (X) — High-frequency broadcasting. Directional antenna systems

Report No. 32 — High-frequency broadcasting. Directional antenna systems

Report No. 75 — High-frequency broadcasting. Directional antenna with reduced subsidiary lobes

Study Programme No. 106 (X) — High-frequency broadcasting. Directional antenna systems

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Question No. 37 (X) — High-frequency broadcasting. Justification for use of more than one frequency per programme

Report No. 76 — The minimum number of frequencies necessary for the transmission of a high-frequency broadcasting programme

Study Programme No. 107 (X)	High-frequency broadcasting. Directional aerial systems for reception areas of unusual size or shape
Study Programme No. 108 (X)	High-frequency broadcasting. Use of synchronised transmitters

---

Question No. 39 (X)	High-frequency broadcasting. Conditions for satisfactory reception
Report No. 14	High-frequency broadcasting reception

Question No. 149 (X)	High-frequency broadcasting. Effects of closer spacing between carrier frequencies

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Question No. 150 (X)	Frequency-modulation broadcasting in the VHF (metric) band
Report No. 77	Frequency-modulation sound broadcasting in the VHF (metric) band

---

Question No. 151 (X)	Measurement of programme level in sound broadcasting
Study Programme No. 109 (X)	Measurement of programme level in sound broadcasting

---

*Study Programme No. 74 (X)	Standards of sound recording for the international exchange of programmes
Report No. 78	Measurement of wow and flutter in equipment for sound recording and reproduction
Report No. 79	Standards of sound recording for the international exchange of programmes
Report No. 80	Width of magnetic tape
Resolution No. 30	Width of magnetic tape
Question No. 170 (X)	Stereophonic broadcasting

STUDY GROUP No. XI
(Television)

Chairman : Mr. E. ESPING (Sweden)
Vice-Chairman : Mr. G. HANSEN (Belgium)

Question No. 66 (XI)	Television recording

Question No. 117 (XI)	Single value of signal-to-noise ratio for different television systems
Question No. 118 (XI)	Colour television standards
Report No. 83	Television systems
Study Programme No. 80 (XI)	Standards for video colour television signals
Study Programme No. 81 (XI)	Standards for radiated colour television signals
Study Programme No. 110 (XI)	Distortion of television signals due to the use of vestigial-sideband transmission

---

Question No. 119 (XI)	Ratio of the wanted to the unwanted signal in television
Report No. 82	Ratio of the wanted to the unwanted signal in monochrome television
Study Programme No. 111 (XI)	Ratio of the wanted to the unwanted signal in television. Use of the offset method when there are great differences between the carrier frequencies of the interfering stations

---

Question No. 120 (XI)	Exchange of television programmes

Question No. 121 (XI)	Transmission of monochrome and colour television signals over long distances
Report No. 84	Requirements for the transmission of television over long distances
Resolution No. 32	Transmission of monochrome and colour television signals over long distances
Study Programme No. 32 (XI)	Requirements for the transmission of television over long distances
Study Programme No. 35 (XI)	Reduction of the bandwidth for television
Study Programme No. 36 (XI)	Conversion of a television signal from one standard to another

---

Question No. 152 (XI)	Assessment of the quality of television pictures

---

Question No. 153 (XI)	Resolving power and differential sensitivity of the human eye
Question No. 166 (XI)	Single value of signal-to-noise ratio for different television systems
Study Programme No. 116 (XI)	Single value of the signal-to-noise ratio for different television systems
Study Programme No. 117 (XI)	Constitution of a system of stereoscopic television
Study Programme No. 118 (XI)	Radio of the wanted to the unwanted signal in television
Study Programme No. 119 (XI)	Reduction of the channel capacity required for a television signal
Study Programme No. 123 (XI)	Ratio of the wanted to the unwanted signal in monochrome television

STUDY GROUP No. XII
(Tropical broadcasting)

Chairman : Mr. B. V. BALIGA (India)
Vice-Chairman : Dr. M. B. SARWATE (India)

Question No. 102 (XII)	Interference in the bands shared with broadcasting
Report No. 89	Interference in the bands shared with broadcasting
Study Programme No. 112 (XII)	Short distance high-frequency broadcasting in the tropical zone (tropical broadcasting)
Study Programme No. 113 (XII)	Interference in the bands shared with broadcasting
Study Programme No. 114 (XII)	Interference in the frequency bands used for tropical broadcasting

---

Question No. 154 (XII)	Best method for calculating the field strength produced by a tropical broadcasting transmitter
Report No. 88	Best method for calculating the sky-wave field strength produced by a tropical broadcasting transmitter

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Question No. 155 (XII)	Determination of noise level for tropical broadcasting

---

Question No. 156 (XII)	Design of transmitting aerials for tropical broadcasting
Report No. 86	Design of aerials for tropical broadcasting
Report No. 87	Design of transmitting aerials for tropical broadcasting (Complement to Report No. 86)

Question No. 157 (XII)	Fading allowances for tropical broadcast transmissions

STUDY GROUP No. XIII
(Mobile services)

Chairman : Mr. J.-D. H. van der TOORN (Netherlands)
Vice-Chairman : Mr. J. SÖBERG (Norway)

*Report No. 90	Publication of service codes in use in the international telegraph service

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Question No. 158 (XIII)	Marine identification device
Report No. 92	Marine identification device

Question No. 159 (XIII)	Bearing and position classification for direction finding in the VHF (metric), HF (decametric) and the 2 Mc/s bands
Report No. 93	HF (decametric) and VHF (metric) direction finding

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Question No. 160 (XIII)	Selective calling devices for use in the international VHF (metric) maritime mobile service
Question No. 161 (XIII)	Spurious emissions from frequency-modulated VHF (metric) maritime equipment
Question No. 162 (XIII)	Technical characteristics of single-sideband aeronautical mobile and maritime radio-telephone equipments
Question No. 163 (XIII)	Characteristics of equipments and principles governing the allocation of channels in the VHF (metric) and UHF (decimetric) land mobile services
Question No. 164 (XIII)	Interference due to intermodulation products in the VHF (metric) maritime service

STUDY GROUP No. XIV
(Vocabulary)

Chairman: Prof. T. Gorio (Italy)
Vice-Chairman: Mr. R. Villeneuve (France)

*Resolution No. 5	Means of expression. Definitions, vocabulary, graphical and letter symbols
*Resolution No. 34	Definitions of certain basic words used in the International Telecommunication Convention
*Report No. 94	Means of expression
Question No. 72 (XIV)	Decimal classification
Report No. 37	Decimal classification
Report No. 95	Decimal classification. Complement to Report No. 37

QUESTIONS SUBMITTED TO OTHER CONSULTATIVE COMMITTEES
(Art. 7, § 2, International Telecommunication Convention, Buenos Aires, 1952)

a) *Submitted to the C.C.I.T.*

Question No. 109	Use of radio circuits in association with 5-unit start-stop telegraph apparatus: Signals other than those specified by the International Telegraph Alphabet No. 2
Question No. 110	Use of radio circuits in association with 5-unit start-stop telegraph apparatus: Maximum tolerable signal error rates

b) *Submitted to the C.C.I.F.*

Question No. 111	Signal amplitudes in individual channels of multi-channel telephone systems
Question No. 112	Information required on the transmission characteristics of line systems for use in the design of wide-band radio relay systems

VARIOUS ORGANISATIONS MENTIONED IN THIS VOLUME

The name of each organisation in this list is followed by the reference numbers of the texts in which the organisation is mentioned.

The numbers of the texts most closely connected with the organisation are shown in *italics*.

Bureau International de l'Heure (B.I.H.)

Recommendation No. *179*.

International Telegraph Consultative Committee (C.C.I.T.)

Recommendations Nos. 144, 150, *151*, 167, 227.
Reports Nos. *19*, 37, 40, *90*.
Resolutions Nos. *15*, *33*.
Questions Nos. *18 (I)*, *43 (III)*, *94 (III)*, *109*, *110*, *129 (III)*.
Study Programmes Nos. *28 (IX)*, 46 (III).

International Telephone Consultative Committee (C.C.I.F.)

Recommendations Nos. 40, 75, 77, *144*, 145, 149, 183, 185, 186, 188, 189, 197, 200, 201, 202, 203, 204, 227
Reports Nos. 33, 37, 71, *72*, *73*, 84.
Resolutions Nos. *29*, *32*.
Questions Nos. 97 (IX), *111*, *112*, *117 (XI)*, 121 (XI).
Study Programmes Nos. *28 (IX)*, *32 (XI)*, *45 (III)*.

International Telegraph and Telephone Consultative Committee (C.C.I.T.T.)

Resolutions Nos. *32*, *34*, *38*.

International Frequency Registration Board (I.F.R.B.)

Recommendations Nos. *19*, *22*, *176*, *177*, 178, 180, *220*.
Reports Nos. 55, *56*, 61, *63*, 66.
Resolutions Nos. *19*, *24*, *28*.
Study Programmes Nos. *63 (VI)*, 102 (VIII), 115 (VIII).

International Radio Maritime Committee (C.I.R.M.)

Question No. 78 (II).

International Special Committee on Radio Interference (C.I.S.P.R.)

Recommendations Nos. *27*, *131*, *159*, *160*.
Resolution No. *20*.
Questions Nos. *75 (i)*, *84 (III)*, *125 (II)*, 126 (II).
Study Programme No. *84 (I)*.

International Electrotechnical Commission (I.E.C.)

Recommendations Nos. 27, 131, 143, 144, *157*, *158*, *160*.
Reports Nos. 81, 94.
Resolution No. *31*.
Questions Nos. 126 (II), 127 (II).

Joint Study Groups C.C.I.T.T.-C.C.I.R.

Recommendation No. 227.
Report No. *84*.
Resolution No. *15*.
Questions Nos. *94 (III)*, *130 (III)*.

International Federation of Documentation (F.I.D.)

Reports Nos. 37, 95.
Question No. *72 (XIV)*.

International Civil Aviation Organisation (I.C.A.O.)
Reports Nos. 66, 93.
Question No. 159 (XIII).

International Organisation for Standardisation (I.S.O.)
Recommendation No. 211.
Report No. 81.
Recommendation No. *31.*

International Broadcasting Organisation (O.I.R.)
Report No. 83.

World Meteorological Organisation (W.M.O.)
Recommendation No. *121.*
Resolution No. *25.*
Study Programmes Nos. *90 (V), 96 (VI).*

European Broadcasting Union (E.B.U.)
Reports Nos. 63, 79.
Question No. 78 (II).

International Scientific Radio Union (U.R.S.I.)
Recommendations Nos. *59, 165, 166, 173, 179.*
Reports Nos. *46,* 48, 54, 57, 58, 59, 62, 64.
Resolutions Nos. *26, 27.*
Questions Nos. *125 (II),* 133 (III), *137 (V).*
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ALPHABETICAL INDEX

In this list each of the texts relating to a subject is given in numerical order preceded by one of the following abbreviations:

Rec. for a Recommendation
Rep. for a Report
Res. for a Resolution
Qu. for a Question
S.P. for a Study Programme