INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

C.C.I.R.

DOCUMENTS OF THE

Xth PLENARY ASSEMBLY

GENEVA, 1963

VOLUME III

FIXED AND MOBILE SERVICES
STANDARD-FREQUENCIES AND TIME-SIGNALS
MONITORING OF EMISSIONS

Published by the
INTERNATIONAL TELECOMMUNICATION UNION
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FIXED SERVICES	Recommendations of Section C (Fixed services) Reports of Section C (Fixed services) Questions and Study Programmes assigned to Study Group III (Fixed service systems); Opinions and Resolutions of interest to this Study Group; List of documents of the Xth Plenary Assembly concerning Study Group III
MOBILE SERVICES	Recommendations of Section D (Mobile services) Reports of Section D (Mobile services) Questions and Study Programmes assigned to Study Group XIII (Mobile services); Opinions and Resolutions of interest to this Study Group; List of documents of the Xth Plenary Assembly concerning Study Group XIII
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* This list includes only those Study Programmes which do not derive from Questions. A Study Programme derived from a Question carries the same serial number as this Question, followed by a letter (e.g. S.P. 102A (XII)). It is inserted in the book immediately after the text of the Question from which it is derived.

ARRANGEMENT OF VOLUMES I TO VII OF THE DOCUMENTS OF THE Xth PLENARY ASSEMBLY OF THE C.C.I.R.

(Geneva, 1963)

VOLUME I	Emission. Reception. Vocabulary (Sections A, B, K and Study Groups I, II and XIV).
VOLUME II	Propagation (Section G and Study Groups V and VI).
VOLUME III	Fixed and mobile services. Standard-frequencies and time-signals. International monitoring (Sections C, D, H and J and Study Groups III, XIII, VII and VIII).
VOLUME IV	Radio-relay systems. Space systems and Radioastronomy (Sections F and L and Study Groups IX and IV).
VOLUME V	Sound broadcasting and Television (Section E, Study Groups X, XI and XII and the C.M.T.T.).
VOLUME VI	Resolutions of a general nature. Reports to the Plenary Assembly. List of participants. List of documents in numerical order.
VOLUME VII	Minutes of the Plenary Meetings.

Note 1. – To facilitate references, the pagination in the English and French texts is the same

Note 2. – At the beginning of Volume VI will be found information concerning the Xth Plenary Assembly of the C.C.I.R. and the participation at this meeting, on the presentation of texts (Definitions, origins, numbering, complete lists, etc.), together with general information on the organization of the C.C.I.R.

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RECOMMENDATION 75

CLASSIFICATION AND ESSENTIAL CHARACTERISTICS OF FEED-BACK SUPPRESSORS

(Question 31)

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

CONSIDERING

that the feedback suppressors now generally used are of a type, the operation of which is sufficiently independent of the characteristics of those at the opposite end of the circuit;

UNANIMOUSLY RECOMMENDS

that no classification of types nor terminology should be adopted.

Essential characteristics

(§ *(b)* of Question 31)

The essential characteristics of the feedback suppressors, used on radiotelephone circuits in the United Kingdom and in the United States of America for fixed services, are described respectively in Docs. 49 and 51 of Geneva, 1951. These are in substantial accord with the characteristics described in C.C.I.F., 1950–1951, 5th Study Group, Doc. 7, Question 2.

RECOMMENDATION 100

REDUCTION OF OCCUPIED BANDWIDTH AND TRANSMITTER POWER IN RADIOTELEPHONY

(Question 3(III))

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

CONSIDERING

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

(b) that a very great improvement in the use of the spectrum will arise from the replacement of double-sideband by single-sideband technique (see Recommendation 335, §§ 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 339);

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 106

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(Question 43(III))

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

CONSIDERING

(a) that diversity reception is not a common practice on radiotelegraph circuits;

(b) that, when 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 if no means of diversity reception is provided;

(c) that, in the presence of fading, space– or frequency–diversity gives comparable improvements in the quality of reception of telegraph signals transmitted over 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, as compared with frequency diversity, but usually requires more equipment;

UNANIMOUSLY RECOMMENDS

1. that, when voice-frequency telegraph 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, for 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.

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* 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.

RECOMMENDATION 162 *

USE OF DIRECTIONAL ANTENNAE

(Question 3(III) – Study Programme 45)

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 to a minimum the necessary channel spacing;

(c) that the use of directional transmitting antennae considerably reduces the level of interference by
- providing the necessary field-strength at the receiver with reduced transmitted power,
- reducing the received field-strength 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, highly directional antennae can be constructed, using known techniques;

(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;

(g) that it is not yet possible to give full and precise answers to the questions posed in Study Programme 45, §§ 1.1.9 and 1.2.9.

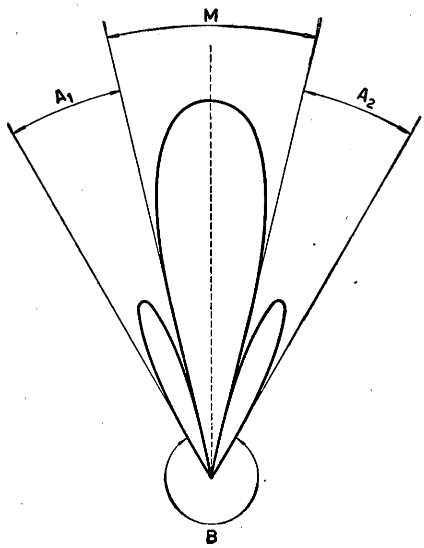

FIGURE 1

* This Recommendation replaces Recommendation 103.

UNANIMOUSLY RECOMMENDS

1. that the characteristics, which might reasonably be expected in practice for rhombic antennae in use at present for point-to-point circuits, should be considered in three main arcs as shown in Fig. 1, i. e.:

   (*M*) the main arc, including only the main lobe,

   (*A*) 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, 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 to 10 000 km.

ANNEX

Frequency range (Mc/s)	Median value of gain relative to optimum gain for half-wave dipole at the same height (db)			Azimuthal range (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

RECOMMENDATION 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 240 *

SIGNAL-TO-INTERFERENCE PROTECTION RATIOS

(Question 3(III) – Study Programme 3A(III))

The C.C.I.R., (London, 1953 – Warsaw, 1956 – Los Angeles, 1959)

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 340;
2. that the values shown in the Table are appropriate to emissions indicated.

* This Recommendation replaces Recommendation 163. The R.P. of Bulgaria, the Ukrainian S.S.R., the Czechoslovak S.R. and the U.S.S.R. reserved their opinion on this Recommendation.

TABLE

Minimum protection ratios and frequency separations required under stable conditions

Wanted signal	Interfering signal																			
Type of service	A1 50 bauds(1)				A1 100 bauds				F1 50 bauds 2D = 280 c/s(1)				F1 100 bauds 2D = 400 c/s				Broadcast(5)			
	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)		
A1–50 baud teleprinter $B = 500$ c/s	11	0·36	0·44	1·14	(2) 12	(2) 0·25	(2) 0·35		13	0·46	0·54	1·24	(2) 3	(2) 0·40	(2) 0·55					
F1–50 baud teleprinter $2D = 280$ c/s, $B = 500$ c/s	1	0·2	0·28	0·6					7	0·32	0·39	0·67								
F1–50 baud teleprinter $2D = 280$ c/s, $B = 3000$ c/s																	(3) 18	(3) 3	(3) 4·5	(3) 7·5
F1–50 baud teleprinter $2D = 400$ c/s, $B = 500$ c/s					(2) 3	(2) 0·35	(2) 0·50						(2) 2	(2) 0·45	(2) 0·60					
F1–171 baud ARQ system $2D = 400$ c/s, $B = 500$ c/s					(4) 4	(4) 0·40	(4) 0·55						(4) 4	(4) 0·50	(4) 0·70					
F4-phototelegraphy, 60 r.p.m. $B = 1000$ c/s					15	1·00	1·20						15	1·10	1·20					

In the column " Type of service ", B represents the receiver bandwidth and $2D$ represents the total frequency shift. Columns numbered 1 give the limiting values of signal-to-interference ratio (db) 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 level of the latter is 0, 6 or 30 db higher than the wanted signal.

(1) Bandwidth of interfering signals limited to 500 c/s;
(2) For a character error rate of 1/10 000;
(3) For a character error rate of 1/1000;
(4) For a traffic efficiency of 90%;
(5) Average modulation degree of 40%; for this test the sideband components extended to ± 9 kc/s.

RECOMMENDATION 246 *

FREQUENCY-SHIFT KEYING

(Question 183(III))

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

The C.C.I.R.,

CONSIDERING

(a) that frequency-shift keying is employed in radiotelegraphy in the fixed service and that its use has also been 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 standardize 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:

- economy of bandwidth and the consequent need to control the shape of the transmitted signals;
- signal distortion due to propagation conditions;
- 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 " on teletype circuits and also that the C.C.I.T., at its VIIth Plenary Assembly, issued Recommendation I.4 introducing new terms; these terms have been published by the I.T.U. in the " List of Definitions of Essential Telecommunication Terms ", Part I, June 1957;

UNANIMOUSLY RECOMMENDS

1. that it is too early to standardize 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; and to assist in this, the characteristics shown below should be used as far as possible;

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 $\pm 3\%$ of its nominal value and, in any case, within $\pm 10\%$;

6. that for circuits using the Morse code, the higher frequency should correspond to the Mark signal, and the lower frequency should correspond to the Space signal;

* This Recommendation replaces Recommendation 150.
** For long-distance communication, see Question 181 (III).

7.* that for circuits using the International Alphabet No. 2 code with start-stop apparatus, the higher frequency should correspond to the start signal (position A) and the lower frequency to the stop signal (position Z);.

8.* that, for telex circuits using the International Alphabet No. 2 code directly on the radio circuit, the higher frequency should correspond to the C.C.I.T.T. " free circuit condition " (position A) and the lower frequency to the C.C.I.T.T. " idle-circuit condition " (position Z);

9.* that for channels of a 7-unit automatic repetition system, which are referred to in the Annex to Recommendation 342 as directly keyed channels (e. g., channel A of a two-channel system), the higher frequency should correspond to the code elements shown as letter A and the lower frequency to the code elements shown as letter Z. For the channels which are to have reversed keying (e. g. channel B of a two-channel system), the higher frequency should correspond to the code elements shown as letter Z and the lower frequency to the code elements shown as letter A.

RECOMMENDATION 335 **

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

The C.C.I.R., (Geneva, 1951 – Geneva, 1963)

CONSIDERING

(a) that, at the present time, radiotelephone systems connecting the various continents usually employ carrier frequencies below 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.a such a radiotelephone circuit is subject to attenuation variation with the special difficulty of fading;

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

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

c.d 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, as far as possible, under conditions of full loading, whatever may be the nature and the attenuation of the telephone system connected to the radiotelephone circuit;

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

c.f although the recommended frequency band, to be effectively transmitted by international landline circuits, has been determined by a study of the requirements of the human ear, this band (for 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-

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* When modification of equipment is necessary, it is recognized that it may take some time before the recommendations of these paragraphs can be implemented on circuits between different Administrations.

** This Recommendation replaces Recommendation 40.

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

frequency spectrum and so that each telephone channel does not occupy a radio-frequency band larger than necessary;

c.g 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.g.a 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.g.b 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, to make the allocation of radio frequencies less difficult; where this can be realized, the objective should be to attain the transmission performance recommended by the C.C.I.T.T. for international telephone circuits on metallic conductors.

2. Circuits below 30 Mc/s

2.1 that, since it becomes necessary to economize 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.T.T. for land-line circuits and, preferably, to reduce the upper frequency to less than 3000 c/s, but not below 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;

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 the echo suppressor frequently;

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

2.5 that such a radiotelephone circuit should be equipped with automatic gain control to compensate automatically, as 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, 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 controls should be adjusted, as often as necessary, by an operator to ensure optimum adjustment of transmitter loading, received volume and the operating conditions of the reaction suppressor.

Note. – Although the requirements contained in § 2 of this Recommendation are much less severe than those imposed on international land-line circuits, the objective 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.T.T. 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 §§ 1 and 2, 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 § 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.T.T. 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 336 *

PRINCIPLES OF THE DEVICES USED TO ACHIEVE PRIVACY IN RADIOTELEPHONE CONVERSATIONS

(Question 30)

The C.C.I.R., (Geneva, 1951 – Geneva, 1963)

CONSIDERING

(a) that the devices referred to are intended to achieve *privacy* rather than *secrecy* in radiotelephone conversations;

(b) that, in the interest 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 30, for radio circuits operating at frequencies less than about 30 Mc/s;

1.1 *Principles of the devices*

Two general types of system are used, to achieve privacy in radiotelephone circuits operating at frequencies less than about 30 Mc/s:

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 and independent-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 synchronization of the switching processes at the two terminals is required;

1.2 *Characteristics of the devices*

1.2.1 the band-splitting system provides privacy superior to that obtained with the inverter system, but for satisfactory operation it can tolerate less radio distortion;

1.2.2 the apparatus is designed to reduce attenuation distortion and the levels of unwanted products of modulation and of carrier signals to a minimum. 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;

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* This Recommendation replaces Recommendation 74.

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 337 *

CHANNEL SEPARATION

The C.C.I.R., (Stockholm, 1948 – Geneva, 1951 – London, 1953 – Geneva, 1963)

CONSIDERING

(a) that, in the more usual cases, the primary factors which determine frequency separation between channels 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 many factors are involved, among which are the properties of the transmission medium (which are variable in character and difficult to determine), the characteristics of the receiver and, for aural reception, the discriminating properties of the human ear;

UNANIMOUSLY RECOMMENDS

1. that the required separation between channels should be calculated by the following method:
- determine the signal power intercepted by the receiver;
- determine the interfering power intercepted, including both noise and interfering signal;
- determine, from these data, the degree of frequency separation that produces acceptable ratios of signal power to interfering power, for an acceptable percentage of the time. Account should be taken of the fluctuating nature both of the signal and of the 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,

RECOMMENDATION 338 **

BANDWIDTH REQUIRED AT THE OUTPUT OF A TELEGRAPH OR TELEPHONE RECEIVER

(Question 3(III))

The C.C.I.R., (London, 1953 – Geneva, 1963)

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;

* This Recommendation replaces Recommendation 97.

** This Recommendation replaces Recommendation 101.

(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, for telegraphy, the permissible degree of distortion is not yet defined;

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

UNANIMOUSLY RECOMMENDS

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

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 (c/s) 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, for 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 335, the upper limit frequency should be reduced to 3000 c/s or less but not lower than 2600 c/s;

2.2 the lower frequency limit of speech channels should be 250 c/s, and that of broadcast relay channels should be 150 c/s;

2.3 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 339 *

BANDWIDTHS AND SIGNAL-TO-NOISE RATIOS IN COMPLETE SYSTEMS

(Question 3(III))

The C.C.I.R., (Geneva, 1951 – London, 1953 – Warsaw, 1956 – Geneva, 1963)

CONSIDERING

that it is not yet possible to give a full and accurate answer to Question 3(III), but to assist in giving such an answer, it is desirable to classify the important points with which future study will have to deal;

UNANIMOUSLY RECOMMENDS

1. that meanwhile, the values given in Table I should be adopted as provisional values for the signal-to-noise ratio required for the classes of emission concerned;

2. that, in further study relating to the minimum separation between frequencies of stations operating on adjacent channels, the factors detailed in Annex I should be taken into consideration.

* This Recommendation replaces Recommendation 161.

TABLE I

Signal-to-noise ratios required
(Stable conditions (Note 6))

Class of emission	Audio bandwidth of receiver (kc/s)	Audio signal-to-noise ratio (db)	Bandwidth of receiver (kc/s)	Ratio of peak RF signal-noise in a 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
F3 telephony([3])				
D is the frequency deviation (kc/s)	3		$2M+2DK$	
M is the audio bandwidth (kc/s)				
K is normally 1, but sometimes a higher value is necessary				
(The ratio of peak RF signal-to-noise in a 6 kc/s band, is lower by ($4{\cdot}77+20 \log D/M$) db than that required for A3 double-sideband telephony)				
Phototelegraphy F4				
Sub-carrier frequency-modulation single-sideband emission	3	15	3	12
Hellschreiber				
Frequency-shift	1·5	6	3	3
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([1])
Single-sideband and independent-sideband,				
1 channel	3	33	3	26([1])
2 channels	3	33	3([2])	28([1])
3 channels	3	33	3([2])	29([1])
4 channels	3	33	3([2])	30([1])

([1]) Assuming 10 db improvement due to the use of noise reducers.

([2]) Per channel.

([3]) No. 466 of the Radio Regulations, Geneva 1959, prohibits F3 emissions for the fixed services in the bands below 30 Mc/s.

Note 1. – Measured as the ratio of the r.m.s. signal corresponding to peak output of the transmitter and the r.m.s. noise in a 6 kc/s band, assuming stable conditions.

Note 2. – Carrier keyed. Beat-frequency oscillator used.

Note 3. – For telephony, the figures in this column represent the ratio of the audio signal, as measured on a standard VU-meter, to the 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 Doc. 138 of Washington, 1950, Doc. 112 of Geneva, 1951, and Doc. 11 of The Hague, 1952.

ANNEX I

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:
- out-of-band radiation;
- frequency instability.

4. Propagation:
- allowances for fluctuations due to absorption and fading.

5. Receivers:
- necessary bandwidth;
- attenuation slope;
- frequency instability.

6. Effect of:
- inequalities of received field-strength on wanted and adjacent channels;
- antenna directivity at transmitter and receiver.

RECOMMENDATION 340 *

FADING ALLOWANCES FOR THE VARIOUS CLASSES OF EMISSION

(Question 3(III) – Study Programme 3A(III))

The C.C.I.R., (Geneva, 1951 – London, 1953 – Warsaw, 1956 – Geneva, 1963)

CONSIDERING

(a) that Annex I to Recommendation 339 is a provisional and partial reply to Question 3(III), applying to stable conditions;

* This Recommendation replaces Recommendation 164.

(b) that there is a need for figures which take into account fading and fluctuations in field intensity;

(c) that it is not yet possible to give a full answer to Study Programme 3A (III);

(d) that, however, the information contained in Reports 248 and 266 give some results from which provisional data on fading allowances can be derived;

UNANIMOUSLY RECOMMENDS

1. that the studies in connection with Recommendation 339 and Study Programme 3A (III) should be continued, in conjunction with those of Study Programme 148 (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 339, Annex 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 fluctuations in intensity of atmospheric noise are also taken to be 10 db for 90% of the days. Assuming that there is no correlation between the fluctuations in intensity of the noise and those of the signal (the worst condition likely to exist), a good estimate of the combined signal and noise factor is:

$$\sqrt{10^2 + 10^2} = 14 \text{ db}$$

The combined fading allowance in Column 1 is obtained by adding 14 db to the fading safety factor applied to each type of service. 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 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 applied in accordance with Doc. 443 (U.S.A.) of London, 1953. The combined intensity fluctuation allowance for two signals has been taken as 7 db, which represents a compromise between the 0 db allowance, appropriate to perfectly correlated intensity fluctuations of the two signals, and the 14 db allowance, appropriate to uncorrelated intensity fluctuations of the two signals (see Note 1).

General Note. – Use of the recommended values only permits an estimate to be obtained, which may have to be adjusted for radio circuits of different lengths, depending on the quality of transmission required. In calculating the fading safety factor for rapid or short period fading a log-normal amplitude distribution of the received fading signal has been used (using 7 db for the ratio of median level to level exceeded for 10% or 90% of the time) except for

Provisional total fading allowances[1]

Class of emission[2]	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 and ISB {1 channel . . . . / 2 channels. . . . . / 3 channels. . . . . / 4 channels. . . . .} (Note 12)	21	17

(1) Combined fading safety factor and intensity fluctuation allowances.
(2) From Recommendation 339, Annex I.

high-speed automatic telegraphy services, where the protection has been calculated on the assumption of a 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. An allowance of 4 db is made for 90% protection (8 baud), and 6 db for 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 341 *

THE CONCEPT OF TRANSMISSION LOSS IN STUDIES OF RADIO SYSTEMS

(Question 3(III) and Study Programme 3A(III))

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that the radio-frequency signal power, p_a, available ** at the terminals of a receiving antenna for a given power input, p_t, to the terminals of a transmitting antenna, provides a measure which is useful in determining, at the terminals of the receiving antenna, the service from, or the interference produced by, a radio system involving a transmitting antenna, a receiving antenna, and the intervening propagation medium;

(b) that the ratio, p_t/p_a, which will be called the system loss, is a convenient dimensionless form for expressing this measure of the combined radio propagation and circuit loss characteristics of such a system;

(c) that the available power, at the terminals of the receiving antenna, is sometimes a simpler and more directly useful concept than that of the effective field-strength, especially where the effective field is the resultant of a large number of received field components, corresponding to several modes of propagation, arriving at the receiving antenna at different angles and possibly with different polarizations;

(d) that the relationship between the system loss and the conditions in the neighbourhood of the receiving antenna, does not depend solely on the received field-strength, because the impedance of the antenna depends itself upon the conditions in its neighbourhood;

* This Recommendation replaces Recommendation 241.

** The available power, p_a, is the power which would go to the load if it were matched to the antenna impedance.

(e) that the power, P_t', radiated from the transmitting antenna, required for satisfactory reception in the presence of noise, is precisely determined for a system with transmission loss, L, by the simple relation: $P_t' = L + P$; P is the minimum signal power that is required to provide satisfactory reception (as defined in Report 322), available from an equivalent lossless receiving antenna;

(f) that it is desirable to standardize terminology and notation for describing system loss and its various components;

UNANIMOUSLY RECOMMENDS

that the terminology and notation given in the Annex should be adopted for use by the C.C.I.R., in accordance with the further discussion of the use of these terms given in Report 112.

ANNEX

1. System loss (L_s)

The system loss of a radio circuit, consisting of a transmitting antenna, a receiving antenna and the intervening propagation medium, is defined as the ratio, p_t/p_a, where p_t is the radio-frequency power input to the terminals of the transmitting antenna and p_a is the resultant radio-frequency signal-power available at the terminals of the receiving antenna. Both p_t and p_a are expressed in watts. The system loss is usually expressed in decibels: *

$$L_s = 10 \log_{10} (p_t/p_a) = P_t - P_a \quad .$$

Note that the system loss, as defined above, excludes any transmitting or receiving antenna transmission line losses, since it is considered that such losses are readily measurable. On the other hand, the system loss includes all of the losses in the transmitting and receiving antenna circuits, including, not only the transmission loss due to radiation from the transmitting antenna and re-radiation from the receiving antenna, but also any ground losses, dielectric losses, antenna loading coil losses, terminating resistor losses in rhombic antennae, etc. The inclusion of all of the antenna circuit losses in the definition of system loss provides a quantity which can always be accurately measured and which is directly applicable to the solution of radio system problems.

2. Transmission loss (L)

The transmission loss of a radio circuit, consisting of a transmitting antenna, a receiving antenna, and the intervening propagation medium, is defined as the dimensionless ratio, p_t'/p_a', where p_t' is the radio-frequency power radiated from the transmitting antenna, and p_a' is the resultant radio-frequency signal power which would be available from the receiving antenna, if there were no circuit losses other than those associated with its radiation resistance. The transmission loss is usually expressed in decibels:

$$L = 10 \log_{10} (p_t'/p_a') = L_s - L_{tc} - L_{rc}$$

where L_{tc} and L_{rc} are the losses, expressed in decibels, in the transmitting and receiving antennae circuits respectively, excluding the losses associated with the antennae radiation resistances; i. e., the definitions of L_{tc} and L_{rc} are $10 \log_{10} (r'/r)$, where r' is the resistive component of the antenna circuit and r is the radiation resistance.

3. Basic transmission loss (L_b)

The basic transmission loss (sometimes called path loss), of a radio circuit, is the transmission loss expected between ideal, loss-free, isotropic, transmitting and receiving antennae at the same locations as the actual transmitting and receiving antennae.

* Throughout this Recommendation, capital letters are used to denote the ratios, expressed in decibels, of the corresponding quantities designated with lower-case type; e.g., $P_t = 10 \log_{10} p_t$. P_t is the input power to the transmitting antenna, expressed in decibels above 1 W.

4. Path antenna gain (G_p)

The path antenna gain is equal to the change in the transmission loss when lossless, isotropic, antennae are used at the same locations as the actual antennae:

$$G_p = L_b - L$$

5. Path antenna power gain (G_{pp})

The path antenna power gain is equal to the increase in the system loss when lossless, isotropic, antennae are used at the same locations as the actual antennae:

$$G_{pp} = L_b - L_s = G_p - L_{tc} - L_{rc}$$

Note that G_{pp} will be negative when the antenna circuit losses exceed the path antenna gain.

In some idealized situations, the path antenna power gain, G_{pp}, is simply the sum $(G_{tp} + G_{rp})$ of the free space power gains, G_{tp} and G_{rp}, of the transmitting and receiving antennae relative to lossless, isotropic, antennae. However, in most practical situations, G_{pp} is less than $(G_{tp} + G_{rp})$, because of the complex nature of the received field. The path antenna power gain may be measured, by determining the increase in the system loss when both the transmitting and receiving antennae are replaced *simultaneously*, by simple standard antennae such as short electric or magnetic dipoles, and then adding the calculated path antenna power gain corresponding to the use of the standard antennae. For ionospheric or tropospheric scatter propagation, the path antenna power gain is sometimes substantially smaller than the sum of the free space power gains $(G_{tp} + G_{rp})$; in such cases, the path antenna power gain cannot be defined by the sum of the effective power gains of the transmitting and receiving antennae (as determined by replacing first one antenna and then the other successively by a standard antenna), since such effective power gains depend upon the gain of the antenna used at the other terminal.

For ionospheric or tropospheric propagation, the transmission loss L, the basic transmission loss L_b, and the path antenna gain G_p, are all random variables with respect to time, and tend to be normally distributed about their expected values. Typically, L and G_p are negatively correlated with each other, and thus the variance of L_b is usually substantially less than the sum of the variances of L and of G_p; for this reason, it will often be more practical simply to measure the system loss with the particular antennae intended for use, rather than attempt to calculate the expected system loss and its variance with time, in terms of the measured or calculated values of the basic transmission loss, the path antenna gain, and the losses L_{tc} and L_{rc}.

Note also that the path antenna gain may actually be negative. For example, the path antenna gain will usually be negative for ground wave or tropospheric wave propagation between a vertically polarized and a horizontally polarized antenna, and the concept of path antenna gain should prove to be useful for expressing the results of such cross-polarization measurements.

6. Propagation loss (L_p)

The propagation loss is the system loss expected if the antennae gains and circuit resistances were the same as if the antennae were located in free space:

$$L_p = L_s - L_t - L_r$$

L_t and L_r are defined by $10 \log_{10} (r'/r_f)$ where r' is the actual antenna resistance and r_f is the resistance the antenna would have if it were in free space and there were no losses other than radiation losses.

RECOMMENDATION 342 *

AUTOMATIC ERROR CORRECTING SYSTEM FOR TELEGRAPH SIGNALS TRANSMITTED OVER RADIO LINKS

(Study Programme 3A(III))

(Geneva, 1951 – London, 1953 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

The C.C.I.R.,

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;

(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 by detecting the errors and automatically causing repetition;

(e) that the method using synchronous transmission and automatic repetition (ARQ), is now well proven;

(f) that it is desirable to permit correct phase to be established automatically on setting up a circuit;

(g) that certain circumstances can occur which may result in a loss of the correct phase relationship between a received signal and the receiving apparatus;

(h) that it is desirable to permit the correct phase relationship to be re-established automatically after such a loss, without causing errors;

(i) that, to avoid mis-routing traffic, it is essential to prevent phasing to a signal which has been unintentionally inverted;

(j) that there is sometimes a need to subdivide one or more channels, to provide a number of services at a proportionately reduced character rate;

(k) that the method of automatically achieving the correct phase relationship between the received signal and the sub-channelling apparatus should be an integral part of the phasing process;

(l) that compatibility with existing equipment, designed in accordance with Recommendation 242 (Los Angeles, 1959), is a requirement;

UNANIMOUSLY RECOMMENDS

1. 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 employed;

2. when automatic phasing of such a system is required, the 7-unit system, described in the Annex, should be adopted as a preferred system;

3. that equipment, designed in accordance with § 2, should be provided with switching, to permit operation with equipment designed in accordance with Recommendation 242 (Los Angeles, 1959).

Note. – Methods, in accordance with this Recommendation, are described in Doc. III/17 of Geneva, 1962.

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* This Recommendation replaces Recommendation 242.

ANNEX I

1. Table of conversion

TABLE I

Table of code conversion

	International code No. 2	7-unit code
A	Z Z A A A	A A Z Z A Z A
B	Z A A Z Z	A A Z Z A A Z
C	A Z Z Z A	Z A A Z Z A A
D	Z A A Z A	A A Z Z Z A A
E	Z A A A A	A Z Z Z A A A
F	Z A Z Z A	A A Z A A Z Z
G	A Z A Z Z	Z Z A A A A Z
H	A A Z A Z	Z A Z A A Z A
I	A Z Z A A	Z Z Z A A A A
J	Z Z A Z A	A Z A A A Z Z
K	Z Z Z Z A	A A A Z A Z Z
L	A Z A A Z	Z Z A A A Z A
M	A A Z Z Z	Z A Z A A A Z
N	A A Z Z A	Z A Z A Z A A
O	A A A Z Z	Z A A A Z Z A
P	A Z Z A Z	Z A A Z A Z A
Q	Z Z Z A Z	A A A Z Z A Z
R	A Z A Z A	Z Z A A Z A A
S	Z A Z A A	A Z A Z A Z A
T	A A A A Z	Z A A A Z A Z
U	Z Z Z A A	A Z Z A A Z A
V	A Z Z Z Z	Z A A Z A A Z
W	Z Z A A Z	A Z A A Z A Z
X	Z A Z Z Z	A A Z A Z Z A
Y	Z A Z A Z	A A Z A Z A Z
Z	Z A A A Z	A Z Z A A A Z
Carriage return	A A A Z A	Z A A A A Z Z
Line feed	A Z A A A	Z A Z Z A A A
Figures	Z Z A Z Z	A Z A A Z Z A
Letters	Z Z Z Z Z	A A A Z Z Z A
Space	A A Z A A	Z Z A Z A A A
Unperforated tape	A A A A A	A A A A Z Z Z
Signal repetition		A Z Z A Z A A
Signal α		A Z A Z A A Z
Signal β		A Z A Z Z A A

2. Repetition cycles

2.1 Four characters for normal circuits, which are not subject to excessive propagation time. The cycle should comprise one " signal repetition " and three stored characters.

2.2 Eight characters on circuits for which the four-character repetition cycle is inadequate. The cycle should comprise one " signal repetition ", three signals β and four stored characters, or one " signal repetition " and seven stored characters.

3. Channel arrangement

3.1 *Channel A*

3.1.1 For equipment employing a 4-character repetition cycle: one character inverted followed by three characters erect. (See Fig. 1*a*.)

3.1.2 For equipments employing an 8-character repetition cycle: one character inverted followed by seven characters erect. (See Fig. 2*a*.)

3.2 *Channel B*

3.2.1 For equipments employing a 4-character repetition cycle: one character erect followed by three characters inverted. (See Fig. 1*b*.)

3.2.2 For equipments employing an 8-character repetition cycle: one character erect followed by seven characters inverted. (See Fig. 2*b*.)

3.3 *Channel C*

As for Channel B (See Figs. 1*c* and 2*c*).

3.4 *Channel D*

As for Channel A (See Figs. 1*d* and 2*d*).

3.5 *Order of transmission*

3.5.1 Characters of Channels A and B are transmitted consecutively. (See Figs. 1*e* and 2*e*).

3.5.2 Elements of Channel C are interleaved with those of Channel A. (See Figs. 1*g* and 2*g*).

3.5.3 Elements of Channel D are interleaved with those of Channel B. (See Figs. 1*g* and 2*g*).

3.5.4 In the aggregate signal, A elements precede those of C, and B elements precede those of D. (See Figs. 1*g* and 2*g*.)

3.5.5 The first erect character on A, transmitted after the inverted character on A, is followed by the erect character on B. (See Figs. 1*e* and 2*e*.)

3.5.6 The erect character on C is followed by the inverted character on D. (See Figs. 1*f* and 2*f*.)

3.5.7 The inverted character on A is element-interleaved with the erect character on C. (See Figs. 1*g* and 2*g*.)

4. Sub-channel arrangement

4.1 The character transmission rate of the fundamental sub-channel should be a quarter of the standard character rate.

4.2 Sub-channels should be numbered 1, 2, 3 and 4 consecutively.

4.3 Where a 4-character repetition cycle is used, sub-channel 1 should be that sub-channel which has opposite keying polarity to the other three sub-channels of the same main channel. (See Fig. 3*a-d*.)

Where an 8-character repetition cycle is used, sub-channel 1 should be that sub-channel which has alternately erect and inverted keying polarity. (See Fig. 3*e-h*.)

4.4 When sub-channels of half-character rate, or three-quarter-character rate are required, combinations of the fundamental sub-channels should be arranged as shown in Table II.

TABLE II

Proportion of full-channel character rate	Combination of fundamental sub-channels
(1) quarter (2) quarter (3) half	No. 1 No. 3 Nos. 2 and 4
(1) half (2) half	Nos. 1 and 3 Nos. 2 and 4
(1) quarter (2) three-quarters	No. 1 Nos. 2, 3 and 4

5. Diagrams

As a result of the characteristics specified in §§ 2, 3 and 4 of this Annex, the transmission of characters will be as shown in Figs. 1, 2 and 3.

6. C.C.I.T.T. Recommendation S.12 recommends, that the interval between the beginning of successive start elements of the signals transmitted into the land line network be 145 5/6 ms. Therefore, the duration of the transmission cycle on the radio circuit and also the modulation rate must be chosen correspondingly, if interconnection to the network is required.

Practical values for the modulation rate in bauds and the duration of the transmission cycle, which enable synchronization to be effected by using a single oscillator for three cases, are shown in Table III.

TABLE III

Transmission cycle (ms)	Modulation rate (bauds)	
	2–channel operation	4–channel operation
145 5/6	96	192
This is the preferred standard. See C.C.I.T.T. Recommendations S.12 and S.13		
163 1/3	85 5/7	171 3/7
140	100	200

The transmission cycle of 145 5/6 ms is the preferred standard for connection to 50-baud networks.

The transmission cycle of 163 1/3 ms is suitable for connecting to 45-baud networks.

The transmission cycle of 140 ms is suitable for radio links without direct connection to a landline network.

The tolerance on the stability of the master oscillator, controlling the timing of each terminal equipment, should be $\pm 1 \times 10^{-6}$.

7. C.C.I.T.T. Recommendation U.20 gives the signalling conditions to be used when telex communication is to be established by means of such radio circuits.

7.1 For circuits on switched telegraph networks, the conditions of C.C.I.T.T. Recommendation U.20 should apply.

7.2 For point-to-point circuits, signal β should be transmitted to indicate the " idle circuit " condition.

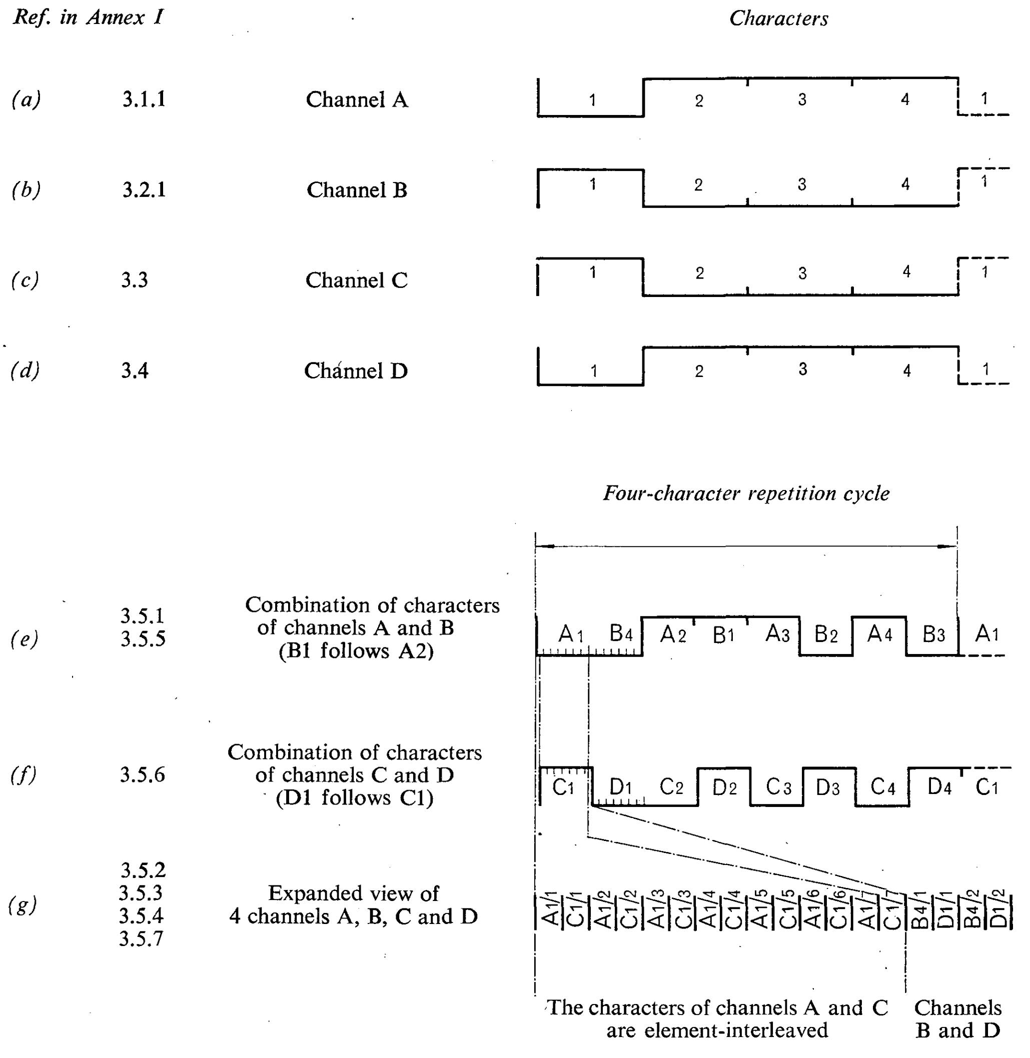

FIGURE 1

Channel arrangement for a four-character repetition cycle

Ref. in Annex 1

(a)	3.1.2	Channel A
(b)	3.2.2	Channel B
(c)	3.3	Channel C
(d)	3.4	Channel D
(e)	3.5.1 3.5.5	Combination of characters of channels A and B (B1 follows A2)
(f)	3.5.6	Combination of characters of channels C and D (D1 follows C1)
(g)	3.5.2 3.5.3 3.5.4 3.5.7	Expanded view of 4 channels A, B, C and D

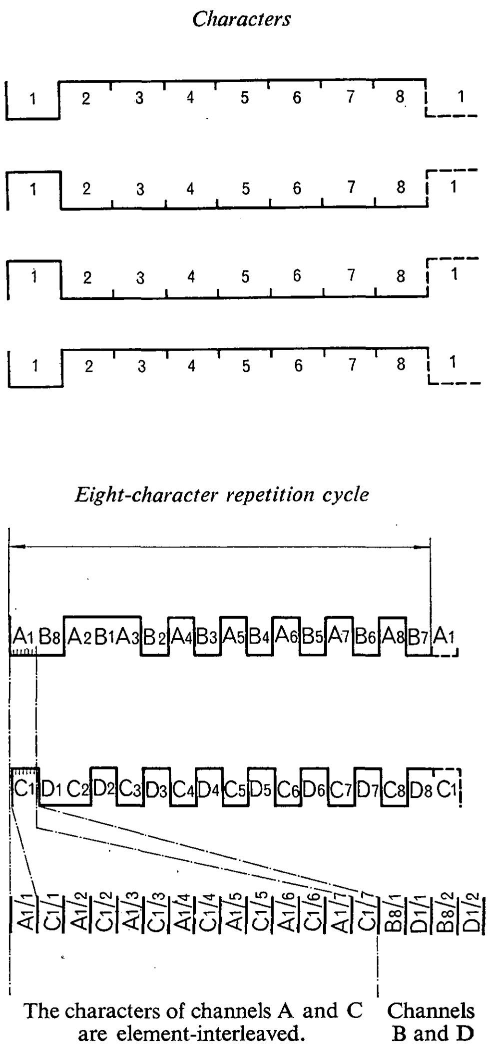

FIGURE 2

Channel arrangement for an eight-character repetition cycle

Ref. in Annex I

(a)	3.1.1 4.2 4.3
(b)	3.2.1 4.2 4.3
(c)	3.3 4.2 4.3
(d)	3.4 4.2 4.3
(e)	3.1.2 4.2 4.3
(f)	3.2.2 4.2 4.3
(g)	3.3 4.2 4.3
(h)	3.4 4.2 4.3

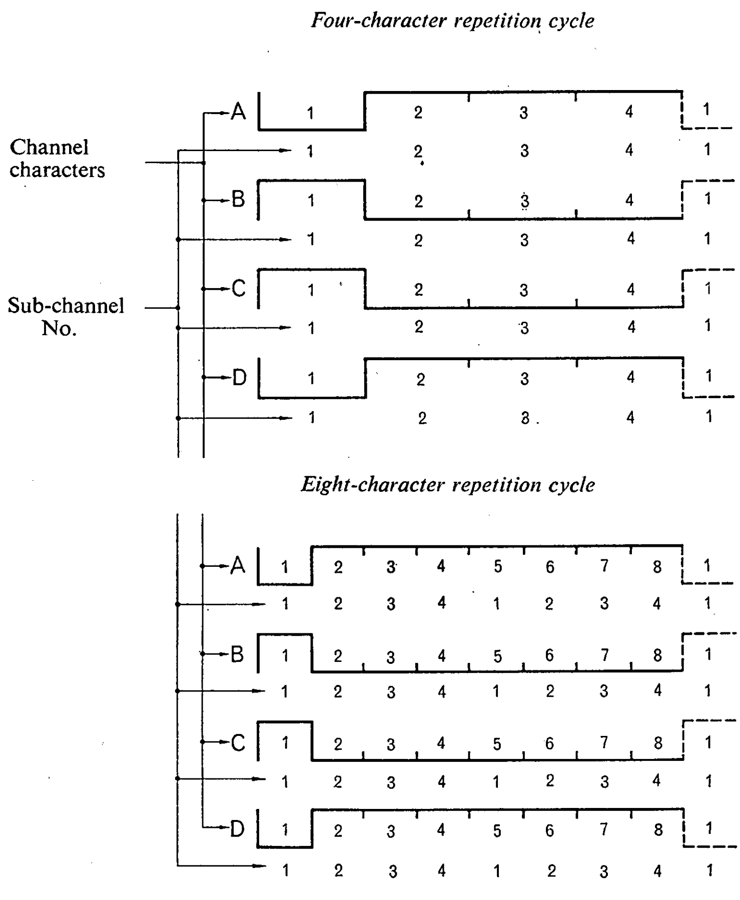

FIGURE 3

Sub-channelling arrangements for a four and an eight-character repetition cycle

ANNEX II

Terms related to ARQ-Systems *

Part 1

1. Signal repetition RQ-signal Signal Roman one	– the seven unit combination (AZZAZAA) which is used to request a repetition (RQ-signal) or to precede a re-transmission BQ-signal);
2. Repetition cycle	– the sequence of characters, the number of which is determined by the *loop time-delay of the system*, to provide automatic repetition of information;
3. RQ-cycle Request cycle	– the *repetition cycle* transmitted by ARQ-apparatus at the detection of a mutilation;
4. BQ-cycle Response cycle	– the *repetition cycle* transmitted by ARQ-apparatus at a request for repetition;
5. Non-print cycle	– the interval at the ARQ-receiver, initiated by the detection of a mutilation or a *signal repetition*, that has the same duration as a *repetition cycle* and during which all signals received are prevented from being printed;
6. Gated RQ	– a procedure in which a check is made for the presence of a *signal repetition* during a non-print cycle;
7. Tested RQ	– a procedure in which a check is made for the presence of a *signal repetition* and a check is made for the ratio A/Z on all characters received after the *signal repetition* within the *non-print cycle*;
8. Tested repetition cycle	– a *non-print cycle* in which a check is made for the presence of a *signal repetition* and for the correct ratio A/Z of all the characters received;
9. Cycling	– the condition that a repetition procedure is in progress;
10. Marking pattern	– a specific pattern of polarity inversions applied to characters in an *aggregate signal*;
11. Marked cycle System cycle	– a cycle consisting of a specific character *marking pattern*, that is continuously repeated and has the duration of a *repetition cycle*;
12. System phase Marked cycle phase	– the condition in which the *marking pattern* of the local timing coincides with the *marked cycle* of the received signal;
13. Phasing Phase hunting	– the condition in which a station is hunting for *character phase* or *system phase*;

* The twenty-three terms and definitions in part 1 of this list have been studied by a joint Working Party of Study Groups III and XIV during the Xth Plenary Assembly of the C.C.I.R., Geneva, 1963, as a provisional contribution (see § 2.1 of Annex to Resolution 21) for the " List of Definitions of Essential Telecommunication Terms " (Volume II to be published later).

The other terms and definitions contained in part 2 of this list, which are of more general application, are given as information pending examination by the C.C.I.T.T.

14. Manual phasing – *phasing* by manual action only;

15. Semi-automatic phasing – *phasing* completed automatically after manual initiation;

16. Automatic phasing – *phasing*, initiated and completed automatically after automatic detection of " out-of-phase ";

17. Master station – the station, the transmitting equipment of which is directly driven by a master oscillator but the receiver timing of which is normally synchronized to the incoming signal;

18. Slave station – the station, the receiver and transmitter timing of which are both synchronized to the received signal;

19. End-to-end time delay – the delay between the output terminals of an ARQ-transmitter and the input terminals of the ARQ-receiver at the other end (this is the sum of radio and line circuit delays in one direction of a route);

20. Loop time-delay of a route – the sum of the end-to-end time delays in the send and return directions of a route;

21. Master station delay – the period between the beginning of reception of a *signal repetition* at the ARQ-input terminals at the *master station* and the beginning of transmission of the replying *signal repetition* at that station.

    Note. – This comprises the " scanning " and equipment delays and a further delay which, when added to the *loop time delay of the system*, produces an integral multiple of the *character cycle* duration;

22. Slave station delay – the period between the beginning of reception of a *signal repetition* at the ARQ-input terminals at the *slave station* and the beginning of transmission of the replying *signal repetition* at that station.

    Note. – This comprises " scanning " and equipment delays and a " preset " delay between the receiver and the transmitter;

23. Loop time delay of a system (as seen from the master station) – the sum of the *loop time delay of the route* and the *slave station delay*, measured under working conditions;

Part 2

(a) Aggregate signal – the synchronous signal produced by combining the channel signals;

(b) Balanced aggregate signal – an aggregate signal containing equal numbers of elements of each polarity;

(c) Character cycle – the period in which each channel of a time-division multiplex transmission has completed one character in the synchronous path;

(d) Element synchronism	– in synchronous systems: the condition in which an element of the local timing coincides completely with an element of the received signal;
(e) Synchronizing	– the action of adjustment of element synchronism;
(f) Phase relationship	– in synchronous systems: the relative phase of receiving apparatus and incoming signals, or receiving and sending apparatus;
(g) Character phase	– the condition in which a character cycle of the local timing coincides completely with a character cycle of the received signal. *Note.* – Under these conditions, a character of the aggregate signal transmitted on a particular channel is received on the correct channel.
(h) Sub-channel	– a teleprinter channel which is allocated a quarter rate of a normal channel, or multiples thereof;
(j) Sub-channel phase	– the condition in which a character transmitted on a particular sub-channel is received on the correct sub-channel;
(k) Transposition	– Add to definition 33.25 of the I.T.U. " List of definitions... " (Part I): " Transpositions may be regarded as of first or higher order according to the number of interchanges occurring within a character."

RECOMMENDATION 343 *

FACSIMILE TRANSMISSION OF METEOROLOGICAL CHARTS OVER RADIO CIRCUITS

(Question 232 (III))

The C.C.I.R., (Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

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 standardize certain characteristics of the radio circuits for this purpose;

UNANIMOUSLY RECOMMENDS

1. 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:

centre frequency	1900 c/s,
frequency corresponding to black	1500 c/s,
frequency corresponding to white	2300 c/s;

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* This Recommendation replaces Recommendation 243.

2. that, when direct frequency modulation is employed on radio circuits, the following characteristics should be used:

2.1 *HF (decametric) circuits*

centre frequency (corresponding to the assigned frequency)	f_o,
frequency corresponding to black	$f_o - 400$ c/s,
frequency corresponding to white	$f_o + 400$ c/s;

2.2 *LF (kilometric) circuits*

centre frequency (corresponding to the assigned frequency)	f_o,
frequency corresponding to black	$f_o - 150$ c/s,
frequency corresponding to white	$f_o + 150$ c/s;

3. that this Recommendation should be considered as an answer to Question 130, the study of which is hereby terminated.

Note. – It is to be observed that, whereas with the drum speed of 60 r.p.m. satisfactory reception on HF 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 344 *

STANDARDIZATION OF PHOTOTELEGRAPH SYSTEMS FOR USE ON COMBINED RADIO AND METALLIC CIRCUITS

(Stockholm, 1948 – London, 1953 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that, to facilitate interworking, it is desirable to standardize the characteristics of systems employed for phototelegraph transmission over long-distance HF (decametric) circuits;

(b) that it is desirable to standardize certain characteristics of the systems in such a way as to make them 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 sub-carrier frequency-modulation has proved satisfactory, but requires standardization in respect of the centre frequency and shift frequencies, taking into account the values of the picture-modulation frequencies to be transmitted;

(f) that, when a direct frequency-modulation system is employed, the terminal equipment normally used for a sub-carrier modulation system, should be usable without serious modifications;

(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 500 c/s;

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* This Recommendation replaces Recommendation 244.

UNANIMOUSLY RECOMMENDS

1. that over the radio path,

1.1 when a sub-carrier frequency-modulation system is used, the following characteristics should be observed:

centre frequency	1900 c/s,
frequency corresponding to white	1500 c/s,
frequency corresponding to black	2300 c/s;

(The 1500 c/s frequency is also used for the phase-synchronizing frequency)

1.2 when a direct frequency modulation system is employed, the following characteristics should be observed:

centre frequency (corresponding to the assigned frequency)	f_o,
frequency corresponding to white	$f_o - 400$ c/s,
frequency corresponding to black	$f_o + 400$ c/s;

1.3 in both systems, it is as yet too early to state definite frequency tolerances *, but pending a decision on this matter, the frequency stability should, in all cases, be at least:

8 c/s in any period of 30 s;
16 c/s in any period of 15 min;

2. that, for the present, the following alternative characteristics should be used:

	a	*b*	
index of cooperation	352	264	
speed of rotation of drum in r.p.m.	60	90/45	(The lower speed is for use when the 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.T. Recommendations T.1, T.11 and T.15.

Each Administration will decide, when the question arises, on the location of modulation converters. They will be placed either at the terminal phototelegraph station or at the control station associated with the radio station, to facilitate speech on the circuit used for phototelegraphy, if the radio channel will carry speech.

Note. – The provisions of § 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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* See Doc. III/66 (Rev.) of Geneva, 1962.

RECOMMENDATION 345 *

TELEGRAPH DISTORTION

(Question 18)

The C.C.I.R., (London, 1953 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

that the definitions applying to telegraph distortion and to the mutilation of telegraphic signals, which appear in Section 33, Part I, of the " List of Definitions of Essential Telecommunication Terms ", published by the International Telecommunication Union, give an answer to Question 18, which required a general definition of telegraph distortion capable of being usefully applied to the cause of radiotelegraphy;

UNANIMOUSLY RECOMMENDS

that the following definitions, contained in Section 33 of the above-mentioned " List of Definitions of Essential Telecommunication Terms ", should be applied to radiotelegraphy:

Perfect modulation (or restitution) (Definition 33.01 of the List)

Modulation (or restitution) such, that all the significant intervals are associated with correct significant conditions and conform accurately to their theoretical durations.

Incorrect modulation (or restitution)
Defective modulation (or restitution) } (Definition 33.03 of the List)

Modulation (or restitution) containing one or more elements, the significant condition of which differs from that corresponding to the kind prescribed by the code.

Telegraph distortion (of a modulation or a restitution) (Definition 33.04 of the List)

(a) A modulation (or restitution) suffers from telegraph distortion, when the significant intervals have not all exactly their theoretical durations.

(b) A modulation (or restitution) is affected by telegraph distortion, when significant instants do not coincide with the corresponding theoretical instants.

Transmitter distortion (Definition 33.059 of the 1st Supplement to the List)

A signal transmitted by an apparatus (or a signal at the output of a local line with its termination), is affected by telegraph distortion, when the significant intervals of this signal have not exactly their theoretical durations.

Degree of individual distortion of a particular significant instant (of a modulation or of a restitution) (Definition 33.06 of the List)

Ratio to the unit interval of the displacement, expressed algebraically, of this significant instant from an ideal instant.

This displacement is considered positive when the significant instant occurs after the ideal instant.

The degree of individual distortion is usually expressed as a percentage.

Degree of isochronous distortion (Definition 33.07 of the 1st Supplement to the List)

(a) Ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and the theoretical intervals separating any two significant instants of modulation (or of restitution), these instants being not necessarily consecutive.

(b) Algebraical difference between the highest and lowest value of individual distortion affecting the significant instants of an isochronous modulation. (The difference is independent of the choice of the reference ideal instant.)

The degree of distortion (of an isochronous modulation or restitution), is usually expressed as a percentage.

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* This Recommendation replaces Recommendation 245.

Note. – The result of the measurement should be completed by an indication of the period, usually limited, of the observation.

For a prolonged modulation (or restitution), it will be appropriate to consider the probability that an assigned value of the degree of distortion will be exceeded.

Degree of start-stop distortion (Definition 33.08 of the 1st Supplement to the List)

(a) Ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and theoretical intervals separating any significant instant of modulation (or of restitution) from the significant instant of the start element immediately preceding it.

(b) The highest absolute value of individual distortion affecting the significant instants of a start-stop modulation.

The degree of distortion of a start-stop modulation (or restitution) is usually expressed as a percentage.

Note 1. – Same as the note to Definition 33.07.

Note 2. – Distinction can be made between the degree of *late* (or positive) distortion and the degree of *early* (or negative) distortion.

Degree of gross start-stop distortion (Definition 33.09 of the List)

Degree of distortion determined when the unit interval and the theoretical intervals assumed are exactly those appropriate to the standardized modulation rate.

Note. – As for Definition 33.07.

Degree of synchronous start-stop distortion (i. e. at the actual mean modulation rate) (Definition 33.10 of the List)

Degree of distortion determined when the unit interval and the theoretical intervals assumed are those appropriate to the actual mean rate of modulation (or of restitution).

Note 1. – As for Definition 33.07.

Note 2. – For the determination of the actual mean modulation rate, account is only taken of those significant instants of modulation (or of restitution), which correspond to a change of condition in the same sense as that occurring at the beginning of the start element.

Characteristic distortion (Definition 33.15 of the List)

Distortion caused by transients which, as a result of the modulation, are present in the transmission channel and depend on its transmission qualities.

Fortuitous distortion (Definition 33.16 of the List)

Distortion resulting from causes generally subject to random laws (accidental irregularities in the operation of the apparatus and of the moving parts, distubances affecting the transmission channel, etc.).

Bias distortion, Asymmetrical distortion (Definition 33.17 of the List)

Distortion affecting a two-condition (or binary) modulation (or restitution), in which all the significant intervals corresponding to one of the two significant conditions have longer or shorter durations than the corresponding theoretical durations.

Character error rate of a telegraph communication (Definition 33.19 of the 1st Supplement to the List)

Ratio of the number of alphabetic signals of a message incorrectly received (after automatic translation, where applicable), to the number of alphabetic signals of the message, the keying being correct.

Note 1. – A telegraph communication may have a different error rate for the two directions of transmission.

Note 2. – The notion of character error rate could be applied to any operation taking place in a telegraph communication (e. g. keying, translation, etc.).

Note 3. – The statement of the error rate will be accompanied by that of the time interval, generally limited, during which the observation was made. For a communication established for a sufficiently long time, the probability of exceeding an assigned value of error rate could be considered.

Note 4. – Faulty translation, resulting from a previous error in functional control (such as shift, line feed, synchronism, etc.), is not counted in calculating a character error rate; in such a case, the error in the functional control signal is alone counted and is counted only once.

Element error rate (Doc. 203 of Geneva, 1963)

The ratio of the number of unit elements incorrectly received to the total number of unit elements sent.

Efficiency factor in time (of a telegraph communication with automatic repetition for the correction of errors) (Definition 33.23 of the List)

Ratio of the time necessary to transmit a text automatically without repetition, at a specified modulation rate, to the time actually taken to receive the same text with a given error rate.

Note 1. – The whole of the apparatus comprising the communication is assumed to be in the normal conditions of adjustment and operation.

Note 2. – A telegraph communication may have a different efficiency factor in time for the two directions of transmission.

Note 3. – The actual conditions in which the measurement is made should be specified, in particular the duration of the measurement.

Mutilation (Definition 33.24 of the List)

A transmission defect in which a signal element becomes changed from one significant condition to another.

Transposition * (Definition 33.25 of the List)

A transmission defect in which, during one character period, one or more signal elements are changed from one significant condition to the other, and an equal number of elements are changed in the opposite sense.

RECOMMENDATION 346 **

FOUR-FREQUENCY DIPLEX SYSTEMS

(Question 183(III))

The C.C.I.R., (Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

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 signals corresponding to two telegraph channels; it being understood that either one, 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 standardize 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 correspondence between the frequencies and the significant conditions of the channels;

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* See also Annex II, Part 2, definition *k* of Recommendation 342.

** This Recommendation replaces Recommendation 247.

(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;
- that 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;

(g) that it is desirable to use only one coding system, the simpler the better;

UNANIMOUSLY RECOMMENDS

1. that the following preferred values should 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*	200**

2. that the following coding system should be adopted: ***

Frequency of emission	Channel 1		Channel 2	
	Teleprinter	Morse	Teleprinter	Morse
f_4 (highest frequency)	A	Mark	A	Mark
f_3	A	Mark	Z	Space
f_2	Z	Space	A	Mark
f_1 (lowest frequency)	Z	Space	Z	Space

where f_1, f_2, f_3, f_4 designate the frequencies of the emissions; the spacings between adjacent frequencies $(f_4 - f_3)$ $(f_3 - f_2)$ $(f_2 - f_1)$, being equal,
A represents the start signal of the teleprinter,
Z represents the stop signal of the teleprinter;

3. 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;

4. that, when the two channels are not synchronized, it is desirable to limit the maximum rate of change of frequency to minimize the bandwidth of the emission.

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* Lower telegraph speeds may be used with these spacings at present.

** Synchronous operation with phase-locked channels.

*** Where modification of equipment is required, it is recognized that it may take some time before the coding systems indicated in this paragraph can be implemented on circuits between different Administrations.

RECOMMENDATION 347 *

CLASSIFICATION OF MULTI-CHANNEL RADIOTELEGRAPH SYSTEMS FOR LONG-RANGE CIRCUITS OPERATING AT FREQUENCIES BELOW ABOUT 30 Mc/s AND THE DESIGNATION OF THE CHANNELS IN THESE SYSTEMS

The C.C.I.R., (Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that there exists a large number of long-range multi-channel radiotelegraph systems using frequencies below about 30 Mc/s and that it is desirable to classify them in categories;

(b) that the lack of uniformity in the arrangement and designation of the channels in these systems, may give rise to certain difficulties when one transmitting station has to work with several receiving stations;

(c) 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 systems should be classified and the different categories designated by letters, as follows:

1.1 *Time-division multiplex systems :* capital letter T (for example, synchronous systems, such as Baudot, RCA and TOR multiplex and double-current cable code);

1.2 *Frequency-division multiplex systems*

1.2.1 Systems with *constant* frequency arrangements of significant conditions: capital letter U (for example: voice-frequency multiplex with frequency shift);

1.2.2 Systems with *variable* frequency arrangements of significant conditions: capital letter V (for example: four-frequency diplex);

1.3 *Multi-channel systems using a combination of these processes*

1.3.1 Frequency-division systems, with constant frequency arrangement, combined with a time-division multiplex; 1.3.2 Four-frequency diplex system, combined with a time-division multiplex system.	combination of the above-mentioned letters (always beginning with the frequency division letters U or V)

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 348;

3. when a multi-channel telegraph signal is applied to an independent-sideband transmitter used solely for telegraphy, the designation of the sideband should come first in the sequence. The letter H should denote the upper sideband, and the letter L the lower sideband;

4. that in time-division systems, the telegraph channels should be designated by capital letters A, B, C, D, etc.; for sub-division, the sub-channels should be designated by A1, A2, A3, A4, B1, B2, B3, B4, etc.;

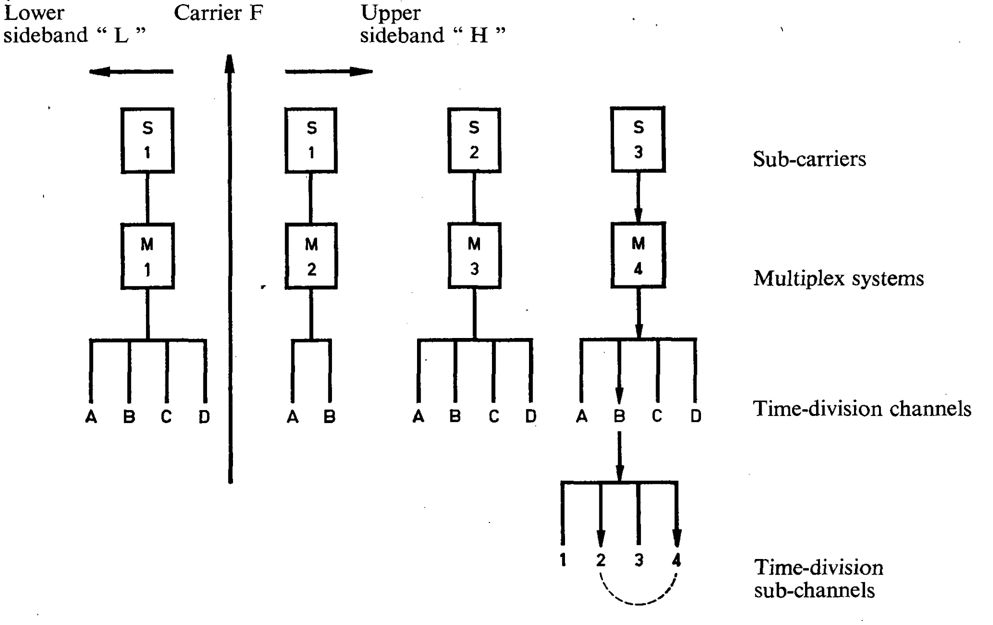
5. that in frequency-division systems, the telegraph channels should be designated by figures;

* This Recommendation replaces Recommendation 248.

6. 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 (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 ";
where channel B of the time-division system is sub-divided 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, the corresponding designation would be " BU3TB " or " BU3TB2 ";
if the above-mentioned system is applied to the upper sideband of an independent-sideband multi-channel transmitter used solely for telegraphy, the corresponding designation would be " HU3TB " or " HU3TB2 ";
where additional information is required, the multiplex system may be identified by a number inserted between the letters T and B, and where two sub-channels (quarter-channels) are linked together to form a half-speed sub-channel (half-channel), each quarter-speed sub-channel component may be designated by the use of numbers separated by an oblique stroke. The full designation " HU3T4B2/4 " would be applicable to the arrangement shown diagrammatically by the arrows on the right of the figure below;
in established communication networks, where the sub-carrier, multiplex system, channels and sub-channels arrangements are mutually known to the station management at each end of the circuit, it shall be permissible to shorten the full designation " HU3T4B2/4 " above, beginning at the first letter or number which is of major significance for identification purposes. For example, in the given instance " 4B2/4 " will identify the specific area illustrated by the arrows to the right of the figure below.



Multi-channel independent-sideband radiotelegraph transmitter

Note. – Sub-carriers are numbered sequentially in both upper and lower sidebands, starting with the number 1, adjacent to the carrier (radiated or suppressed).

RECOMMENDATION 348 *

ARRANGEMENT OF CHANNELS IN MULTI-CHANNEL SINGLE-SIDEBAND AND INDEPENDENT-SIDEBAND TRANSMITTERS FOR LONG-RANGE CIRCUITS OPERATING AT FREQUENCIES BELOW ABOUT 30 Mc/s

(Question 74(III))

The C.C.I.R., (London, 1953 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

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 economize in the use of the radio-frequency spectrum, when considering inter-continental circuits consisting mainly of single long-distance radio links, operating on frequencies below 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.T.T. for land-line circuits;
- to reduce the upper frequency to 3000 c/s or less but not below 2600 c/s, except in special circumstances;

(c) that there are already in operation international multi-channel radiotelephone circuits, in which the bandwidth allocated to each channel is 3000 c/s, but are 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;

(g) that there are advantages in adopting channel arrangements which are the same in all parts of the HF (decametric) range;

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, 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*;

* This Recommendation replaces Recommendation 249.

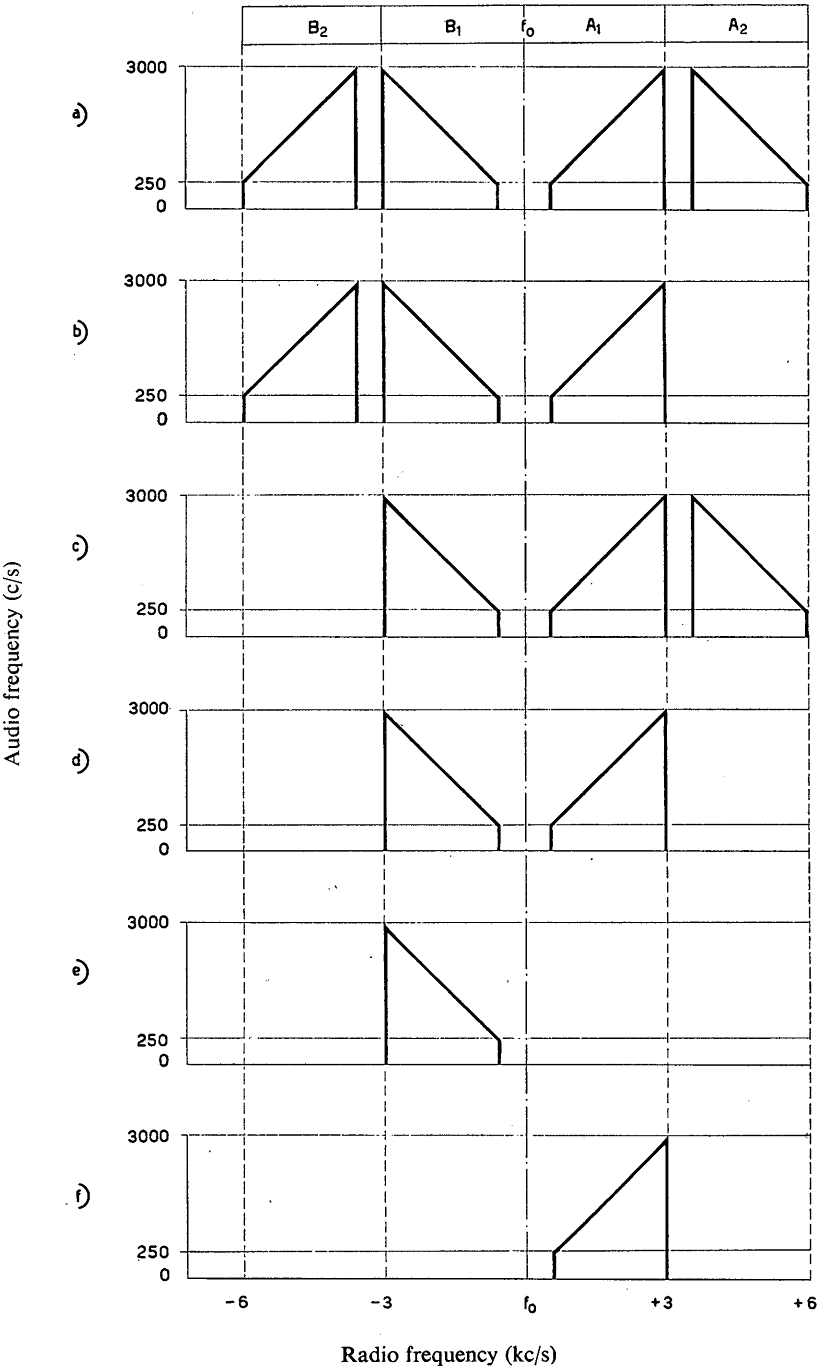


FIGURE 1

Relationship between audio-frequencies and radio-frequencies for the various channel arrangements

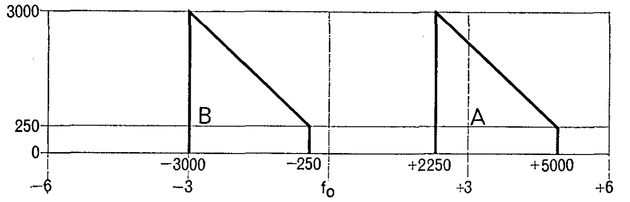


FIGURE 2

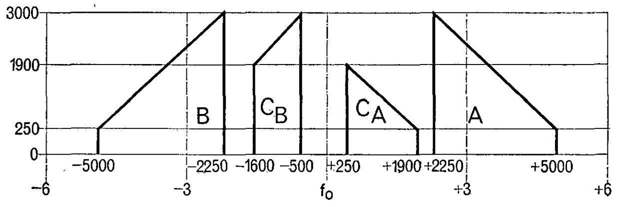


FIGURE 3

Note. – It is necessary that the subdivision of channel C into two parts, CA and CB, as well as the arrangements of these parts, should be agreed upon by the operating organizations.

6. 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 minimize cross-talk;

7. 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;

8. that the effective date of these arrangements be fixed by the next Administrative Radio Conference.

RECOMMENDATION 349

FREQUENCY STABILITY REQUIRED FOR SINGLE-SIDEBAND, INDEPENDENT-SIDEBAND AND TELEGRAPH SYSTEMS TO MAKE THE USE OF AUTOMATIC FREQUENCY CONTROL SUPERFLUOUS

(Question 182(III))

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that it is the practice with single-sideband (SSB) and independent-sideband (ISB) telephone systems, and with many telegraph systems, to employ automatic frequency control (a.f.c.) to adjust the receiver oscillator frequency in sympathy with frequency variations of the transmitted signal;

(b) that such a.f.c. systems may give rise to difficulty under unfavourable conditions of propagation;

(c) that the frequency stability, which can now be achieved, is much higher than that laid down in Appendix 3 to the Radio Regulations, Geneva, 1959, and is approaching a value which could provide sufficient inherent stability to enable a.f.c. to be dispensed with. However, in certain cases when narrow-shift telegraph systems are employed, reasons other than stability require the use of a.f.c.;

UNANIMOUSLY RECOMMENDS

1. that the values of permissible frequency deviations, given in the Table below, should be considered as suitable for use on systems dispensing with automatic frequency control;

2. that in view of § *d)* of Question 182(III), the study of this Question should be continued for narrow-shift systems.

System	Maximum permissible overall error (c/s)	Frequency deviation (c/s)		Permissible frequency errors due to the radio-frequency translating stages at both ends and to the propagation path (c/s)(3)
		Modulator stages	Demodulator stages	
1. SSB and ISB telephony	20	5	5	10
2. Radiotelegraphy:				
2.1 Two-tone multichannel VF (e.g. 100 baud, channel spacing 340 c/s)	12(1)	3	3	6
2.2 Phototelegraphy(2)	16	4	4	8
2.3 F1 or F6 systems using narrow band filters at the receiving end	12	3	3	6
2.4 Reception by limiter/discriminator; mod. index $\approx$ 2; 196 baud, 400 c/s shift	20	3	3	14

(1) See Doc. III/27 of Geneva, 1962.

(2) For short-term frequency stability, see Recommendation 344. The figures under § 2.2 should be considered as provisional pending a reply by the C.C.I.T.T. to the questions put to it by the C.C.I.R. (see Doc. III/66 (Rev.) of Geneva, 1962).

(3) This is the maximum error at the demodulator in the frequency of the carrier, if transmitted.

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REPORTS OF SECTION C: FIXED SERVICES

REPORT 19 *

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(Question 43(III))

(London, 1953)

The C.C.I.R. has carried out certain studies, in answer to Question 43(III), 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.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-frequency 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;
- 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 realized that the use of voice-frequency equipment on radio circuits may become impossible when reception conditions are poor.

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* This Report was adopted unanimously.

REPORT 42 *

USE OF RADIO CIRCUITS IN ASSOCIATION WITH 5-UNIT START-STOP TELEGRAPH APPARATUS

(Study Programme 3A(III))

(London, 1953 – Warsaw, 1956)

The principal factors determining the error rate in a radiotelegraphy transmission arise from the fact that:

– radio propagation is essentially variable,

– 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 frequency. 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 emphasizes 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.

For relatively high telegraph speeds (200 bauds), when the appearance of errors may correspond with an increase in the distortion of the signal received, synchronized systems are more reliable because of the wider margin they provide.

For lower speeds, the chief disadvantage of start-stop systems lies in the risk of a transient loss of synchronizm during the mutilation of a start or a stop signal.

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* This Report, which replaces Report 30, was adopted unanimously.

REPORT 106 *

IMPROVEMENT OBTAINABLE FROM THE USE OF DIRECTIONAL ANTENNAE

(Question 81(III))

(London, 1953 – Warsaw, 1956 – Los Angeles, 1959)

1. Introduction

Contributions by Administrations to the VIIIth Plenary Assembly, Warsaw, 1956, and to the interim meeting of Study Group III, Geneva, 1958, provide a basis for a preliminary report on the question of signal power gain, and signal-to-interference discrimination, afforded in practice by rhombic antennae. The experimental observations given by Docs. III/4 and III/31 of Geneva, 1958, are summarized, as well as the pertinent Docs. 19, 139, 265, 320 and 532 of Warsaw, 1956. The relation of these preliminary results to the median gain, given by Recommendation 162, is indicated.

In the text below:

l = length of leg (m).
φ = half the obtuse angle (deg).
h = height above ground (m).

2. Summary and discussion of reported results

Doc. III/4 (Federal Republic of Germany) of Geneva, 1958, contains a summary (Table I below) of median values of measurements made, using a rhombic of a type in general service in the Post Administration, having $l = 115$ m, $h = 20$ m, $\varphi = 75°$. This first set of measurements was made relative to a *vertical antenna*; the results are otherwise expressed in the form of the Annex to Recommendation 162:

TABLE I

Frequency (Mc/s)	Median value of gain relative to main lobe (direction of optimum gain) (db)				Azimuthal ranges (degrees)		
	main lobe	In Arc *A*	In Arc *B*		Half of main arc	Arc $A_1 = A_2$	Half of arc *B*
			Unidirectional antenna	Reversible antenna			
10	0	−8	−21	−12	23	22	135
15	0	−6		−17	18	29	133
20	0	−8	−23	−15	13	24	143

In Doc. III/31 of Geneva, 1958, there are also reported the results of observations of the gain of the rhombic antenna in the main lobe, relative to a half-wave horizontal antenna. These observations were, in the main, made at 15 Mc/s receiving WWV which transmits with an omnidirectional antenna, but there is also one set of observations made at 18 Mc/s receiving

* This Report was adopted by correspondence without reservations.

PPZ which transmits with a directional antenna. The data show the realized gain to be less than the plain-wave gain in direction of maximum response, and to have a striking variability with time of day and/or signal strength. The data are not adequate to establish a systematic diurnal variation, but the 15 Mc/s data suggest that the greatest values of gain are realized at times of high signal intensity. This result is contradicted by the observations at 18 Mc/s of transmissions from a distant directional antenna, which emphasizes the need for additional observations and draws attention to the virtually certain dependence of all such observations on the *directivity of antennae at both ends of the path.* Table II below gives the decile and median values of the gain realized in these tests.

TABLE II

Period	Gain 10% (db)	Gain 50% (db)	Gain 90% (db)
Receiving WWV 15 Mc/s			
11–22 June 1956 130 observations	12·9	9·1	6·7
28 July–6 August 1956 117 observations	15·2	11·7	7·7
29 Sep.–11 Oct. 1956 217 observations	12·9	10·7	6·8
28 Feb.–23 Mar. 1957 405 observations	10·8	7·1	0·0
15–25 January 1958 162 observations	11·1	8·5	3·2
Receiving PPZ 18 Mc/s			
29 Sep.–10 Oct. 1956	13·0	7·8	4·4

Doc. 139 (United Kingdom) of Warsaw, 1956, gives results of the power gain and discrimination of rhombic receiving antennae, that is, off-azimuth response relative to maximum response. The measurements were made receiving distant transmissions at 13 and 20 Mc/s, using a ring of 30 antennae having $l = 81$ m, $h = 23$ m, $\varphi = 70^{\circ}$. The results are given in Table III for the main lobe and the forward arc (180°) excluding the main lobe, and for the backward arc.

TABLE III

Frequency	Main lobe gain (db)	Gain relative to half-wave horizontal dipole(1) (db)					
		Forward arc (180°) excluding main lobe			Backward arc (180°)		
		Gain 10%	Gain 50%	Gain 90%	Gain 10%	Gain 50%	Gain 90%
13·4 Mc/s (New York)	11	−2·5	−11	−19·5	−8·3	−12·7	−17
20·4 Mc/s (Pretoria)	15	3·5	− 5·0	−13·5	−4·3	− 8·7	−13
20·4 Mc/s (Pretoria)	15	2·5	− 6·0	−14·5	−9·2	−13·6	−18

(1) Median and decile values, are relative to the arc except for the main lobe.

More detailed data are given in the same document; an examination of the data for all observed azimuths has been made, and median values of gain obtained for the arcs specified in Recommendation 162, as follows:

TABLE IIIa

Frequency	Median value (¹) of gain relative to half-wave dipole (db)			Azimuthal range (degrees) (Rec. 162)		
	Main azimuth	Arc *A*	Arc *B*	Half of main arc	Arc $A_1 = A_2$	Half of arc *B*
13·4 Mc/s (New York)	11	−5	−13	12	21	147
20·4 Mc/s (Pretoria)	15	2	−10	8½	18½	153

(¹) Median values, are relative to the arc except for the main azimuth.

It is worth noting that values given in Table IIIa, with respect to discrimination against off-azimuth signals, are somewhat better than the values shown in Recommendation 162; it seems unlikely that values as favourable as those given in Tables III and IIIa are generally realized in practice. The value for arc *A* at 13 Mc/s is in fact better than might, at first sight, be expected; but, especially in arc *A*, the available data were not adequate to establish a median value with much confidence.

Doc. 265 (Netherlands) of Warsaw, 1956, summarized experimental observations of the power gain in the main azimuth, and for certain discrete directions off the main azimuth are given. The values of gain are for receiving rhombic antennae, expressed relative to a horizontal half-wave antenna at the same height. Directional antennae were also used at the transmitters for the measurements. The design data for the receiving antennae used at Amsterdam, for which observations are summarized in this document, are as follows:

Antenna	*A*	*B*
Length *l* (m)	120	174·5
Height *h* (m)	33	29·5
Angle φ (deg)	71	70
Design frequency (Mc/s)	14·5	7·5

The gain measurements for the main lobe were made on a long propagation path (7500 km), whereas some of the observations of gain off-azimuth were for a medium range path (3000 km). The results gave values of realized gain which are less than expected theoretically. The data showed marked variability of gain and/or discrimination with time of day and somewhat with season, though the data did not establish a systematic seasonal dependence, there was an apparent tendency for the highest values of gain in the main azimuth to be observed during periods corresponding to maximum daylight on the path; a depression of gain appeared systematically in the morning hours on the path. These data were reported for 13 Mc/s which was not worked throughout the night hours. Values of gain in directions off the main azimuth also showed marked variability with time of day and season, but the data were not conclusive as to any systematic pattern. Table IV below summarizes the observations.

TABLEAU IV

Antenna	Frequency (Mc/s)	Gain relative to half-wave horizontal antenna (db)									
		Main lobe				Distance (km)	Azimuth relative to main lobe (degrees)	Off-azimuth			
		Hours of obs.	Gain 10%	Gain 50%	Gain 90%			Hours of obs.	Gain 10%	Gain 50%	Gain 90%
A	7·7	83	9·4	8·3	6·7	2000	317	17	8·5	5·6	2·4
	13·7	158	13·4	11·4	8·8	3200	236	49	−7·3	− 8·7	−10·3
	13·7					9300	143	56	−2·9	−10·7	−13·5
	13·7					2000	14	14	1·8	0·5	− 1·4
	13·7					5800	37	42	6·1	4·5	0·2
	17·6	46	14·2	13·3	12·1						
B	7·7	30	15·0	11·4	7·6						
	13·7	50	13·7	11·0	9·2						
	17·6	34	9·9	7·8	6·0						

Doc. 320 (Japan) of Warsaw, 1956, concludes that discrimination of greater than 15 to 20 decibels cannot be relied upon; a number of observations are cited for values of discrimination (response outside the main lobe, relative to response in the main lobe), for a rhombic antenna having values of $l = 120$ m and $\varphi = 70°$ (height unspecified). These are shown in Table V below; there were not enough data available to permit statistical analysis in terms of the arcs of Recommendation 162.

Doc. 19 of Warsaw, 1956, draws attention to azimuthal variations of signals propagated over great distances via the ionosphere, in relation to realized directivity of antennae at great distances. Measured azimuths show only slight differences among the values of deviation for propagation paths of various lengths. 80% of the measurements showed less than $\pm 2°$ average deviation; 98% showed average deviation less than $\pm 4°$. The shortest link observed (2000 km), showed the greatest deviation and the longest path the least deviation.

3. Conclusions

The present data do not offer an adequate basis for revision of Recommendation 162. The results show striking variability of gain and/or discrimination with time, especially time of day and, to some extent, season of the year. There are undoubtedly important effects near times of sunrise and sunset, at times of signal failure on operating frequencies near the MUF, and at times of ionospheric disturbance when great azimuth deviations can be observed. Statistical correlation of values of gain with values of transmission loss would be of interest and the data expected from Study Programme 81A(III) may be expected to show whether, and under which circumstances, such a correlation exists. The data given above suggest the extent of azimuth deviation encountered during normal propagation conditions. It must be noted that, because of the influence of irregularities in the ionosphere, such as give rise to azimuth-deviations, the directivity gain realized at the receiving terminal depends in a fundamental way on the directivity of the transmitting antenna—and vice versa. It is, therefore, important in carrying out observations (such as those outlined in Study Programme 81A(III)), to specify the directivity of antennae at both terminals.

TABLE V

Median values of discrimination in decibels

(Off-azimuth response relative to main lobe)

Difference in azimuth (degrees)	Frequency ranges (Mc/s)					
	10·3 to 12·2		13·3 to 14·5		14·5 to 15·6	
	Median	Median standard deviation	Median	Median standard deviation	Median	Median standard deviation
6					3·8	2·1
12½			12·5	2·0	8·9	2·5
18½					8·0	3·2
21					9·8	1·4
22			7·5	2·9		
25½	9·3	1·4				
27					13·5	1·7
39½					12·5	2·1
46½					14·5	1·4
52½					17·6	2·0
79½			19·8	2·8		
93			12·5	3·6		
109½			20·3	3·8		
117	15·5	2·1				
168½			11·8	3·4		

REPORT 107 *

DIRECTIVITY OF ANTENNAE AT GREAT DISTANCES

(Question 81(III))

(Los Angeles, 1959)

Methods of testing the directivity of antennae at great distances have been:

(a) the " Statistical method ", a comparison of numerous observations of the same signal on different fixed antennae at the same location but at different orientations. [1, 2 and 3.]

(b) Mechanical rotation of antenna structures with various approaches to data statistics. [4 and 5.]

(c) the " Back-scatter " method, a comparison of back-scatter signals in a method similar to that of *(a)* above. [6.]

Most of the studies have been made at high frequencies, although at least one was performed in the standard MF broadcast band [7].

References [4] and [5] indicate that, at moderately long distances the main lobes are on the average preserved, even under conditions of severe ionospheric disturbance. A more serious matter, which merits further study, is the question of preservation of nulls and front-to-back ratios. Reference [7] indicates that these are not preserved at medium frequencies. Measurements of these effects are very difficult because of noise and interference. Besides, electrical balance, at both polarizations in antennae, feeders, and equipment antenna circuits, is a very critical matter in the realization of nulls and minima with rhombic antennae in ionospheric propagation [8].

References [9] and [10] deal with non-great-circle effects. These effects were noted in the 1930's [11].

The effect of the propagation medium on transmission loss at different antenna orientations is dealt with in [12].

The directivity of antennae at great distances is dealt with in the following documents:

- Question 81(III) – Directivity of antennae at great distances.
- Study Programme 81A(III) – Improvement obtainable from the use of directional antennae.
- Recommendation 162 – The use of directional antennae.
- Report 106, – Report on Study Programme 85, outlining the results of experiments in the Federal Republic of Germany (Docs. III/4 and III/31 of Geneva, 1958), United Kingdom (Doc. 139 of Warsaw, 1956), Netherlands (Doc. 265 of Warsaw, 1956) and Japan (Doc. 320 of Warsaw, 1956), in which the " statistical method " was used for the determination of gain in the 3 azimuthal arcs *M*, *A*, and *B*, specified in Recommendation 162. It was recognized that these gains were in some way dependent upon ionospheric conditions. It was also noted that the directivity gains were to some extent a function of the directivity of both antennae.

Note. – It is noteworthy that in the IRE Standards on transmitters, modulation systems and antennae, 1948, the definition of " directivity " is: " the value of the directive gain in the direction of the maximum value ", thus differing from the usage of this Report.

* This Report was adopted by correspondence without reservations.

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REPORT 109 *

RADIO SYSTEMS EMPLOYING IONOSPHERIC-SCATTER PROPAGATION

(Question 132(III))

(Los Angeles, 1959)

A contribution, relating to Question 132(III), has been received from the U.S.A. (Doc. III/29 of Geneva, 1958); references are cited in which information on ionospheric-scatter propagation relevant to exploitation of systems has been published [1, 6].

1. Variation with frequency of propagation characteristics relevant to the use of systems

For estimation of the performance of fixed systems, it is important to know the variation with frequency, of the mean signal intensity, the fading characteristics, such as short term amplitude distribution and fading rate, and the background galactic noise level. For practical

* This Report was adopted by correspondence. The United Kingdom reserved its opinion on this Report.

purposes, received power may be considered inversely proportional to approximately the 7th power of the frequency, using scaled antennae. The background galactic noise is inversely proportional to the 7/3 power of the frequency. The resulting signal-to-noise ratio, using scaled antennae, is proportional approximately to f^{-5}. Studies have shown that the frequency dependence during hours of weakest signal intensity is not significantly different from that observed for the mean signal intensity. The short-term amplitude distribution of signal intensity approximates a Rayleigh distribution at frequencies observed in the range of 30 to 74 Mc/s. The typical measured fading rate (median crossings), at 50 Mc/s, is approximately 1 c/s; the fading rate is proportional to operating frequency raised to a power of 0·7 to 1·2, depending on conditions.

Another important propagation characteristic which varies with frequency is the occurrence of long distance F2 propagation giving rise to mutual interference and back-scatter, which represents a source of self-interference to a scatter system used for high-speed telegraph services. The occurrence of this type of propagation is dealt with in the following paragraphs, along with consideration of mutual interference.

2. The extent to which systems employing this mode of propagation and operating on the same or neighbouring frequencies are liable to interfere with each other and with other services

The propagation modes, most significant in long distance interference between scatter services and other services, are sporadic-E and F2. Adequate world-wide measurements of sporadic-E are not yet available to permit a complete evaluation of the percentage of time that interference is likely to occur. A comprehensive study of world-wide occurrence of Es observed at HF by ionosphere recorders has been published [7, 8]. For practical purposes, ionospheric-scatter circuits, to avoid sporadic-E interference, should have their transmitting and receiving terminals geographically separated from other circuits or services by at least 3000 km. Figs. 1–12 represent contours of F2—4000 km MUF exceeded 1% and 10% of the hours during three seasons of the year at times of sunspot maximum and minimum. These are derived from standard C.R.P.L. F2 prediction data, using measured distributions of day-to-day values of F2 MUF about the median. A circle of 2000 km radius centred on the station gives the locus of frequencies at which propagation over 4000 km paths occurs 1% or 10% of the time during the season indicated. The percentage of the time is less for paths longer or shorter than 4000 km. Figs. 1–12 inclusive may be regarded as provisional and subject to revision at such time as the C.C.I.R. may adopt appropriate data regarding F2 MUF values.*

3. Radio frequency and baseband characteristics of ionospheric-scatter systems

Ionospheric-scatter systems of high reliability are currently in operation and the number of such systems may be expected to increase. These systems employ highly directional antennae and transmitter output powers of the order of 40 kW.

In view of rapid technical advances, standardization is not practical at this time. Therefore, the modulation characteristics of typical systems in use or under consideration are presented for illustration:

(a) a single voice channel of response from 300 to 3100 c/s using SSB, or narrow-band frequency modulation with a peak deviation of 3 kc/s;

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* Revised versions of Figs. 1, 3 and 5 have been issued as Fig. 1, 2 and 3 in Report 260 (Vol. II, Section G).

(b) four to sixteen channel, time-division multiplex, at a rate of 150 to 600 bauds with frequency-shift keying; a separation of 6 kc/s is commonly used between mark and space frequencies, to minimize errors due to Doppler components;

(c) combinations of the above, using linear transmitters, such as a voice channel and an FSK system or two independent FSK systems; as an alternative, two transmitters may be used, with one carrying voice intelligence and the other teleprinter;

(d) a system has been proposed with a single voice channel and four channels of teleprinter, using error correction and detection techniques at 177 bauds. A typical assignment for 20 kc/s spectrum occupancy is shown in Fig. 13.

Modulation characteristics of the propagation medium must be considered in system application. Some pertinent characteristics are:

(a) diversity reception is beneficial for voice or teleprinter operation. Dual or triple diversity is commonly used;

(b) the coherence bandwidth, as determined by multipath considerations of the transmission medium, is limited to approximately 3 kc/s;

(c) meteoric multipath will, in general, limit the maximum baud rate;

(d) during periods where the MUF may be above the operating frequency, F2 propagation may be expected. The above conditions are frequently accompanied by long-delay multipath echoes, ranging up to 50 ms or more. The echo pulses may have amplitudes comparable to or even greater than the desired signal, thus resulting in a very high error rate. Long-delay multipath problems may find solution by the use of antennae having more desirable directivity characteristics, the use of a frequency above MUF, or by the use of special modulation techniques;

(e) ionospheric-scatter systems characteristically employ high power and highly directional antennae; during periods of sporadic-E or high MUF, they must be considered as potential sources of interference to other services sharing the same frequency band;

(f) current four-channel teleprinter systems, using dual-space diversity, typically require a signal-to-noise ratio of 24 db (noise measured in a 250 c/s band), for a binary error rate of 1×10^{-4};

(g) voice systems currently in use will provide usable operator-to-operator quality over a single link with a radio-frequency signal-to-noise ratio of approximately 14 db, as measured in a 3 kc/s noise bandwidth.

The frequencies used for this mode of propagation are generally between 30 and 40 Mc/s. A few circuits currently being installed will use dual-frequency operation. Higher frequencies, perhaps as high as 60 Mc/s, will be useful as a means to avoid distance propagation during periods of high F2 MUF's at time of maximum solar activity.

The distances over which these circuits operate generally range from 1000 to 2000 km, and several of these circuits are now in operation in arctic regions.

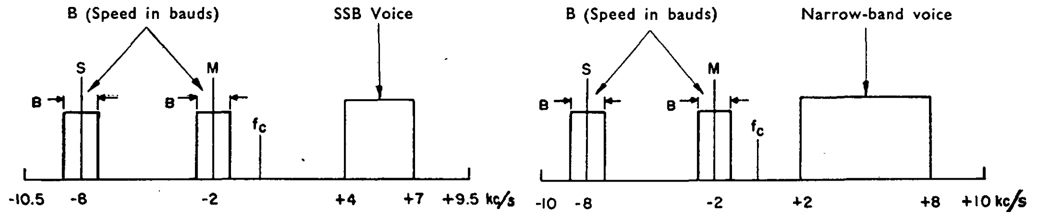

FIGURE 13

Typical 20 kc/s spectrum assignments for ionospheric-scatter transmission
(B is the frequency in c/s corresponding to the telegraph speed in bauds)

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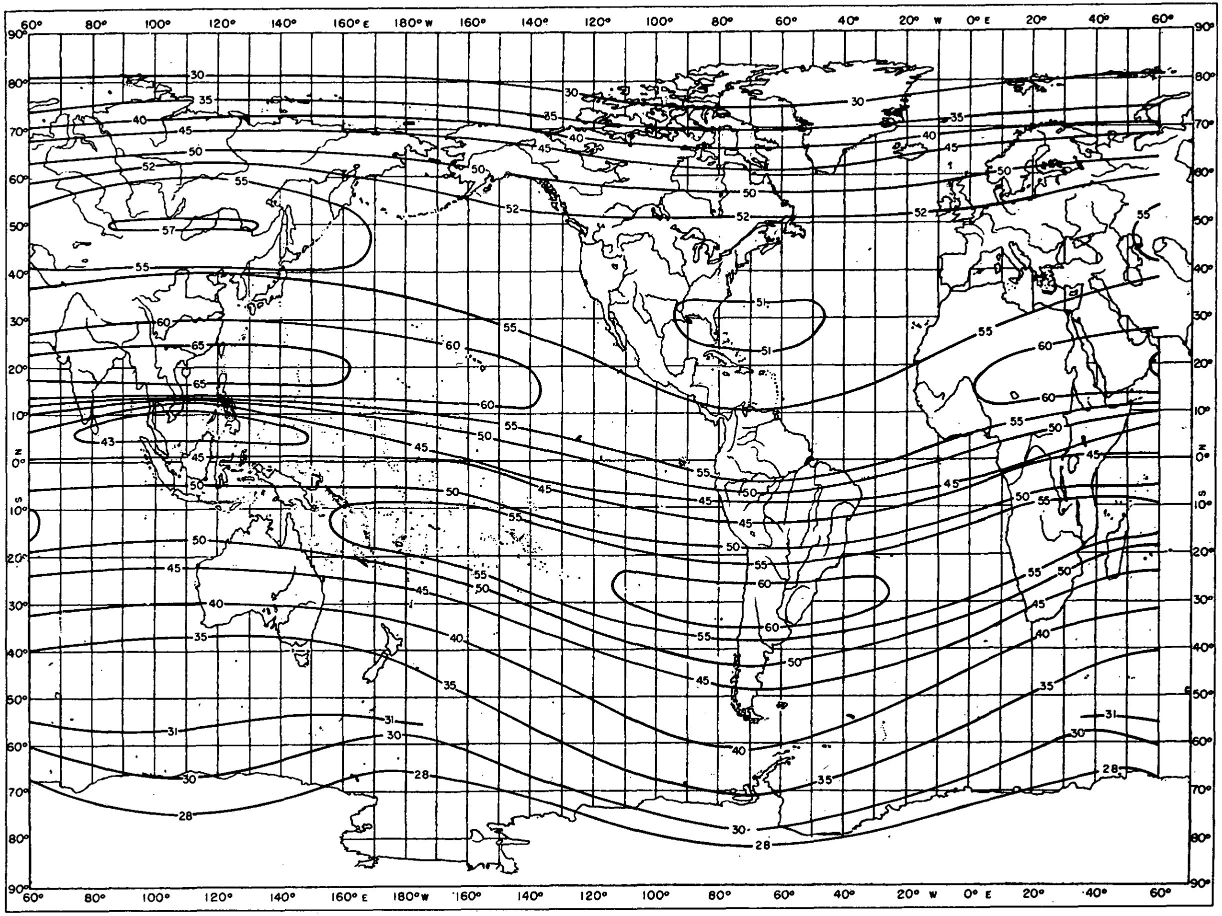

FIGURE 1

Values of the F2 4000 MUF exceeded for 1% of hours; December solstice, sunspot maximum

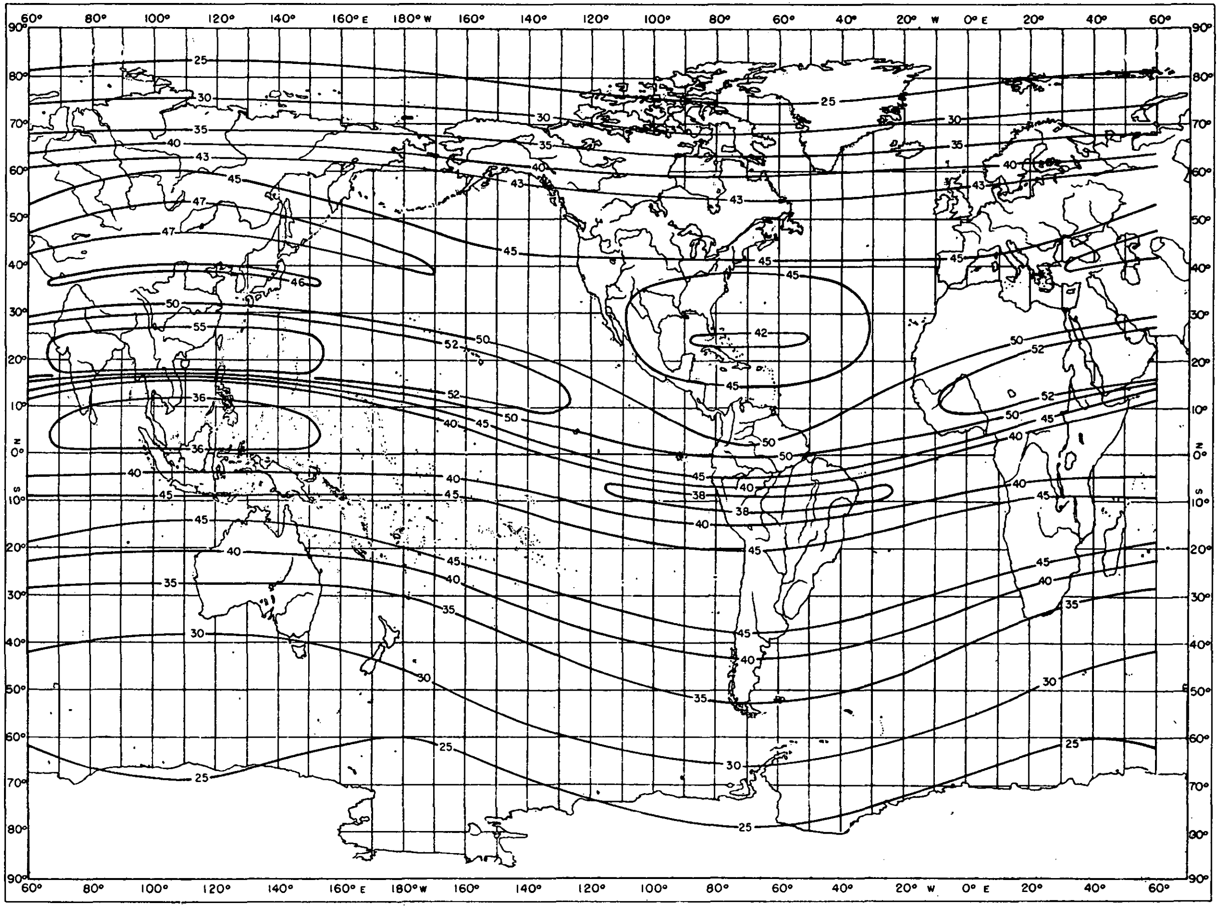

FIGURE 2

Values of the F2 4000 MUF exceeded for 10% of hours; December solstice, sunspot maximum

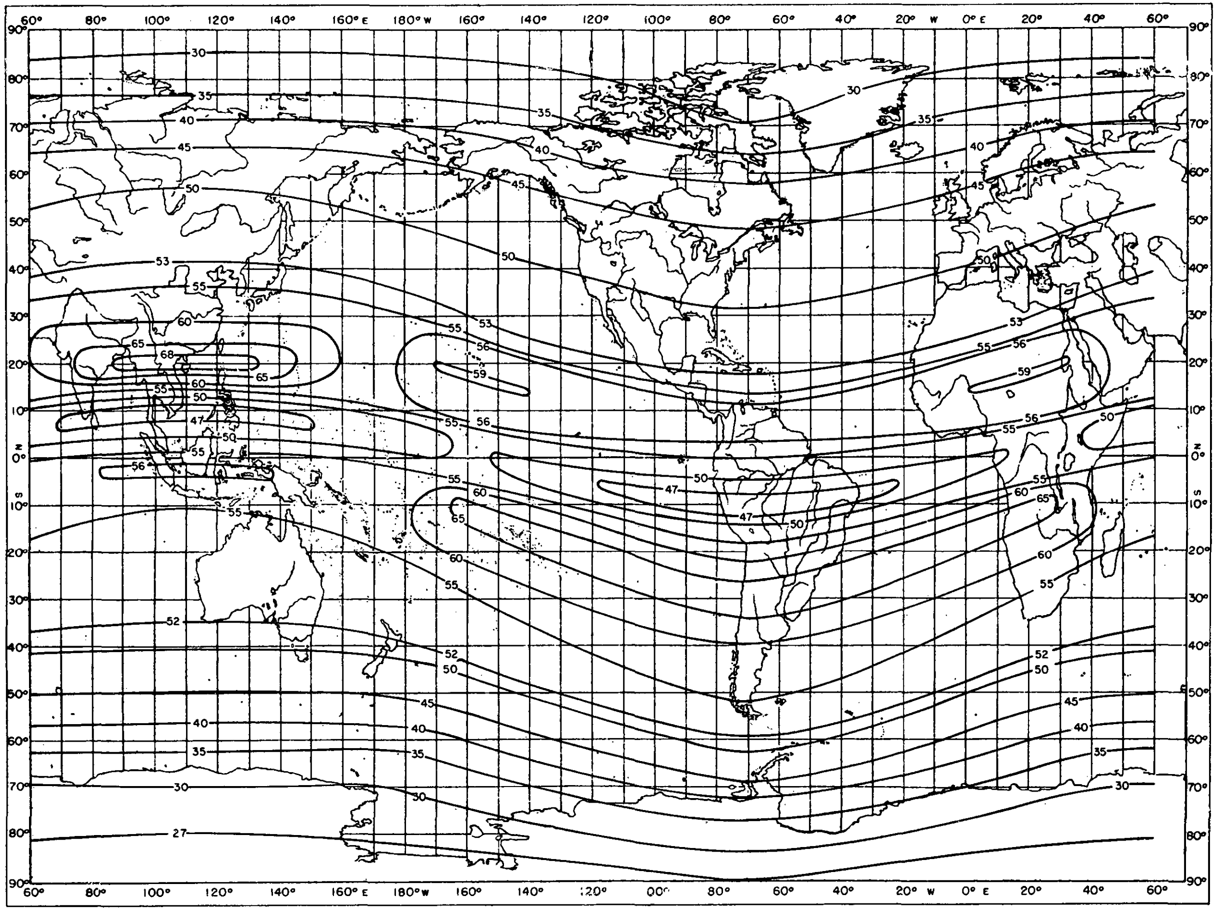

FIGURE 3

Values of the F2 4000 MUF exceeded for 1% of hours; Equinox, sunspot maximum

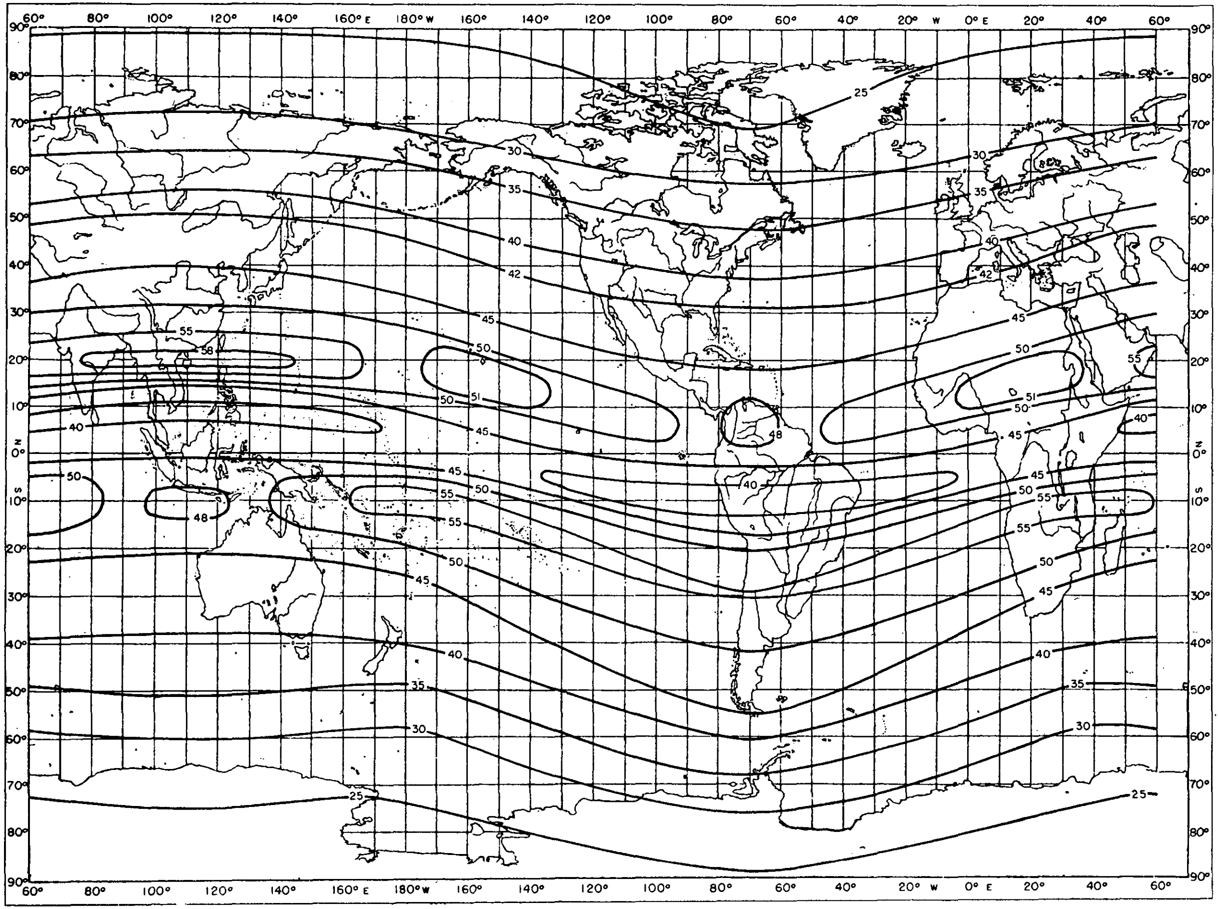

FIGURE 4

Values of the F2 4000 MUF exceeded for 10% of hours; Equinox, sunspot maximum

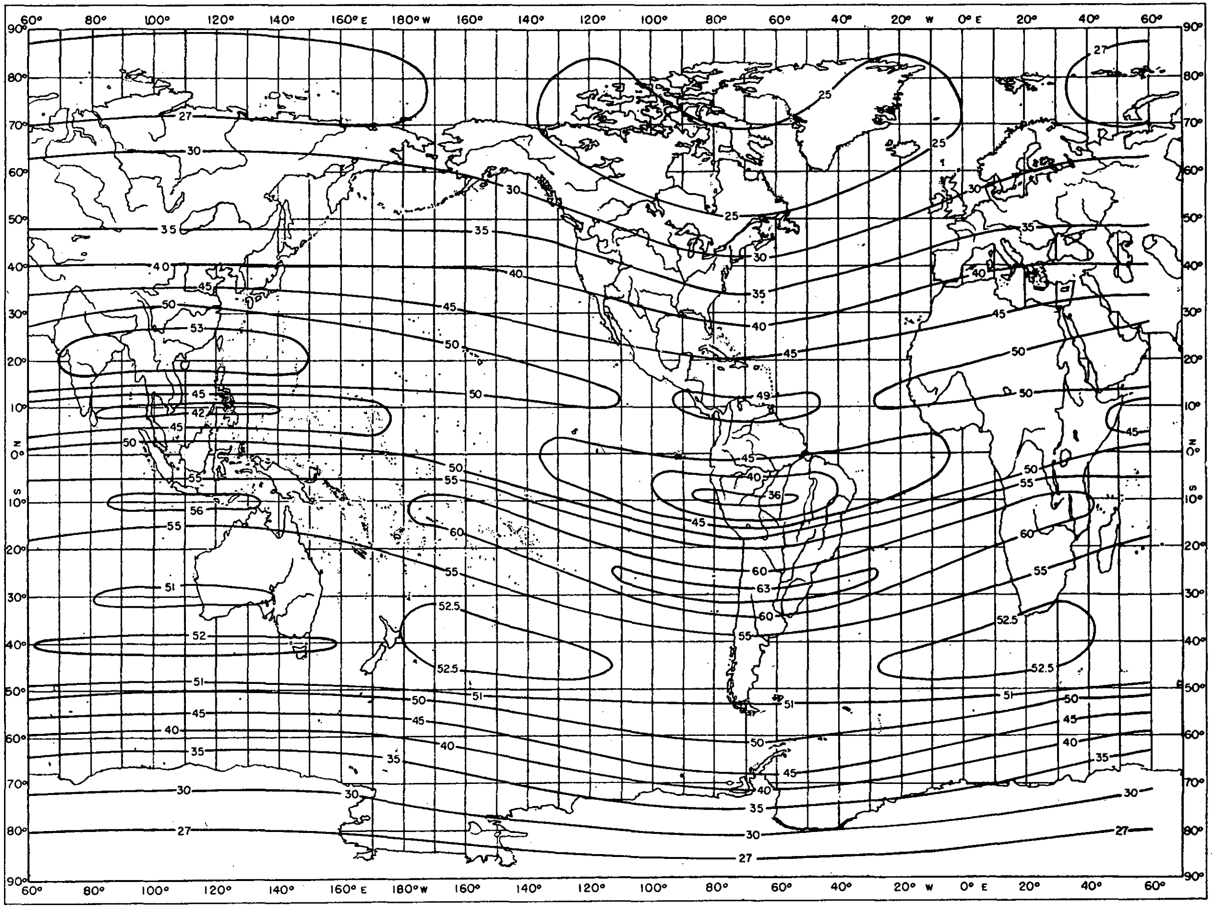

FIGURE 5

Values of the F2 4000 MUF exceeded for 1% of hours; June solstice, sunspot maximum

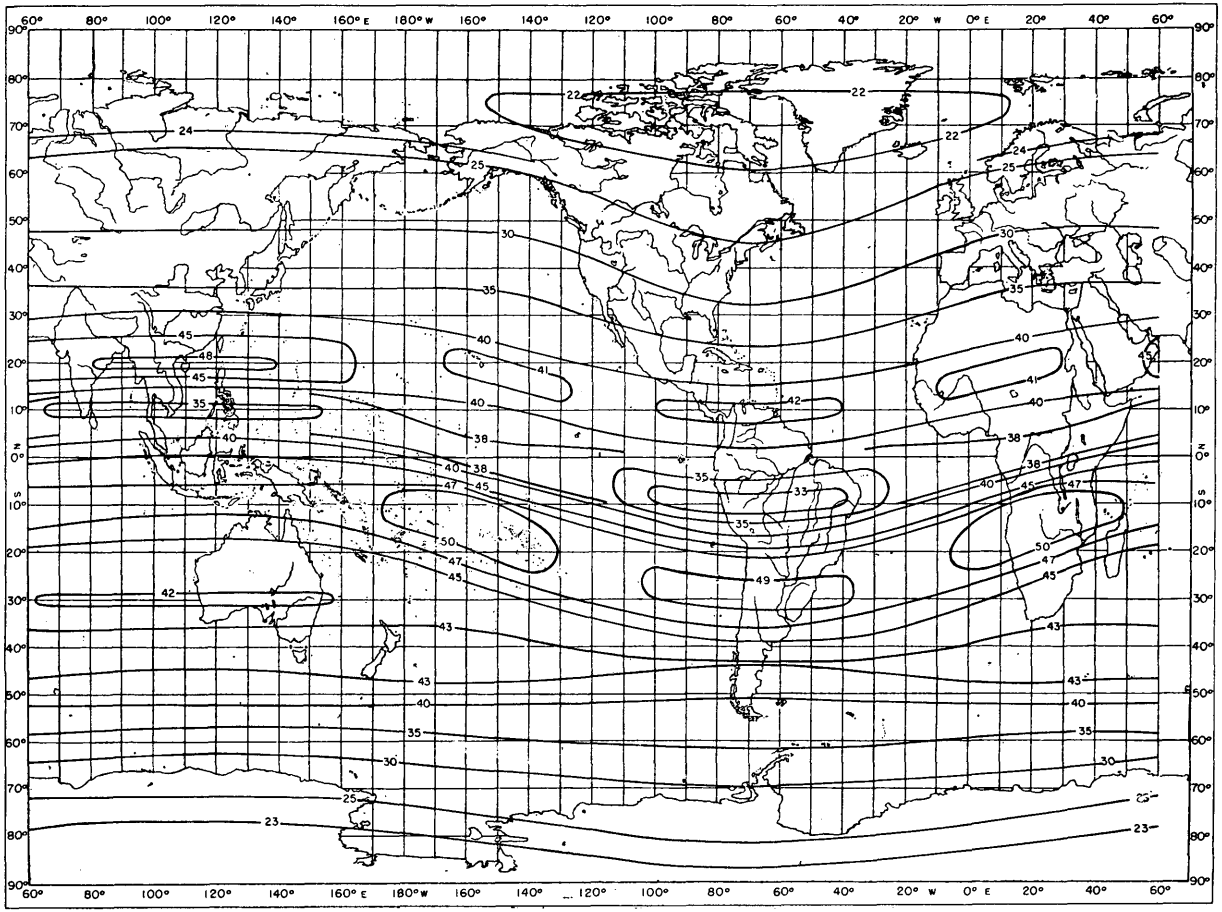

FIGURE 6

Values of the F2 4000 MUF exceeded for 10% of hours; June solstice, sunspot maximum

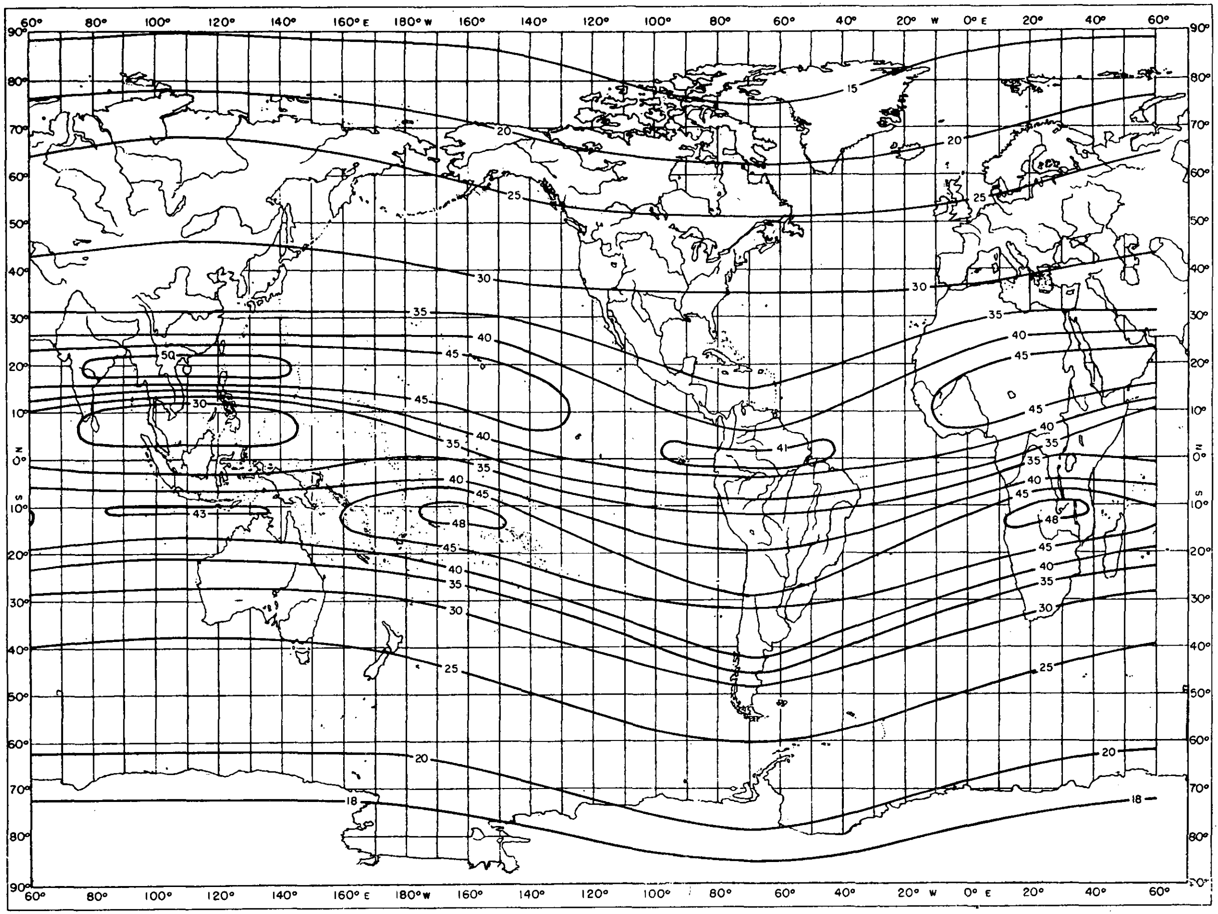

FIGURE 7

Values of the F2 4000 MUF exceeded for 1% of hours; December solstice, sunspot minimum

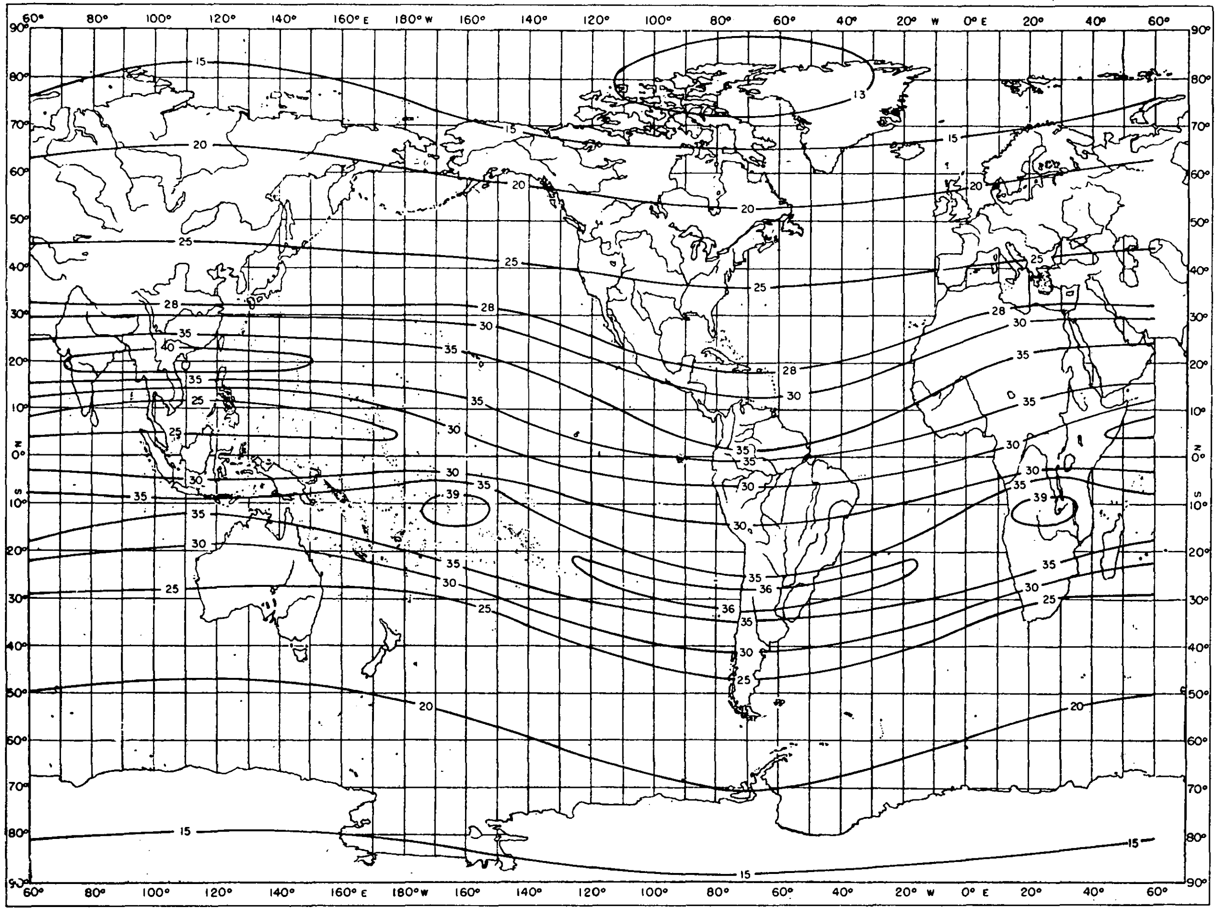

FIGURE 8

Values of the F2 4000 MUF exceeded for 10% of hours; December solstice, sunspot minimum

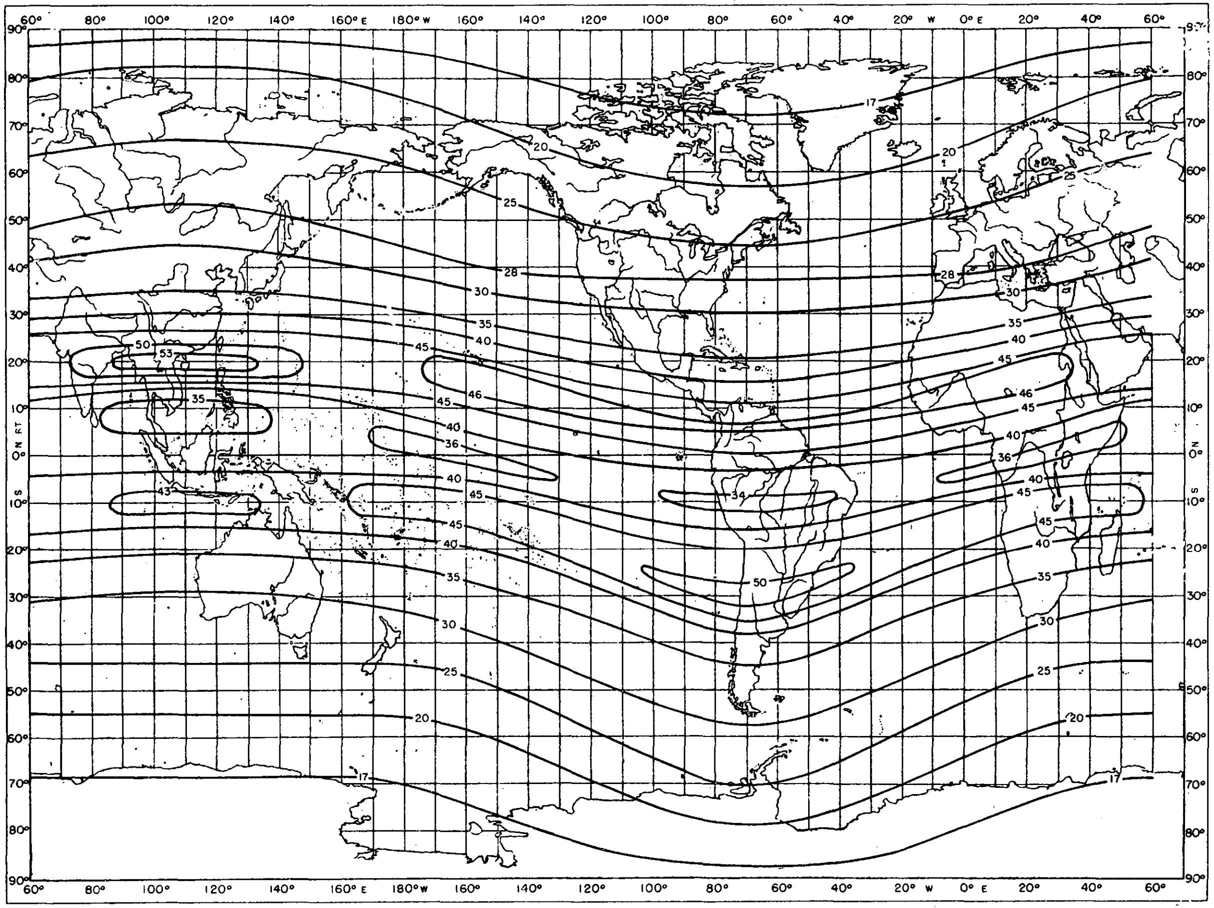

FIGURE 9

Values of the F2 4000 MUF exceeded for 1% of hours; Equinox, sunspot minimum

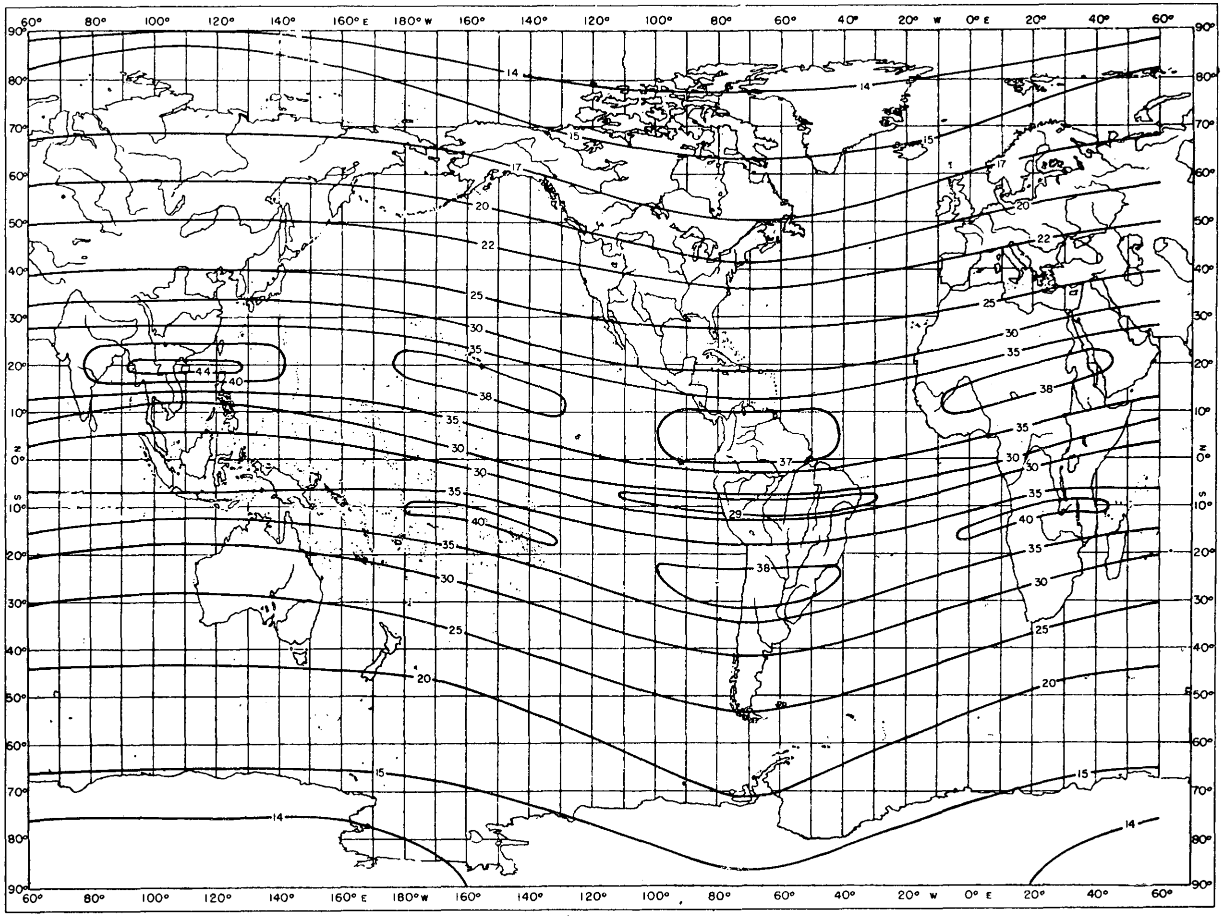

FIGURE 10

Values of the F2 4000 MUF exceeded for 10% of hours; Equinox, sunspot minimum

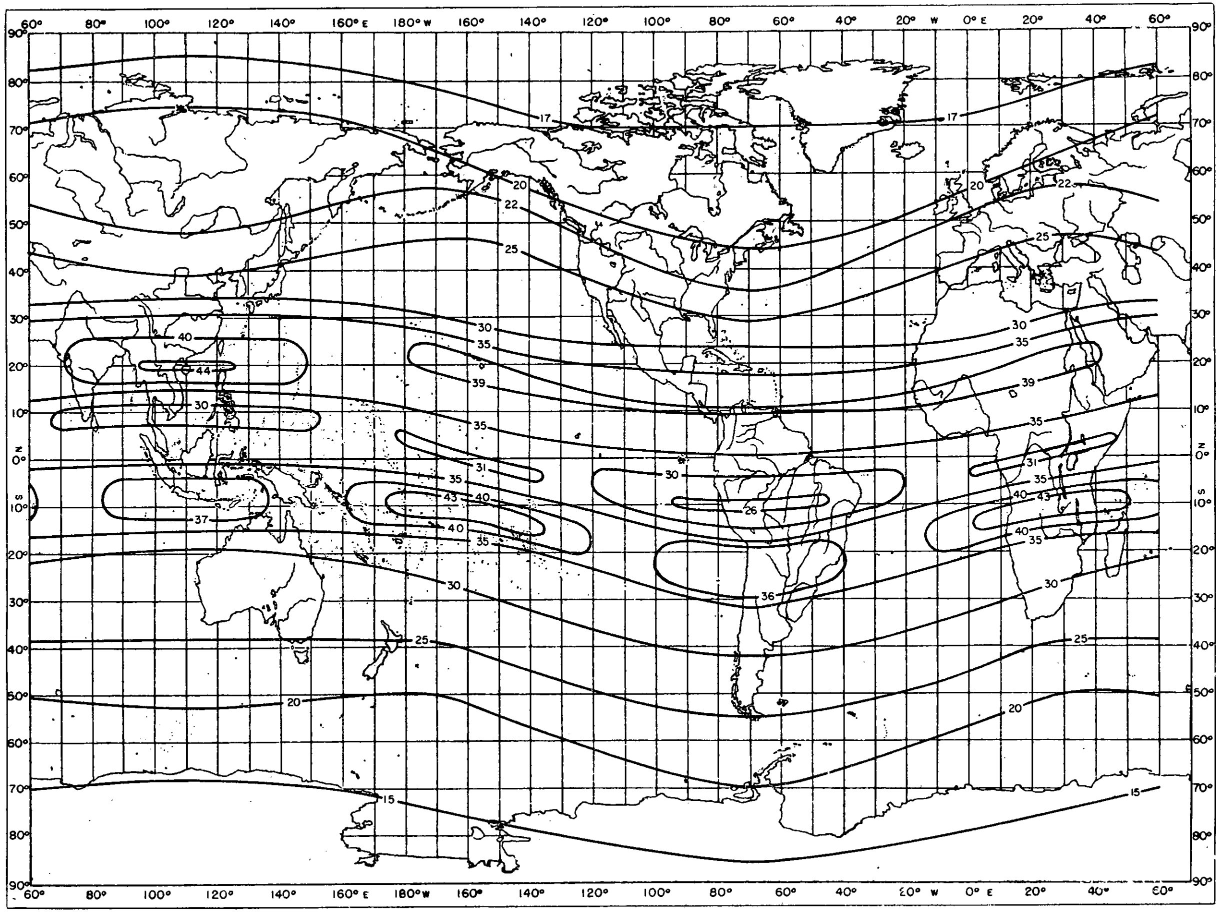

FIGURE 11

Values of the F2 4000 MUF exceeded for 1% of hours; June solstice, sunspot minimum

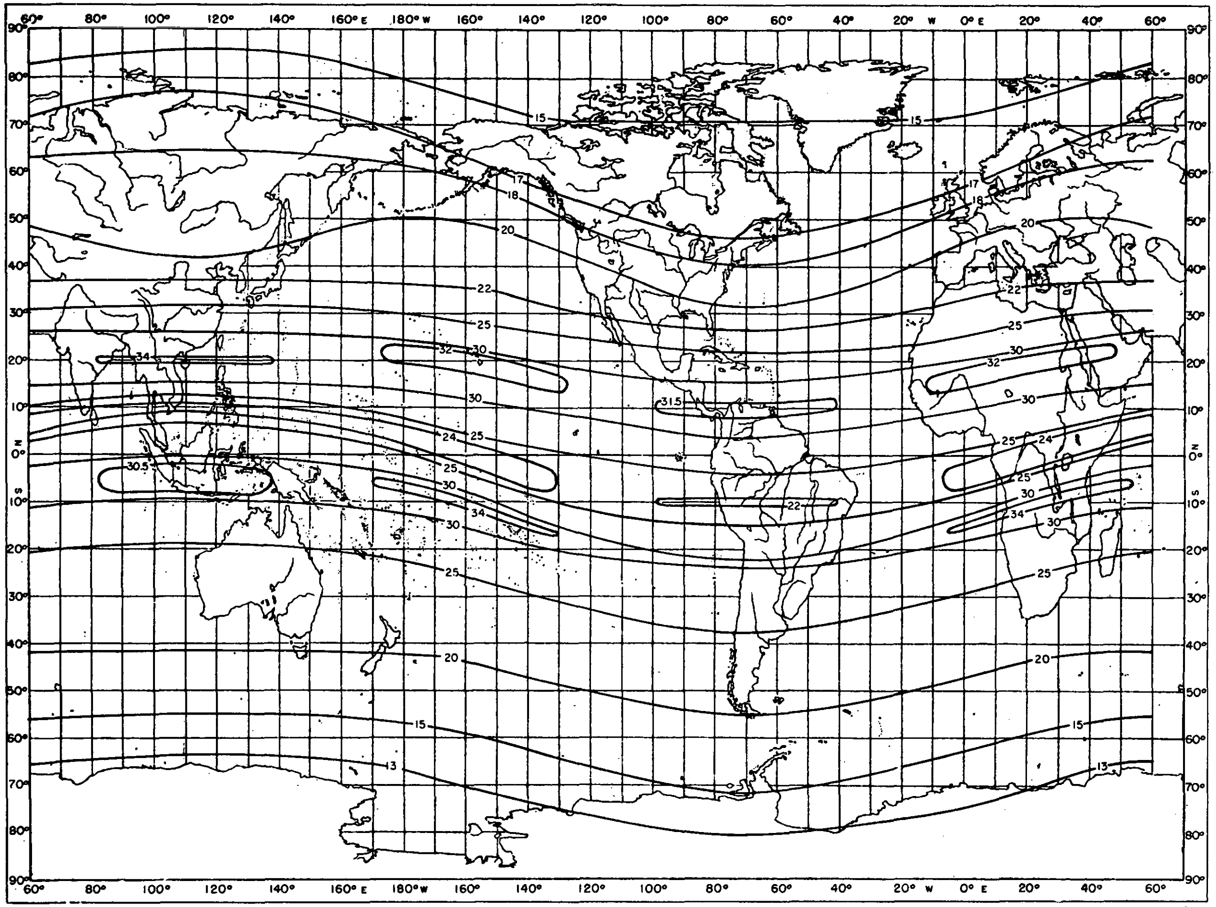

FIGURE 12

Values of the F2 4000 MUF exceeded for 10% of hours; June solstice, sunspot minimum

REPORT 111 *

INFLUENCE ON LONG-DISTANCE HF COMMUNICATIONS USING FREQUENCY-SHIFT KEYING OF FREQUENCY DEVIATIONS ASSOCIATED WITH PASSAGE THROUGH THE IONOSPHERE

(Question 181(III))

(Los Angeles, 1959)

1. Introduction

This Report, based mainly on Doc. III/34 (U.S.A.) of Geneva, 1958, deals with three aspects of the question. Firstly, the magnitude and time duration of the frequency changes to be expected are considered. Secondly, upper bounds of error rates for frequency-shift systems are calculated. Thirdly, experimental element-to-element phase changes are shown, relevant to phase modulation techniques.

The present Report gives only partial information on the subject and a more complete study may be expected, to provide definitive information on the minimum frequency shift which is feasible in practical systems.

2. Characteristics of frequency changes over HF circuits

It is well known that the rapid fading observed on HF circuits is the result of interference between a number of different waves that have been reflected from different portions of the ionosphere. The ionosphere may be thought of as an irregular reflecting surface that is drifting across the sky. Because of this drift, waves that arrive at the receiving site are being reflected from elemental surfaces that are in motion; consequently, each reflected wave will have a small Doppler frequency change. The interference of these frequency-shifted waves gives rise to rapid fading. (This Report will be concerned only with rapid fading and not slow variations resulting from changes in absorption.) This being the case, a reasonable model describing the fading signal is to assume it has the character of very narrow band Gaussian noise. This approach was probably first described by J. A. Ratcliffe [1].

When the narrow-band noise representation is used, it is then possible to use the extensive work done by S. O. Rice [2], in determining the nature of a fading HF signal.

Now the relationship between the fading rate " N_G " (defined as the mean number of times per second the signal envelope passes through the median signal level with positive slope), and the corresponding " equivalent noise bandwidth " of the fading signal is

$$N_G = 1{\cdot}48\ \sigma$$

where σ is the standard deviation of an assumed Gaussian shaped band pass filter. (This equivalent noise bandwidth refers to the received signal only and not the noise that may accompany it.) It is equivalent to the 2·17 db half-bandwidth of the filter. If a rectangular filter is assumed then the fading rate N_R is

$$N_R = B/2{\cdot}32$$

where B is the bandwidth of the filter. The Gaussian shaped filter seems to be a close approximation to the true fading bandwidth of an HF signal [3]; however, for convenience only a

* This Report was adopted by correspondence without reservation.

rectangular filter will be considered. Once we have a measure of the bandwidth of the fading signal, we may proceed to find the probability distribution of the instantaneous frequency along with several other statistics.

Fig. 1 shows the cumulative probability distribution of the instantaneous frequency. This curve has been normalized to the fading rate. For a fading rate of one cycle per second, the instantaneous frequency will be within about 20 cycles of the carrier frequency 99·96% of the time.

Taking into account the fading rate indicated in Report 266, the values of excursion of instantaneous frequency are not inconsistent with the deviations of 3 parts in 10^6 for a few milliseconds duration reported in Doc. III/3 (United Kingdom) of Geneva, 1958.

The mean duration of the instantaneous frequency deviation may also be found with the aid of results worked out by Rice. He derives the expression for the mean number of times per second that the instantaneous frequency exceeds or crosses a given instantaneous frequency, when the bandwidth of the filter is known. Taking the reciprocal of these crossings-per-second gives the mean time interval between them. And since we also know the percentage of the time the instantaneous frequency spends beyond the given crossings, we may compute the mean time duration it spends there. This is simply the product of the probability that it will be beyond the crossing and the mean time interval between the crossing. This mean time interval, $\overline{\Delta t}$, versus frequency change from the centre frequency, is shown in Fig. 2. Fading rate is the parameter. If the fading rate is known, the mean duration of exceeding a given frequency change may be found. It is interesting to note that $\overline{\Delta t}$, is practically independent of the fading rate.

It should be noted that a more complete study is required, to provide the cumulative distribution of the time durations for various specified frequency changes. This is beyond the scope of the present Report.

3. The effects on FSK of frequency changes due to passage through the ionosphere

To determine the effect of frequency changes associated with passage through the ionosphere, we shall assume that no noise is present and that our detector is a frequency discriminator. Our system will make an error, if the transmitted frequency is changed far enough to cross over into the wrong side of the discriminator and remains there for a period comparable to half the element length. We shall choose 20 ms as the element length.

If we assume a fading rate of one per second and a frequency shift of 40 c/s, we find, referring to Fig. 1, that the frequency of either the mark or space channel will change by 20 c/s and cross over into the wrong side of the discriminator for only 0·04% of the time. The 0·04% represents the upper limit of the binary error rate to be expected in the no noise case. If reference is made to Fig. 2, we find that $\overline{\Delta t}$ is only 6·2 ms; consequently, even when the instantaneous frequency does lie on the wrong side of the discriminator, its duration is so short that only rarely will an error be made.

Fig. 3 shows the maximum binary error rate to be expected versus the frequency shift of the system with the fading rate as a parameter. It is assumed that errors occur with the probability that the instantaneous frequency has been displaced to the wrong side of the discriminator. This over-estimates the true error rate due to frequency changes, when the mean length of time of the change is small compared with the signal pulse length, since the discriminator (or post detection filter) time constant has been ignored. As an aid in estimating the region where this time constant becomes effective, points on the curves, corresponding to $\overline{\Delta t}$ of 10 ms, have been located from the curves of Fig. 2.

4. Experimental data relevant to phase modulation

Several experimental studies have been conducted, to determine the performance of the FSK systems and a phase-shift (synchronous) system over sky-wave transmission in the HF band. The phase-shift modulation system requires reasonable phase stability over an approximate 44 ms period. Results of these studies are pertinent to this study of Doppler frequency changes.

A short study has been made of the phase stability of signals from WWV as received in Burbank, California [4]. Measurements were made at frequencies of 5, 10 and 15 Mc/s. A sequence of discrete phase comparisons were made at a 50-cycle rate. Each measurement compared the phase of the incoming signals during a 20 ms period with that during the following such period.

Stability of receiving equipment for such measurements is of primary importance. For this test, all receiving gear was frequency controlled by a single high stability local standard oscillator (1 part in 10^8), thus ensuring that apparent phase shifts due to frequency error were insignificant compared to phase changes due to the propagation.

In general terms, the measuring technique consists of driving an extremely high Q resonator circuit with the received signal for 20 ms. The resonator was then allowed to ring, while the second resonator was driven by the signal for another 20 ms. The relative phase between the two resonators was then measured in a phase detector. This resultant measurement was the phase difference between two integration-phase samples taken 20 ms apart. By a suitable connection between two quadrature phase detectors, a polar display of relative phase and amplitude was presented on an oscilloscope face. The oscilloscope intensity level was blanked except at the end of each 20 ms integration period. The resulting display is a series of dots representing the tips of vectors, whose lengths from the origin are proportional to the amplitude of the applied signal, and having angles equal to the signal phase changes between samples. Photographs of these dot displays were made with exposure times of from 15 s to 5 min. The major results of the study were polar displays of signal phase shift and amplitude. Fig. 4 shows approximate probability contours drawn from these displays. These indicate a decrease in phase stability at higher frequencies, as expected, and give an indication of the degree of phase uncertainty, which cannot be attributed to additive noise.

5. Conclusions

To the degree that the theoretical model describes the behaviour of an HF fading signal, it appears that frequency changes imposed by the propagation are small for typical fading rates. This conclusion is supported by some experimental evidence on phase uncertainty obtained over HF paths. Further studies, especially of the distribution of the duration of frequency changes are needed to improve the estimates of errors imposed in FSK systems.

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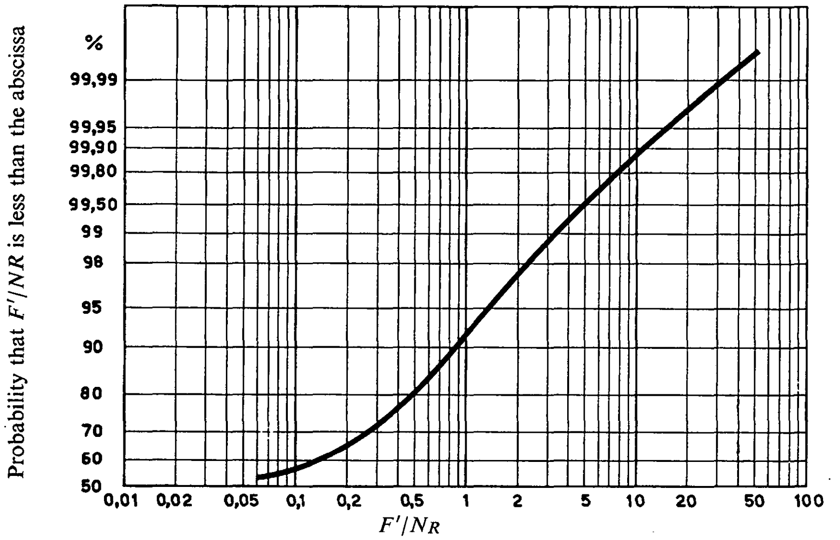
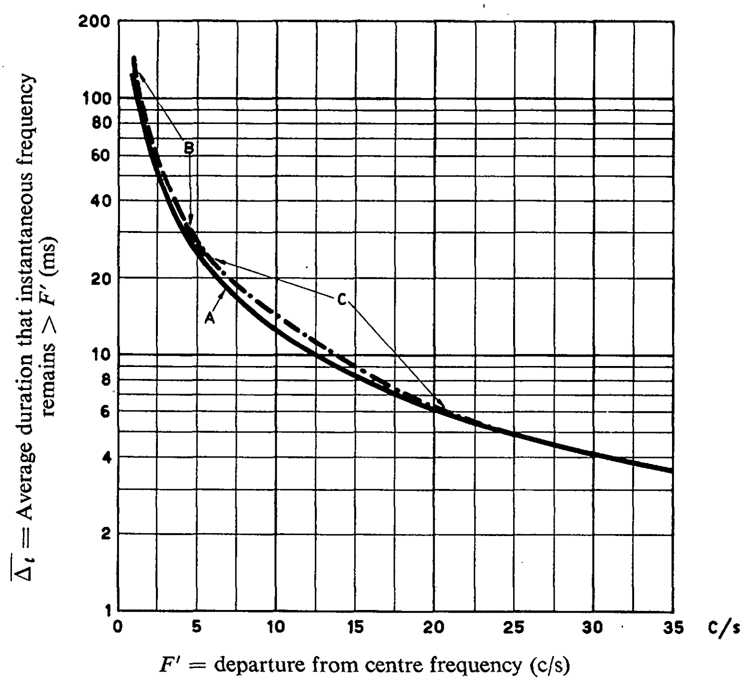


F' = Instantaneous departure from centre frequency (c/s)
N_R = Fading rate (fades per second)

FIGURE 1

Cumulative probability distribution of instantaneous frequency-change



F' = departure from centre frequency (c/s)

Curve A: 0·2 fades/second Curve B: 1 fade/second Curve C: 5 fades/second

FIGURE 2

Average duration that instantaneous frequency change due to the ionosphere exceeds F', with fading rates of 0·2, 1·0, and 5·0 fades per second (assuming a model of narrow-band Gaussian noise)

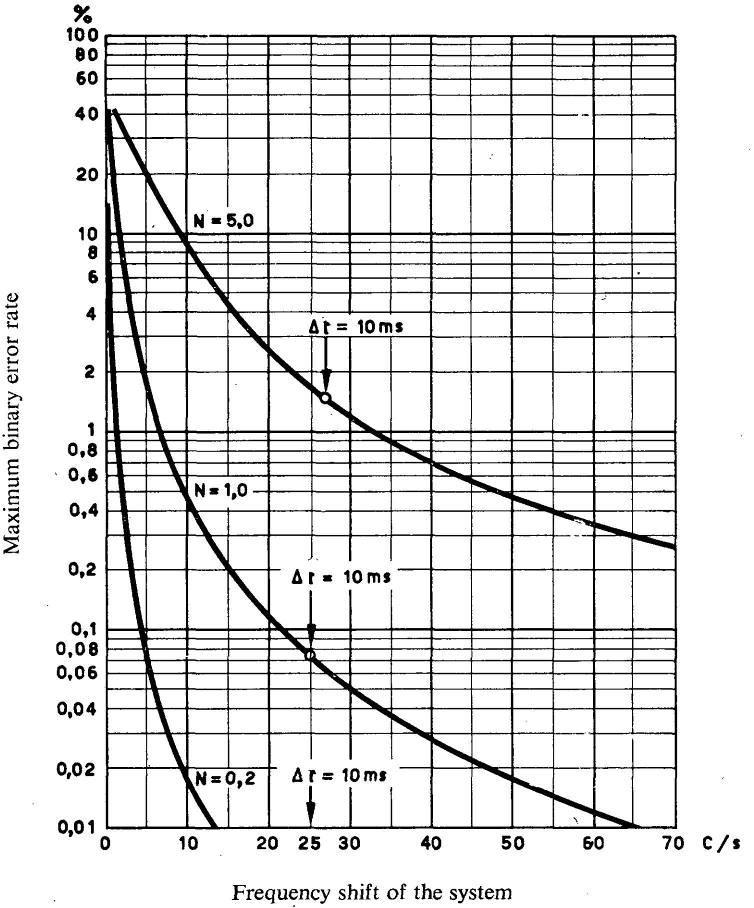


FIGURE 3

Relation between binary error-rate and frequency-shift of the system for fading rates, N, of 0·2, 1 and 5 fades per second. Element length = 20 ms (50 bauds)

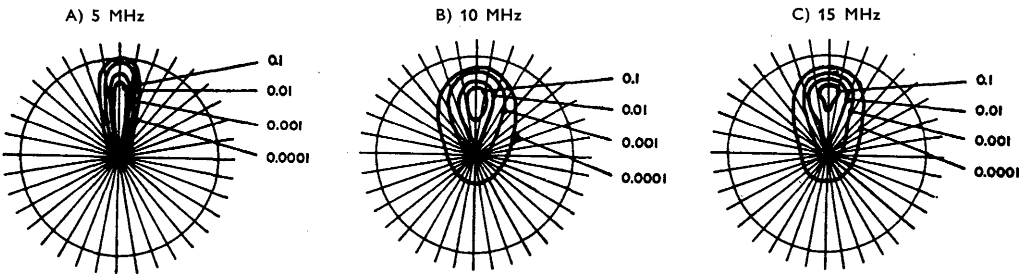


FIGURE 4

Polar probability contours of phase change and amplitude of WWV

The numbers shown represent the probability that a measurement will fall outside the contours.

REPORT 112 *

TRANSMISSION LOSS IN STUDIES OF RADIO SYSTEMS

(Question 3(III))

(Los Angeles, 1959)

1. Definitions of system loss, transmission loss, basic transmission loss, path antenna directivity gain and path antenna power gain

Definitions and standard notations ** have been given in Recommendation 341 for the system loss L_s, the transmission loss L, the propagation loss L_p, the basic transmission loss L_b, the path antenna directivity gain G_p and the path antenna power gain G_{pp}. It is the purpose of this Report to illustrate the use of these terms and the concepts involved, and to show their relationship to other parameters.

2. Transmission loss in free space

As an example of the simplicity of transmission loss calculations in some cases, we may consider the transmission loss between two isotropic antennae in free space. At a distance, d, very much greater than the wavelength, λ, the power flux density (field intensity), expressed in watts per square metre, is simply $p_t'/(4\pi d^2)$, since the power is radiated uniformly in all directions. Since the effective absorbing area of the receiving antenna is $\lambda^2/(4\pi)$, the available power at the terminals of the loss-free isotropic receiving antenna is given by:

$$p_a' = \left(\frac{\lambda^2}{4\pi}\right)\left(\frac{p_t'}{4\pi d^2}\right) \tag{1}$$

Consequently, the basic transmission loss in free space may be expressed by:

$$L_{bf} = 10 \log_{10} (4\pi d/\lambda)^2 \qquad (d \gg \lambda) \tag{2}$$

Since the free-space gain of a short lossless electric dipole is $g_t = g_r = 1{\cdot}5$, the path antenna gain for two optimally oriented short electric lossless dipoles in free space is:

$$G_p = G_t + G_r = 3{\cdot}52 \text{ db} \tag{3}$$

Consequently, the transmission loss between two optimally oriented short lossless electric dipoles in free space is:

$$L = 10 \log_{10} (4\pi d/\lambda)^2 - 3{\cdot}52 \text{ db} \tag{4}$$

3. The concept of propagation loss and the influence of the environment of the antenna

To illustrate the influence of changes in the impedances of the antennae, caused by environmental factors which are independent of the antennae circuit losses, we will consider

* This Report was adopted by correspondence without reservation.

** Throughout this Report, capital letters are used to denote the ratios, expressed in decibels, of the corresponding quantities designated with lower-case type; e.g., $P_t = 10 \log_{10} p_t$. P_t is the input power to the transmitting antenna expressed in decibels relative to 1 watt.

the transmission loss between two short vertical lossless electric dipoles at heights h_t and h_r, respectively, above a plane perfectly conducting surface and separated by a distance, d, large with respect to the wavelength, along the surface. In free space, the field strength e (V/m), at a distance d (m) in the equatorial plane of a short lossless electric dipole radiating p_r (W), is given by:

$$e^2/\eta_o = 1{\cdot}5\, p_r/(4\,\pi\, d^2) \tag{5}$$

where $\eta_o = 4\pi c \times 10^{-7}$ is the impedance of free space (Ω), and $c = 2{\cdot}997925 \times 10^8$ (m/s), is the velocity of light in free space. The factor (1·5) can be identified as the free space gain of the transmitting dipole antenna. The radiation resistance of a short vertical electric dipole of effective length l at a height h_t, above a perfectly conducting plane, is given by:

$$r = \frac{2\pi\eta_o l^2}{3\lambda^2}(1 + \Delta_t) = r_f(1 + \Delta_t) \tag{6}$$

$$\Delta_t = \frac{3}{(2k\ h_t)^2}\left[\frac{\sin\,(2k\ h_t)}{2k\ h_t} - \cos\,(2k\ h_t)\right] \tag{7*}$$

In the above, $k = 2\pi/\lambda = 2\pi f/c$, i. e., λ is the wavelength in free space. Note that Δ_t approaches zero at large heights above the surface and r approaches its free-space value, r_f. On the other hand, $\Delta_t = 1$ for $h_t = 0$, and the radiation resistance is then just twice its free-space value. The field intensity expressed in W/m² at a height h_r for a short vertical lossless electric dipole at a height h_t over a perfectly conducting plane surface, may be expressed by:

$$\frac{e^2}{\eta_o} \approx \frac{1{\cdot}5\, p_r\left[\,2\cos^2\psi\cdot\cos(kh_t \sin\psi)\,\right]^2}{4\,\pi\, d^2\,(1 + \Delta_t)} \tag{8*}$$

In the above expression, $\tan\psi = h_r/d$ and the distance, d, along the surface must be large with respect to both λ and h; in this case, the distance between the antennae is approximately $d/\cos\psi$. Since $\Delta_t = 1$ for $h_t = 0$, the field intensity is 3 db greater, when $\psi = 0$ and the dipole is on the surface of a perfectly conducting plane (i. e., $e^2/\eta_o = 3p_r/(4\pi d^2)$), than when it is in free space; note that in free space we must use (5) and not (8), since the ground reflection influences the radiation for all values of h_t. In more familiar units, when $h_t = h_r = 0$, (8) may be expressed by:

$$e = 2{\cdot}998962 \times 10^5\,(\sqrt{p_r}/d) \tag{9}$$

where e is in μV/m; p_r is in kW; and d is in km

The effective absorbing area of a short vertical lossless electric dipole receiving antenna, at a height h_r above a perfectly conducting plane, may be expressed by:

$$a_e = \frac{1{\cdot}5\,\lambda^2 \cos^2\psi}{4\pi(1 + \Delta_r)} \tag{10}$$

where Δ_r is defined by (7), with h_t replaced by h_r. Since $p_a = e^2\, a_e/\eta_o$, we find by combining (8) and (10) that the transmission loss between two short vertical lossless electric dipoles, at heights h_t and h_r above a plane perfectly conducting surface, may be expressed by:

$$L \approx 10 \log_{10}\left\{\frac{[4\,\pi\, d/(\lambda\cos\psi)]^2\,(1 + \Delta_t)(1 + \Delta_r)}{(1{\cdot}5)^2\,[2\cos^2\psi\cdot\cos\,(kh_t\sin\psi)]^2}\right\} \tag{11}$$

* These relations are derived by S. A. Schelkunoff in Chapters VI and IX of the book *Electromagnetic Waves*, D. Van Nostrand Co., 1943.

$$\text{or } L = L_{bf} + A + L_t + L_r - G_p - 6{\cdot}02 \text{ (db)} = L_p + L_t + L_r \text{ (db)} \tag{12}$$

where

$L_t = 10 \log_{10} [1 + \Delta_t]$, $L_r = 10 \log_{10} [1 + \Delta_r]$. $G_p \approx 20 \log_{10} [(3/2) \cos^2 \psi]$ and $A \approx -20 \log_{10} [\cos (k\, h_t \sin \psi)]$. It is of interest to note that the transmission loss between the dipoles on the plane perfectly conducting surface, $h_t = h_r = 0$, is the same as if the dipoles were separated by the same distance in free space, although the field intensity is 3 db greater for the same power radiated. On the other hand, when the dipoles are several wavelengths above the perfectly reflecting surface ($h_t = h_r \gg \lambda$), and are separated by a large distance ($\psi \approx 0$), the transmission loss is 6·02 db less than for dipoles separated by the same distance in free space.

The above is not the only logically consistent method of describing the gains and losses in the presence of a perfectly conducting ground. Thus, Schelkunoff, in the reference cited, considered the perfectly reflecting surface to be an integral part of the transmitting and receiving antennae, and set $G_{ts} = 10 \log_{10} [3/(1 + \Delta_t)]$ and $G_{rs} = 10 \log_{10} [3/(1 + \Delta_r)]$. In other words, he referred his maximum gains to those expected for isotropic antennae with the earth removed; this leads to a path antenna gain, referred to that expected between isotropic antennae with the earth removed, given by $G_{ps} = (G_p + 6{\cdot}02 - L_t - I - A)$, and this transmission loss is simply $L = (L_{bf} - G_{ps})$. However, this method of approach is not recommended since:

- it is impracticable to remove the Earth to measure G_{ps};
- it would lead to antenna gains 3 db larger than their free-space values, even when they are many wavelengths above a perfectly reflecting plane surface, and this is inconsistent with the present usage of the concept of antenna gain in the higher frequency ranges.

Although it appears to be desirable to separate the effects of earth reflections from the gains of the antennae, by means of the propagation loss concept described earlier, there will be other situations in which such a separation of environmental effects is undesirable. For example, the power gain of an antenna, mounted on an aircraft, satellite, or spacecraft should be considered as the gain which would be determined by integrating the cymomotive force over all directions as the vehicle is rotated in free space. Equation (12) illustrates the definition of L_p, the propagation loss, i. e., the transmission loss expected if the antennae had the same impedances they would have had if they were in free space. L_t and L_r are defined above for antennae over a perfectly conducting ground plane; more generally, L_t and L_r are defined as $10 \log_{10} (r'/r_f)$, where r' is the actual resistance of the antenna and r_f is the radiation resistance it would have had if it were in free space. We note that L_t and L_r contain the loss components L_{tc} and L_{rc} and may also vary substantially from one antenna site to the next, depending upon polarization and ground conditions. They are also a function of the size of the ground screen used, and depend on other environmental factors, such as the presence of trees or over-head wires. It is thus clear why it is desirable to separate these components from the system loss and to have a propagation loss, L_p, independent of these antenna environmental conditions.

4. Simplification possible at higher frequencies

At higher frequencies, the antennae are usually located several wavelengths away from the ground and other environmental disturbing elements and, in such cases, L_t, L_r, L_{tc} and L_{rc} will all be sufficiently small so that the propagation loss, the transmission loss, and the system loss will all have essentially the same magnitude, and it will then be unnecessary to distinguish between L_p, L and L_s.

5. Relation to current C.C.I.R. terminology

It is desirable to relate the above transmission loss terminology to the terminology used in other C.C.I.R. documentation. We may express the free space cymomotive force

$C = 20 \log_{10} (e.d)$ in db rel. 1 V (e. g., relative to 1 V/m at a distance of 1 m) as in Recommendation 168. In free space, we find by (5), when we note that $P_t' = P_t - L_{tc}$ and $L_t = L_{tc}$:

$$C = 10 \log_{10} (p_r\, c.\, g_t \times 10^{-7}) = P_t - L_t + G_t + 14{\cdot}77 \text{ (db)} \qquad (13)$$

The relation between the available power, p_a, from the receiving antenna and the field strength, e, may be expressed in decibels as follows:

$$E = 10 \log_{10} [4 \pi \eta_0 p_a (r'/r_f) \times 10^{12}/(\lambda^2 g_r)] = P_a + 20 \log f - G_r + L_r + 107{\cdot}22 \text{ db} \quad (14)$$

where f is in Mc/s.

If (13) is solved for P_t and (14) for P_a and we combine the results, the following expression for L_s is obtained:

$$L_s = P_t - P_a = C - E_C - G_p + 20 \log_{10} f + 92{\cdot}45 + L_t + L_r \qquad (15)$$

where f is in Mc/s.

In Recommendation, 370, the curves of tropospheric field strength E, expressed in db relative to 1 μV/m, were referred to a free-space cymomotive force $C = P_t - L_t + G_t + 14{\cdot}77 = 46{\cdot}92$ db relative to 1 V (i. e., 222 V), since they correspond to 1 kW radiated ($P_t - L_t = 30$) from a half-wave dipole ($G_t = 2{\cdot}15$); thus, the propagation loss corresponding to the values of E in those documents is given by:

$$L_p = L_s - L_t - L_r = 139{\cdot}37 - G_p + 20 \log_{10} f - E \qquad (C = 46{\cdot}92) \qquad (16)$$

where f is in Mc/s.

The inverse distance field I (expressed in db relative to 1 V/m at 1 m), may be determined over a perfectly conducting ground plane from (8):

$$I = P_t' - L_t + G_t + 20{\cdot}79 \text{ (db)} \qquad (17)$$

Noting that $P_t' = P_t$ over a perfectly conducting ground plane and then solving (17) for P_t and (14) for P_a and combining the results, the following expression for L_s is obtained:

$$L_s = P_t - P_a = I - E_I - G_p + 20 \log_{10} f + 86{\cdot}43 + L_t + L_r \qquad (18)$$

where f is in Mc/s.

In Recommendation 368, the curves of $E = f(d)$ were referred to a value of $I = 20 \log_{10} 300 = 49{\cdot}54$ db relative to 1 V, i. e., by (17) the inverse distance field corresponding to 1 kW radiated ($P_r = 30$) from a short vertical electric dipole ($G_t = 1{\cdot}76$) over a perfectly conducting ground ($L_t = 3{\cdot}01$) and thus the propagation loss corresponding to the values of E in Recommendation 368 is given by:

$$L_p = L_s - L_t - L_r = 135{\cdot}97 - G_p + 20 \log_{10} f - E \qquad (I = 49{\cdot}54) \qquad (19)$$

where f is in Mc/s.

It is seen from the above discussion that the propagation loss, L_p, may be calculated by (16), from the values of E given in Recommendation 370, or by (19) from the values of E in Recommendation 368. The fact that there are different relations between L_p and the values of E in these documents, illustrates the complexity of the conventions used in past studies of radio wave propagation. There may be some advantage to the C.C.I.R. in adopting the propagation loss, L_p, between short electric dipoles, as a standard method of presenting the results of radio propagation studies such as those in the above documents. This would make possible the use of a *single* convention throughout the spectrum and would result in a presentation which is directly useful to those engaged in radio systems studies. Short electric dipoles are suggested as reference standards for the uniform presentation of propagation data throughout the spectrum, in preference to either isotropic antennae or half-wave dipoles, for the following reasons:

- short electric dipoles are physically realizable throughout the spectrum;
- short electric dipoles have polarization characteristics, as do all real antennae;
- short vertical electric dipoles have some directivity in the vertical plane and thus simulate typical real antennae somewhat better, as regards ionospheric wave propagation in the lower frequency ranges.

It is recognized, that it will often be more convenient, at the higher frequencies, to make propagation measurements using half-wave dipoles, but such measurements can readily be adjusted to the results expected with a short electric dipole, since the maximum gain of a half-wave dipole is just 0·39 db larger than that of a short electric dipole.

If the propagation loss, L_p, between short electric dipoles were used as a standard by the C.C.I.R., then $G_p = 3{\cdot}52$ db and the field $E(C = 46{\cdot}92)$ of Recommendation 370 could, by (16), be determined from:

$$E = 135{\cdot}85 + 20 \log_{10} f - L_p \qquad (C = 46{\cdot}92) \qquad (20)$$

and the field $E(I = 49{\cdot}54)$ of Recommendation 368 could, by (19), be determined from:

$$E = 132{\cdot}45 = 20 \log_{10} f - L_p \qquad (I = 49{\cdot}54) \qquad (21)$$

where f is in Mc/s in both cases.

6. Comparison between the measurement of field strength and the measurement of the available power from the receiving antenna

The essential advantage of measuring or calculating propagation characteristics, in terms of system loss rather than in terms of field strength, is the fact that the former requires the determination of the available power from the receiving antenna for a given input power to the transmitting antenna, and thus automatically allows for both the directivity and the circuit losses of the transmitting and receiving antennae. The available power $p_a = v^2/4r'$, where r' is the resistive component of the receiving antenna output impedance, including both its radiation resistance, r, and loss resistance component, r_c, while v is the open circuit voltage. When the antenna is loaded by the complex conjugate of its output impedance, the voltage appearing across its terminals is $v/2$; thus the available power is simply the power delivered by the receiving antenna to a matched load. The accurate determination of the available power requires the measurements of both r' and v, whereas the field strength is independent of r' and, to this extent, does not provide a direct measure of the expected performance of a radio system, at least in those cases where the receiver noise is comparable to, or larger than, the noise picked up by the receiving antenna.

7. Simplicity of systems problems solved in terms of system losses

Finally, it should be noted that the concept of system loss provides a simple solution to the problem of allowing for the effects of interfering transmissions. Consider, as one example, the determination of the interference to the reception at a particular receiving location of a wanted transmission caused by an unwanted transmission on the same channel. The ratio of the wanted-to-unwanted signal power, available at the terminals of the receiving antenna may be expressed by:

$$R = P_{td} - P_{tu} - L_{sd} + L_{su} \qquad (22)$$

where P_{td} and P_{tu} denote the antenna input powers to the wanted and unwanted transmissions, while L_{sd} and L_{su} denote the system losses for the wanted and unwanted transmission paths. When it is noted that the component L_{rc} is the same in L_{sd} and L_{su}, (22) becomes:

$$R = P_{td}' - P_{tu}' - L_d + L_u \qquad (23)$$

where P_{td}' and P_{tu}' are the radiated powers from wanted and unwanted transmitters, while L_d and L_u are the transmission losses for the wanted and unwanted transmission paths. Both L_d and L_u will vary with time, and these variations will, over long periods of time, be positively correlated, so that the variance of R with time will be somewhat less than the sum of the variances of L_d and L_u. If R exceeds a prescribed minimum acceptable level, R_m, for a sufficiently large percentage of time, then this particular receiving location may be considered to be free of interference. Note that the effect of the directivity of the receiving antenna is appropriately allowed for in determining R, since L_d will be measured (or calculated), with the antenna directed towards the desired station, while L_u is the transmission loss corresponding to the effective receiving antenna gain in the direction of the unwanted transmitter. For a broadcasting service, one may choose a large number of receiving locations within the service area of the wanted station in some systematic way * and at each of these locations determine, in the manner described above, whether it is satisfactorily free of interference. This constitutes a useful solution of the problem of assessing the importance of the interference between stations on the same channel; the same method can also be used for interference between stations on adjacent channels, simply by changing the value of R_m. It is important to notice that the transmission losses, L_d and L_u, will be very much influenced by the irregularities in the terrain profiles to the wanted and unwanted stations respectively. Furthermore, there will be a tendency for L_d and L_u to be correlated as one moves from one receiving location to the next, since unfavourable locations for the reception of the wanted station will also tend to be unfavourable for the reception of the unwanted station.

The above discussion represents one of a number of possible examples of the utility of the concept of transmission loss in systems studies. There are many circumstances, however, as, for example, in assessing the interference potential of Industrial Scientific and Medical equipment, where it is more convenient to specify the interference in terms of field strengths, rather than attempt to specify the parameters involved in system loss calculations, and it is not the intention of this Report to suggest that the concept of system loss should necessarily replace that of field strength. Rather it has been the intention in this Report merely to discuss the possible advantages of this concept and to show its relation to other terms in use by the C.C.I.R.

8. Relationship to other C.C.I.R. Questions and Study Programmes

Note that this method of presenting the results of propagation studies has a direct bearing on the following work of the C.C.I.R.

Questions : 81(III), 132(III), and 246(V).

Study Programmes: 3A(III), 57(V), 81A(III), 139(V), 148(VI), 188(V), 198(VI), 202(VI) and 227A (I).

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* It is convenient to choose these VHF-receiving locations at the intersections of a regular lattice with separations of, say, 2 km, since it is known that there is very little correlation between the transmission losses at VHF for receiving points separated by such distances, and this will permit a maximum of information to be derived with a relatively small sample.

REPORT 195 *

BANDWIDTH AND SIGNAL-TO-NOISE RATIOS IN COMPLETE SYSTEMS

Prediction of the performance of telegraph systems in terms of bandwidth and signal-to-noise ratio

(Study Programme 3A(III))

(Los Angeles, 1959 – Geneva, 1963)

1. Study Programme 3A(III) sets out some questions, the answer to which would form a basis for the evaluation of the performance of complete systems. The questions include terms like " excellent service ", the interpretation of which depends greatly on the type of traffic the system is intended to carry and the grade of service. This Report will not discuss such questions in detail, but rather attempt to give a basis for a more objective method of performance specification in the light of recent work on communication systems.

Theoretical studies of the mechanisms of detection of telegraph signals in the presence of noise, having a Gaussian distribution [1, 2], have made it possible to define the performance of a system, in terms of element error-rate, as a function of the signal-to-noise ratio just prior to the detector. The word " detector " is used here in a very general sense and the detector might be a limiter-discriminator. It is convenient to use a quantity called the " normalized signal-to-noise ratio ", R, which is defined as the quotient of the average of the specific energies of the mark and the space signals, and the noise power per unit bandwidth. For systems which use two equally probable signals of equal energy, this ratio is equal to the signal-to-noise power ratio per baud per unit bandwidth, or the ratio of the signal power to the noise power per unit bandwidth, divided by the number of bauds. Direct comparison between receivers, even when working at different speeds is, therefore, possible.

In these studies, it was also found possible to specify the performance of a telegraph receiver by a single parameter. This parameter has been called the " demodulation factor " and it is the amount (in db), by which the signal-to-noise ratio (normalized), applied to the receiver under test, exceeds that applied to an idealized receiver of the same type for the same element error-rate. For the purpose of this work, we have to distinguish between coherent and non-coherent receivers. The coherent receiver has *a priori* knowledge of the phase of the elementary waveform. The mark- and space-elements are assumed to be equally probable.

1.1 *Coherent reception. No fading*

Assume that $x_1(t)$ and $x_2(t)$ are the two signal waveforms, that τ is the unit interval (duration of one element), and that N is the noise power per c/s. Then if:

$$y^2 = \frac{1}{4N}\int_0^{\tau}[x_1(t) - x_2(t)]^2\, dt,$$

the element error-rate P_e is given by:

$$P_e = \frac{1}{\sqrt{\pi}}\int_0^{\infty}\exp\{-z^2\}\, dz = \tfrac{1}{2}\operatorname{erfc}(y) = \tfrac{1}{2} - \tfrac{1}{2}\operatorname{erf}(y).$$

* This Report, which replaces Report 105, was adopted unanimously.

In terms of the " normalized signal-to-noise ratio ", R, this error-rate can be expressed in the form:

$$P_e = \tfrac{1}{2}\operatorname{erfc}(\alpha R)^{\frac{1}{2}};$$

- for phase-reversal modulation $\alpha_1 = 1$;
- for frequency-shift keying with two orthogonal signals $\alpha_2 = \frac{1}{2}$;
- for amplitude keying (on-off signals) too, $\alpha_3 = \frac{1}{2}$.

For large values of R, the complementary error function can be well approximated by an exponential curve:

$$P_e \approx \frac{1}{2\sqrt{\pi\alpha R}} \exp\{-\alpha R\}$$

1.2 *Non-coherent reception. No fading*

For non-coherent reception of a steady signal, the error-rate is of the form:

$$P_e = \tfrac{1}{2}\exp\{-\alpha R\}$$

Again:

- for differentially coherent reception [3] of phase-reversal modulation $\alpha_1 = 1$;
- for matched filter reception and envelope detection [4] of frequency shift keying $\alpha_2 = \frac{1}{2}$ (for narrow-band FSK with shifts of the order $(0{\cdot}8/\tau)$, the effect of correlation leads to better results);
- for amplitude keying, we get approximately [4] $\alpha_3 = \frac{1}{2}$.

1.3 *Coherent diversity reception. Flat fading*

It is assumed that the fading is of Rayleigh type, that the fadings in different branches are uncorrelated (but that they are the same for mark and space signals), that the mean signal-on energies of all branches are equal, and that the fading is so slow, relative to the speed of signalling, that the signal power may be regarded as constant during any one signal element. The outputs of the diversity branches are assumed to be weighted, according to the signal energy and combined (maximal ratio combination).

For Rayleigh fading and one receiver, we get the following error-rate:

$$P_{e1} = \tfrac{1}{2} - \tfrac{1}{2}\sqrt{\alpha R/(\alpha R + 1)}$$

For dual diversity:

$$P_{e2} = \tfrac{1}{2} - \tfrac{1}{2}\sqrt{\alpha R(\alpha R + \frac{3}{2})^2 \Big/ (\alpha R + 1)^3}$$

For triple diversity:

$$P_{e3} = \tfrac{1}{2} - \tfrac{1}{2}\sqrt{\alpha R\,(\alpha^2 R^2 + \frac{5}{2}\,\alpha R + \frac{5}{2}\cdot\frac{3}{2}\cdot\frac{1}{2!}) \Big/ (\alpha R + 1)^5}$$

For quadruple diversity:

$$P_{e4} = \tfrac{1}{2} - \tfrac{1}{2} \sqrt{\alpha R \left(\alpha^3 R^3 + \frac{7}{2} \alpha^2 R^2 + \frac{7}{2} \cdot \frac{5}{2} \cdot \frac{1}{2!} \alpha R + \frac{7}{2} \cdot \frac{5}{2} \cdot \frac{3}{2} \cdot \frac{1}{3!}\right) \Big/ (\alpha R + 1)^7}$$

For large values of R, these results are closely approximated by:

$P_{e1} = 1/4\alpha R$; $P_{e2} = 3P_{e1}{}^2 = 3/(4\alpha R)^2$; $P_{e3} = 10\, P_{e1}{}^3 = 10/(4\alpha R)^3$; $P_{e4} = 35\, P_{e1}{}^4 = 35/(4\alpha R)^4$ respectively.

In the definition of the normalized signal-to-noise ratio R, the average signal energy and signal power per branch should now be substituted for signal energy and signal power respectively.

The basic curves, for idealized coherent reception of frequency shift signals in fading ($\alpha = \frac{1}{2}$), are given in Fig. 1 for single, double, triple and quadruple diversity systems.

1.4 *Non-coherent reception. Flat fading*

The equations for the error-rate for non-coherent reception, under the circumstances otherwise specified in § 1.3 (maximum ratio combining), are:

$P_{e1} = 1/2\,(1 + \alpha R)$, Rayleigh fading, one receiver;

$P_{e2} = 1/2\,(1 + \alpha R)^2$, Dual diversity;

$P_{e3} = 1/2\,(1 + \alpha R)^3$, Triple diversity;

$P_{e4} = 1/2\,(1 + \alpha R)^4$, Quadruple diversity.

The basic curves for this case are given in Fig. 2, again for the reception of frequency shift signals in fading ($\alpha = \frac{1}{2}$).

1.5 *Coherent reception. Independent fading*

1.6 *Non-coherent reception. Independent fading*

If it may be assumed that the mark and space frequencies are sufficiently widely separated for the fading in the two branches to be independent, then independent reception in the mark and space branches is possible.

If, furthermore, the same assumptions are made as in §§ 1.3 and 1.4, the resulting error rates may be derived directly from the above. Then, going from flat fading to independent fading is equivalent to doubling the order of diversity, while having the power in each diversity branch [6].

2. Demodulation factor

If the performance curve of an actual receiver for coherent reception is of the complementary error function type, then a constant factor indicates the extent by which a practical receiver falls short of the ideal, and it is the same for all types of diversity.

Also, if the performance curve of an actual receiver for non-coherent reception is of the exponential type, the demodulation factor will be a constant.

Equipment for measuring the demodulation factor of a receiver in the laboratory, under simulated fading conditions, has been described elsewhere [5]. Alternatively, a measure of the demodulation factor may be obtained by calculation from the performance of the receiver under non-fading conditions, as in the Annex.

In this Report we have only discussed maximum-ratio combining. In the literature [7], one can find a comparison of this type of diversity with equal-gain, and selection diversity. The loss for equal-gain combining is apparently of the order of 1 db.

The performance of a circuit is usually expressed in terms of character error-rates. Calculations from the probability functions involved give a simple conversion from an element error-rate to a character error-rate for various types of telegraph code, thus providing a simple relationship between the signal-to-noise ratio and the number of errors on the printed copy. The particular case for random arrival of element errors represents a useful limiting condition which is approached closely when the error rate is low.

Relationships between element and character error-rates are shown in Figs. 3 and 4.

In Fig. 3, curve (1) represents the upper limit of the character error-rate for a synchronous seven-unit code, when the element errors are mutually independent. It should be noted here, that the character error-rate is defined as being the number of characters subject to error at the output of the detector and thus an error in " letter shift " or " figure shift " is counted only once and similarly for other errors, such as those occurring in " carriage return " or " line feed ". However, if the fading characteristics give rise to groups of errors, then the curve showing the relationship between element and character error-rates becomes asymptotic to curve (2) which was calculated on the assumption that the signal level remains constant during a character. For element error-rates lower than 10^{-3}, the curve (1) is appropriate.

In Fig. 4, the upper limits are shown as follows:

- Curve (1): for a five-unit synchronous code: $P_c \approx 5P_e$;
- Curve (2): for a seven-unit code: $P_c \approx 7P_e$;
- Curve (3): for a five-unit start-stop system with tape printing and allowing for errors due to loss of synchronism in addition to the simple character-errors $P_c \approx 17P_e$;
- Curve (4): for a five-unit start-stop system with page printing, i. e., including an additional allowance for multiple errors due to carriage return and line-feed failures. Again, as for the previous curves, errors in " letter shift " or " figure shift " are only counted once $P_c = 34P_e$.

An example is given below to demonstrate the way in which the curves may be used. It is stressed that this example shows the method employed in making one of the steps in the calculations necessary to plan circuits for a specified grade of service, but that the demodulation factor of the receiver must be known as a result of measurement.

First, we take the general case for reception of a steady signal.

Let R_o = the pre-detection signal-to-noise ratio (db);

R_n = the normalized signal-to-noise ratio, corresponding to R (db); $R_n = 10 \log_{10} R$;

S = the signalling speed in bauds (elements/sec.);

B = the pre-detection bandwidth (c/s) of the receiver in question;

D = the demodulation factor of the receiver for the signalling speed specified, in db;

then

$$R_o = R_n + 10 \log_{10} (S/B) + D \qquad (1)$$

Example

A coherent receiver, having a pre-detection bandwidth of 1000 c/s, is used for 50 bauds, 5-unit synchronous working, using triple diversity. The measured demodulation factor of the receiver, for this signalling speed and bandwidth, is 10 db. A character error-rate of 10^{-4} is permissible; what must be the pre-detector signal-to-noise ratio?

From Fig. 4, the corresponding element error-rate is 2×10^{-5}. From Fig. 1, an ideal receiver using triple diversity produces an element error-rate of 2×10^{-5} for $R_n = 16$ db.
Using equation (1), we find:

$$R_o = R_n + 10 \log_{10} (S/B) + D$$

and inserting the known values we have

$$R_o = 16 - 13 + 10 = 13 \text{ db.}$$

This is the required signal-to-noise ratio per branch. The signal-to-noise ratio after combining will be 3 R_o or 18 db.

3. Conclusion

Extension of this work, to cover noise other than thermal noise, may result in the need for more parameters to describe fully system performance, but it seems clear that:

- the performance of telegraph circuits should be related to stated character error-rates, and for the engineering planning of circuits and design of equipment it is preferable to have these expressed in corresponding element error-rates;
- the approach indicated in this Report forms a useful starting point in the development of an objective method determining the performance of telegraph systems.

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ANNEX

In the absence of a fading simulator, it is possible to derive an approximate value of the element error-rate under fading conditions from the results of tests under steady conditions. These steady-state tests will give the error-rate as a distribution function $g(R)$, of the normalized signal-to-noise ratio R.

If, for coherent reception, $g(R)$ can be expressed in the following form:

$$g(R) = \tfrac{1}{2} \operatorname{erfc} (bR/2)^{\frac{1}{2}}$$

then the demodulation factor is constant, $10 \log_{10} b$, independent of the order of diversity employed.
In practice, this will not generally be the case and then the demodulation factor will be a function of both R, and q (the order of diversity). However, by an extension of the work in [2], it can be shown that, in general, the element error-rate with q diversity branches will be:

$$P_{eq} = [(q-1)!\, N^q]^{-1} \int_0^\infty y^{q-1} \exp\{-y/R\}\, g(y)\, \mathrm{d}y.$$

For large signal-to-noise ratios, or small error-rates, the following approximation for the demodulation factor D_q, with q diversity branches, and flat fading, can be found:

$$(D_q)^q = [2^q \,.\, q! \,/\, (2q-1)!] \int_0^\infty y^{q-1}\, g(y)\, dy$$

Measured distribution functions under steady-state conditions can be expressed in the following form:

$$g(R) = \sum a_k \,.\, \exp\{-b_k R\}$$

Then for large values of R:

$$(D_q)^q = [2^q \,.\, q!\,(q-1)! \,/\, (2q-1)!] \sum (a_k / b_k{}^q)$$

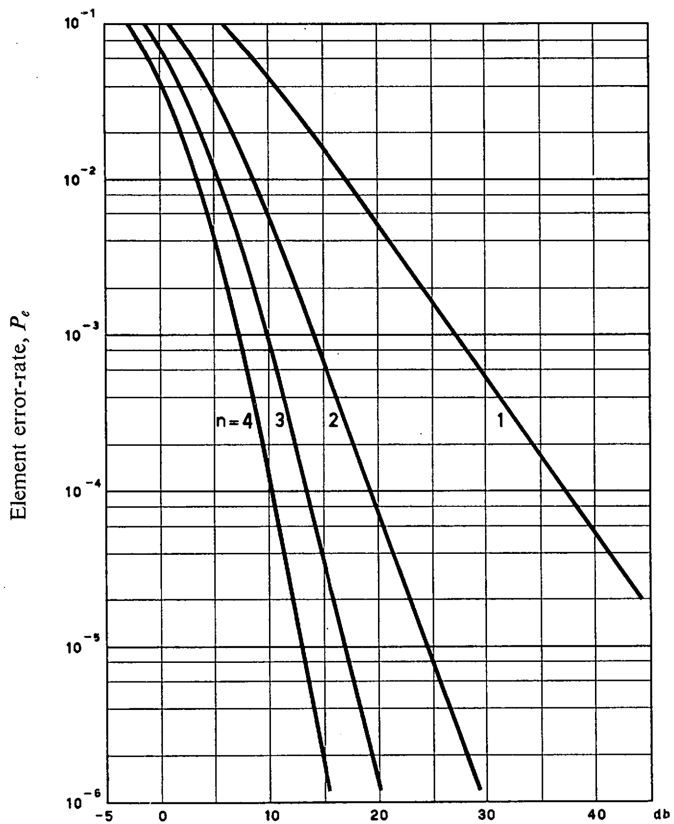
For other forms of the function $g(R)$, similar calculations can be performed.

For non-coherent reception, the reasoning is completely analogous. Again, the answer is simple, if the error-rate under steady conditions can be expressed as a single exponential form.

For the more complicated error performance given by a sum of exponentials, as above, the demodulation factor is given in this case by:

$$(D_q)^q = \sum (a_k/2)\,(2\, b_k)^q$$

Coherent reception



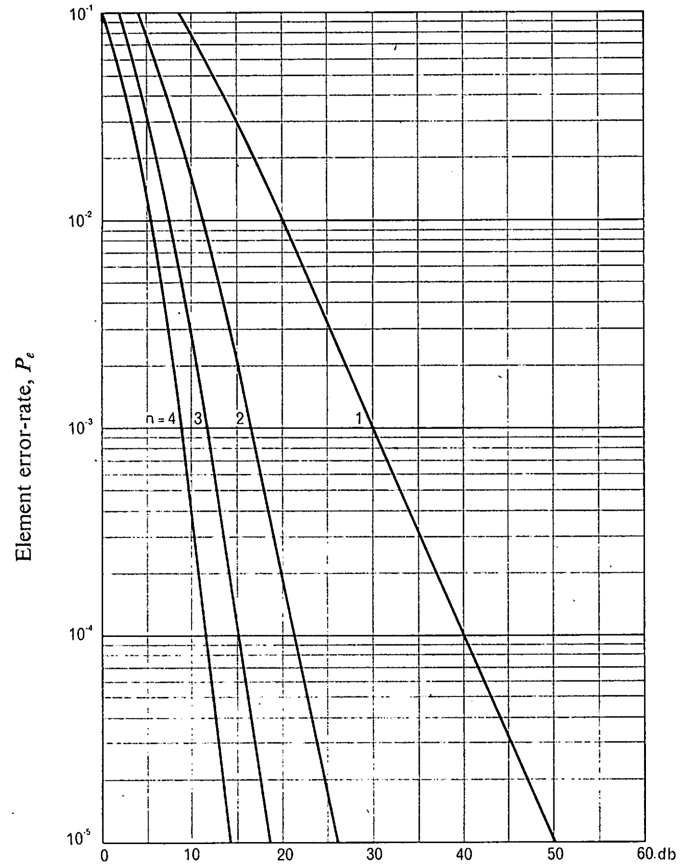
Normalized signal-to-noise ratio per diversity branch (db)

$R_n = 10 \log R$

(n = number of diversity branches)

FIGURE 1

Non-coherent reception



Normalized signal-to-noise ratio per diversity branch (db)

$R_n = 10 \log R$

(n = number of diversity branches)

FIGURE 2

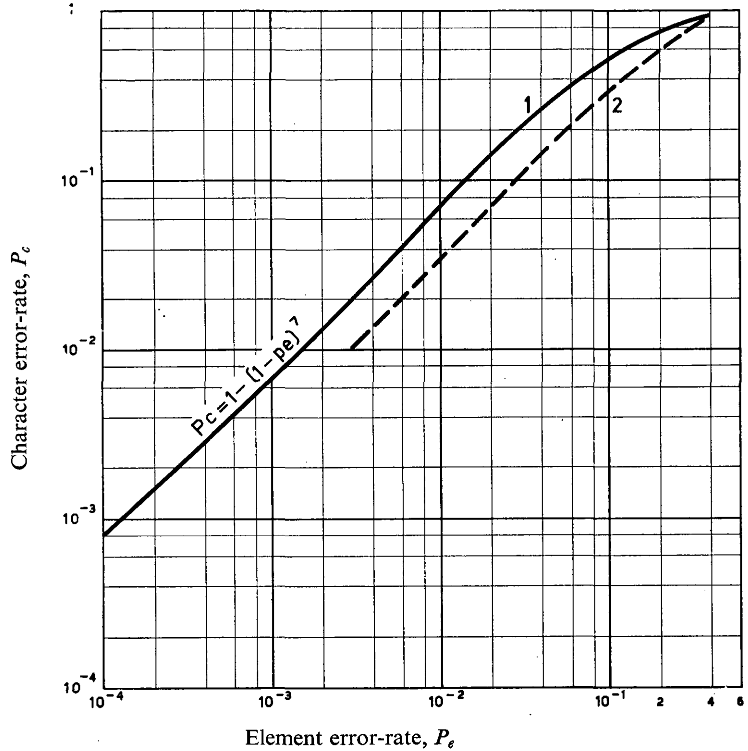


FIGURE 3

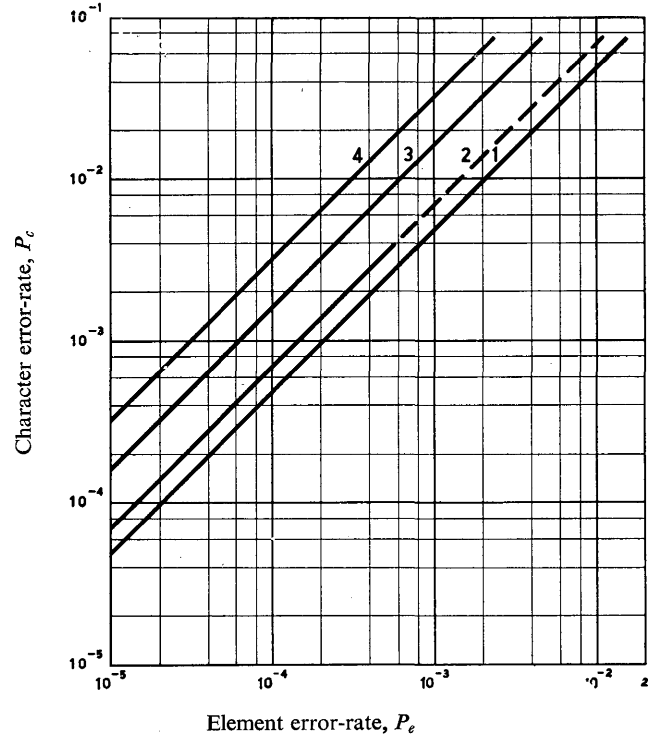


FIGURE 4

Curve 1: 5-unit synchronous code,
2: 7-unit synchronous code,
3: 5-unit start-stop, tape printing,
4: 5-unit start-stop, page printing.

REPORT 196 *

SOME ASPECTS OF THE APPLICATION OF COMMUNICATION THEORY

(Question 133(III))

(Los Angeles, 1959 – Geneva, 1963)

Question 133(III), § 1, has as its subject the relation between permissible delay and residual uncertainty and its dependence on bandwidth utilization.

The permissible delay is related to the length of the code (we will suppose that all code characters have an equal number of elements). If the length of the code character is n elements, the delay is at least the time taken by $2n$ code elements. We shall characterize the behaviour of a channel by its error probability instead of by the residual uncertainty. The bandwidth utilization will be determined by the ratio between the number of check digits and the number of information digits, or by the difference between the information rate and the capacity of a channel. (The minimum ratio of check digits to information digits, required for efficient use of a communication channel, is determined as a function of the capacity.)

For any noisy channel without memory having only a finite number of received signals, the error in transmitting information at a rate $H < C$ and using uniformly good codes of length n is bounded by an expression $F. \exp\{-Bn(C-H)^2\}$, where F and B are constants depending upon the channel parameters, but not upon H or n. This has been shown by Feinstein (1955). H is the information rate and C is the channel capacity. The relation therefore is logarithmic and the coefficient depends on the square of the difference between the rate at which information is sent over a channel and the maximum possible rate.

Shannon (1957), has given more specific results expressed in the distribution function of the transinformation $\rho(x)$. He derives the following theorem: there exists a block code with M messages and a decoding system such, that if these messages are used with equal probability, the probability of error is bounded by:

$$P_e \leq \rho(R+\theta) + \exp\{-n\theta\}$$

where θ may be any given positive constant and $R = (1/n)\log M$. Moreover, the optimal detection system gives a probability of error P_e, satisfying the inequalities:

$$\frac{\rho}{2}(R - \frac{1}{n}\log 2) \leqslant P_e \leqslant \rho(R - \frac{1}{n}\log 2)$$

In 1959, the same author gave more accurate error bounds for channels with additive Gaussian noise, and so did Zetterberg (1961).

In older studies of Rice (1950), curves relating the probability of error to the number of digits in a code were already given for some types of random codes, not necessarily uniformly good. Siforov (1956), has calculated the minimum distance of the code characters (the number of elements in which the code characters must differ), as a function of the element error-rate and the desired probability of error.

Further results for channels with memory have been obtained by Feinstein, Wolfowitz and Blackwell.

From a practical point of view, all these studies have in common that they give proofs of existence for certain codes. The construction of these codes, however, still seems to be out of the reach of even modern calculating machines. After this first problem has been solved, the main technical difficulty will concern decoding. Wozencraft (1957), has found more efficient decoding procedures, whereby the complexity of this operation goes up slower than the square of the length

* This Report, which replaces Report 110, was adopted unanimously.

of the code, instead of growing exponentially with it. (He and Reiffer have developed the " seco " procedure further, and treated it in a book). Even so, the application of these theoretical methods will be an economic problem, where the position may change as the cost of channel capacity goes up, the interest in data transmission increases and the cost of electronic equipment goes down (Fano, 1958).

Block codes of different lengths have been studied extensively. A survey is given in Peterson's book. Though it is not possible to reach information rates near channel capacity in this way, some systems, based on these codes, have been developed to a stage where their use should be seriously considered for digital data transmission systems. It is not yet clear which combination of error-detection or correction, use of null-zone thresholds, and ARQ will prove to be the best compromise. The development should be followed to see whether a substantial gain with respect to methods in use at present and their requirements, can be reached.

From a theoretical point of view, the presence of a return channel does not diminish the probability of error, unless the noise in the go and the return channel are correlated. The return channel, however, simplifies the coding considerably. Theoretical results for decision-feedback systems so far cover only the simplest mathematically tractable models, with additive Gaussian noise and possibly Rayleigh fading.

Time-varying channels, with delay spread, have been studied by Price, Green, Siforov, Kailath, and Turin. The Rake system, adapted to small values of the product of multipath duration and fading rate, has been described in detail.

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REPORT 197 *

FACTORS AFFECTING THE QUALITY OF PERFORMANCE OF COMPLETE SYSTEMS ON THE FIXED SERVICES

(Study Programme 3A(III)

(Geneva, 1963)

1. Urgent need for information

The attention of Administrations is drawn to the urgent need for the information requested in Study Programme 3A(III), for several classes of emission. As requested in the Annex to Study Programme 3A(III), the establishment of minimum protection ratios for additional classes of emission under stable conditions should be given priority. It is realized that no Administration will be able to give all the answers, but partial answers are very welcome. This information will permit an improvement in the calculation of the probability of harmful interference between assignments and the consideration of the possibility of sharing.

The Study Group also needs the information to complete Recommendations 240, 339 and 340 and to bring them up to date **.

The documents received allow only a very partial answer to some of the questions proposed.

2. Number of transposition errors in ARQ systems

In a study of the efficiency factor of a TOR circuit under varying signal-to-noise conditions, a relation was derived between the probability, v, of a correct character being printed and the attendant probability, p, of a transposition being printed [1]. One gets different theoretical limits for flat fading, uncorrelated fading and selective fading.

It has now been shown experimentally, that, under normal traffic conditions the results are nearly those expected for flat fading, or between those expected for flat fading and uncorrelated fading. Under unfavourable conditions, the results are more characteristic of those expected for uncorrelated fading.

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* This Report was adopted unanimously.

** The I.F.R.B. has given a list of the classes of emission in which it is most directly interested in Doc. III/63, of Geneva, 1962.

REPORT 198 *

VOICE-FREQUENCY (CARRIER) TELEGRAPHY ON RADIO CIRCUITS

(Study Programme 43A(III))

(Geneva, 1963)

Theoretical work in Japan (Doc. III/23 of Geneva, 1962), indicates an optimum frequency-shift of 0·8 B (c/s), where B is the number of bauds. This would lead to a required minimum bandwidth (at − 3 db points) of B cycles/sec. Laboratory experiments and measurements on the synchronous ARQ circuit Frankfurt-Osaka, support these conclusions.

It is to be noted, that this shift is preferably to be used on circuits near MUF and that otherwise a larger shift may be beneficial. For asynchronous circuits, some theoretical results indicate B to 2 B as best shift [Akima, Voss]. Further experiments, on circuits of different lengths, in different directions and in different seasons, are desirable before a definite conclusion can be reached.

REPORT 199 *

ARRANGEMENT OF VOICE-FREQUENCY FREQUENCY-SHIFT TELEGRAPH CHANNELS ON RADIO CIRCUITS

(Study Programme 43A(III))

(Geneva, 1963)

1. Introduction

Various types of voice-frequency frequency-shift telegraphy have been tested and put into service by different Administrations during the past few years.** It seems desirable to give particular attention to those systems which appear to occupy a narrower bandwidth, account being taken of propagation conditions and of the type of telegraph modulation used over the circuit.

With this in view, the attention of Administrations is drawn to systems corresponding to the following characteristics.

2. Synchronous telegraphy at 100 bauds with automatic error correction

Various documents and oral contributions were presented at the Interim Meeting of Study Group III, Geneva, 1962, showing the possibilities given by the use of this type of modulation on systems with a channel spacing of 170 c/s. The central frequencies of the channels are given in Table I.

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* This Report was adopted unanimously.

** See Doc. III/1 and III/16 of Geneva, 1962.

TABLE I

Central frequencies of voice-frequency frequency-shift telegraph channels with a channel separation of 170 c/s and a modulation index of about 0·8
(Frequency deviation: ± 42·5 c/s or ± 40 c/s)

Channel No.	Central frequency (c/s)	Channel No.	Central frequency (c/s)
1	425	8	1615
2	595	9	1785
3	765	10	1955
4	935	11	2125
5	1105	12	2295
6	1275	13	2465
7	1445	14	2635
		15	2805

3. Start-stop telegraphy at 50 bauds

For several years, various Administrations have had in service, on certain selected circuits, equipment with a channel spacing of 120 c/s, and central frequencies and frequency deviations which are in agreement with C.C.I.T.T. Recommendation R.35. The central frequencies of these systems are given in Table II.

TABLE II

Central frequencies of voice-frequency frequency-shift telegraph channels with a channel separation of 120 c/s and a modulation index of about 1·4
(Frequency deviation: ± 35 c/s or ± 30 c/s)

Channel No.	Central frequency (c/s)	Channel No.	Central frequency (c/s)
1	420	11	1620
2	540	12	1740
3	660	13	1860
4	780	14	1980
5	900	15	2100
6	1020	16	2220
7	1140	17	2340
8	1260	18	2460
9	1380	19	2580
10	1500	20	2700

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REPORT 200 *

TELEGRAPH DISTORTION, ERROR-RATE

(Geneva, 1963)

1. The study of the relationship between telegraph distortion and error rate received further attention, but the results so far achieved are not usable under the conditions of radio propagation. Nevertheless, the statistical distribution of the distortion could be of value for assessing the quality of a radiotelegraph circuit without knowing the exact message, e. g., for purposes of investigation.

2. Statistical measurements of the error-rate, on the connection Warsaw-New York, did not indicate any direct relationship between the error-rate and the received level of the signal.

REPORT 201 *

REMOTE CONTROL SIGNALS FOR FACSIMILE TRANSMISSIONS

(Question 232(III))

(Geneva, 1963)

With the rapidly increasing use of facsimile transmissions for various purposes, using continuous web (chart type) recorders, it has become desirable for the C.C.I.T.T. to set up standards for the remote control signals to be employed for the connection, starting, phasing, speed control, stopping, etc. of a facsimile transmission.

The World Meteorological Organization has been actively interested in this problem, and, in collaboration with the C.C.I.T.T., have established a set of control signals for use over the leased weather network (see Doc. III/53 of Geneva, 1962).

The C.C.I.T.T. have also examined the problem, and have established a Question No. 7/XIV (Vol. VII, p. 210), in which Administrations have been requested to give their opinion as to the utility of certain types of remote control signal for the transmission of business documents.

The W.M.O. and the C.C.I.T.T. will make known to the C.C.I.R. their proposal for standardization of remote control signals, so that the C.C.I.R. might determine if the proposed standards are acceptable and applicable on radio circuits.

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* This Report was adopted unanimously.

REPORT 202 *

IDENTIFICATION OF THE CARRIER FREQUENCY RELATIVE TO THE ASSIGNED FREQUENCY OF AN EMISSION

(Study Programme 187(III))

(Geneva, 1963)

1. Introduction

The following method of carrier-frequency identification formed the subject of Doc. III/60 (U.S.A.) of Geneva, 1962, and appears to provide a simple and precise method of identifying the carrier frequency of those classes of emission in which the carrier frequency and the centre of the assigned frequency band do not coincide. Examples of the application of this method are given in the Annex to this Report.

2. Description of method

2.1 *Represent the assigned frequency of the emission by X.* Let the *carrier frequency of the emission* be f_c;

2.2 determine the value of the difference ($f_c - X$), let this value be n c/s;

2.3 divide the value of n by 100 to obtain the code number;

2.4 if the value of n is negative (i. e. the carrier frequency lies below the assigned frequency), follow the value $n/100$ by the indicator X;

2.5 if the value of n is positive (i. e. the carrier frequency lies above the assigned frequency), precede the value $n/100$ by the indicator X;

2.6 the results obtained $\left(\frac{n}{100} X \text{ or } X \frac{n}{100}\right)$ give the location of the carrier frequency relative to the assigned frequency.

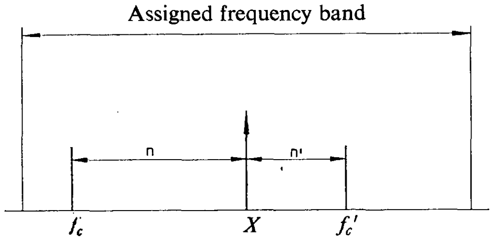
ANNEX

EXAMPLES OF THE APPLICATION OF THE METHOD

Existing station designation	Assigned frequency (kc/s)	Carrier frequency (kc/s)	Frequency difference (c/s)	Value $\frac{n}{100}$	Coded indicator	Coded station designation[1]
WEO86 A3 6840·5 kc/s	6845	6840·5	−4500	−45	45*X*	WEO86 45*X*
WEO86 A 6844·1 kc/s	6845	6844·1	− 900	− 9	9*X*	WEO86 9*X*
WEO86 B 6845·9 kc/s	6845	6845·9	+ 900	+ 9	*X*9	WEO86 *X*9
WEP26 6851·8 kc/s	6852·5	6851·8	− 700	− 7	7*X*	WEP26 7*X*
WER33 A 13448 kc/s	13450	13448	−2000	−20	20*X*	WER33 20*X*
WES38 B 18942 kc/s	18940	18942	+2000	+20	*X*20	WES38 *X*20
WMF27 B2 7717·7 kc/s	7715	7717·7	+2700	+27	*X*27	WMF27 *X*27
WMH30 A2 10387·3 kc/s	10390	10387·3	−2700	−27	27*X*	WMH30 27*X*

(1) For use in the exchange of operating information between the terminals of a radio circuit.

* This Report was adopted unanimously.



Assigned frequency

f_c is a carrier frequency designated $\frac{n}{100} X$

f_c' is a carrier frequency designated $X \frac{n'}{100}$

REPORT 203 *

MULTIPATH PROPAGATION ON HIGH FREQUENCY RADIO CIRCUITS

Measurements of path-time delay differences and their incidence on typical radio links

(Study Programme 3A(III))

(Geneva, 1963)

1. Measurements on high-frequency radio circuits of the fixed service

1.1 *Summary*

Some 4000 facsimile pictures, received over a number of important radiotelegraph circuits terminating in London, during the period from sunspot minimum to sunspot maximum (1953 to 1957), have been examined, to ascertain the incidence of multipath propagation and to measure the dispersion of path-time delays. Multipath conditions were found to obtain for a considerable proportion of the time throughout the whole period and path-time differences were observed up to 2·5 ms. The measurements were made on pictures received from New York (1420 pictures), Melbourne (1600 pictures) and Moscow (350 pictures), together with a few less-frequently used circuits. The technique of measurement is outlined below and is similar to that given by Japan in a contribution to the VIIth Plenary Assembly.

1.2 *Method of measurement*

The facsimile transmissions use frequency-modulation so that, in general, the received picture will be derived from the predominating path. If, due to fading, signals from different paths of unequal length predominate at different times, a sharp, straight line in the transmitted picture, at right angles to the line of scan, will appear as a jagged line in the received picture.

* This Report was adopted unanimously.

By measuring the width of the ripple of the received line, it is thus possible to determine the difference in propagation time over the shortest and longest paths that predominate from time to time during the transmission of the picture.

The spread in path-time delay, as seen on the facsimile pictures, was obtained by measuring the ripple on a line, at right angles to the direction of scan, which could be safely assumed to be sharp and straight when transmitted. A low-power microscope, having a graticule divided into squares, was used to measure the ripple. The magnification was adjusted so that one square represented a time difference of 2 ms for the machines most generally used. Displacements were estimated to the nearest 0·5 ms and, when a number of different delays were observed, only the maximum delay difference was recorded. In some cases, this maximum delay was not typical of the distortion throughout the picture as a whole.

A check was made under controlled conditions, using a fading machine which was adjusted to produce random fading with known differences in path-time delay and with various median signal levels on the two paths. The incidence of multipath observed in these tests was almost identical with that obtained by mathematical analysis.

1.3 *Measurement on facsimile pictures*

Each picture was examined to determine the maximum path-time delay difference. Since the values of delay were approximated to the nearest 0·5 ms, the probable distribution of differences in path-time delay between 0 and 2·5 ms was obtained by the usual method of apportioning the number of pictures at each value of delay, other than zero, equally between the adjacent delay ranges.

The incidence of multipath distortion on each picture was assessed according to four categories, viz: none, rare, frequent, continuous.

For each month, the percentages of pictures received for each range of delay difference and for each category of incidence were obtained. For simplicity, these monthly percentages have been averaged over a complete year, and the results are shown in Fig. 1.

1.4 *Discussion of results*

The results show that, for each of the four years 1953 to 1957, frequent or continuous multipath was in evidence on between 40 and 50% of the pictures analyzed. Approximately half the pictures affected by multipath showed path-time delay difference of 1 ms or more, and nearly 30% had delay differences of 1·5 ms or more.

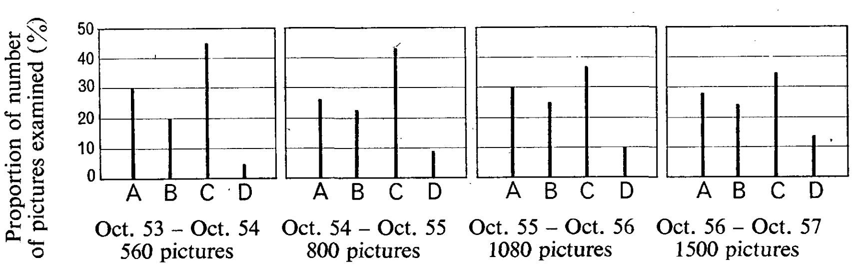
Multipath effects such as these are not particularly troublesome in facsimile transmission. Facsimile pictures have been used merely as a convenient means of obtaining data on incidence and delay difference over a long period on typical high-frequency fixed-service radio links. The effect of such multipath propagation could be more serious on telegraphy and data circuits, particularly where the path-time delay difference is appreciable in relation to the duration of the telegraph element. For example, a path-time delay difference of 2 ms would have an adverse effect on the performance of a telegraîh circuit working at 200 bauds, since the delay difference is equal to 40% of the duration of the signalling element. Circuits working at lower modulation rates would be less affected by multipath propagation, since the path-time delay difference would be smaller in relation to the duration of the telegraph element. For example, a 2 ms delay difference would equal only 20% of the element duration at 100 bauds.

2. Measurement on meteorological broadcast services

Section 1 of this Report shows the incidence of multipath propagation and path-time delay differences observed on typical point-to-point high-frequency radio circuits. More severe multipath effects may, however, be experienced when frequencies below optimum have to be used. Such circumstances often arise, for example, in high-frequency meteorological broadcast services, and an analysis has been made of meteorological charts received in the United Kingdom by facsimile transmissions from Washington, D.C., and from Japan.

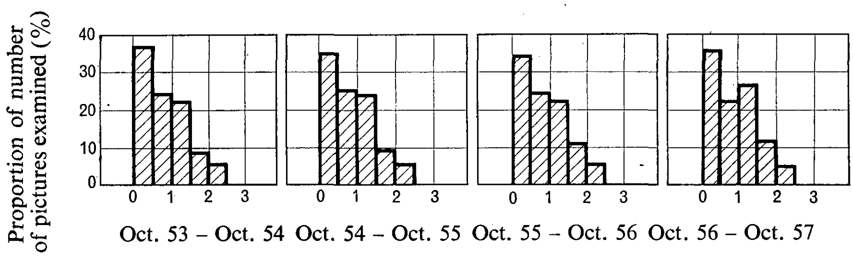
Some 1600 charts received during the period June to September, 1961, have been analyzed. Of these, 1000 were received from Washington and 600 from Japan. The method of neasuring the path-time delay differences was similar to that described in § 1 of this Report. The results are tabulated below and are shown graphically in Fig. 2.

Multipath time delay difference (ms)	Percentage of charts for each circuit	
	Washington, D.C. to United Kingdom (6000 km)	Japan to United Kingdom (9600 km)
0 - ½	10	0
½–1	20	5
1 –1½	28	9
1½–2	21	10
2 –2½	10	30
2½–3	6	26
3 –3½	2	11
3½–4	2	6
4 –4½	1	2



(a) *Incidence of multipath*

A – none
B – rare,
C – frequent,
D – continuous.



(b) *Range of multipath delay-differences (ms)*

FIGURE 1

Multipath propagation on HF radio circuits of the fixed service

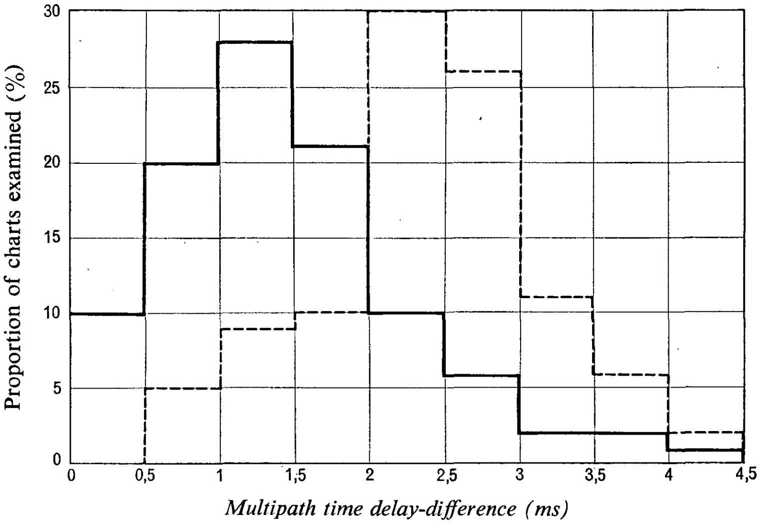


FIGURE 2

Multipath propagation on circuits of the meteorological broadcast service

———— Path, Washington, D.C. to United Kingdom,
- - - - - - Path, Japan to United Kingdom.

STUDY GROUP III

(Fixed service systems)

Terms of reference :

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.

Chairman : Dr. H. C. A. VAN DUUREN (Netherlands)
Vice-Chairman : Dr. S. NAMBA (Japan)

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP III

1. The scope of the work of Study Group III covers the study of world-wide radiocommunications in the fixed services, for which the HF (decametric) band is mainly used. The study aims at recommending methods of two-way radiocommunication by means of telephony, telegraphy and facsimile. The application of such methods will enable Administrations to interconnect their landline network via radio to the world-wide communication network. The Recommendations of the Study Group contain the best solutions agreed upon internationally for obtaining commercial quality.

2. Recommendations 100, 335, 336, 338, 348 and 349 contain information to carry telephony over radio by the application of single-sideband and independent-sideband systems (information concerning: system bandwidth and frequency tolerances, channel arrangements, privacy equipment and echo suppression).

3. Recommendations 106, 248, 338, 342, 345 346, 347, and 349 deal with communication by means of telegraphy (information concerning: system bandwidth and frequency tolerances, operation on FSK and twinplex channel and on ARQ-systems, classification of channels and definitions on the telegraphic distortion).

4. Recommendations 343 and 344 deal with facsimile transmissions of meteorological charts and the transmission of phototelegraphy on radio links, connected to the landline network.

5. Operation on radio links is hampered by fading and noise under unfavourable conditions of radio propagation, or by interference from unwanted emissions. The study of the difficulties encountered and of measures to increase the time of operational quality for the several systems, is covered mainly by Question 3(III) and Study Programme 3A(III). This study continues, and the fixing of protection ratios against unwanted interfering emissions, is in progress in cooperation with the I.F.R.B. (Report 197). Some information is available in Recommendations 240, 339 and 340. An international Working Party has been set up to work by correspondence, which will advise the C.C.I.R. on definitions and procedures to obtain a better use of the radio-frequency spectrum (Resolution 1). Research work on propagation effects has been recorded in Reports 109, 111, 198 and 203.

6. The use of the radio path will be improved by the application of directional antennae. Recommendation 341 gives definitions on transmission gain and loss, and Report 112 shows the application of those concepts. The study on the directivity of antennae at great distances has not yet been finished. Some data are available in Recommendation 162 and Report 106.

7. Communication theory gives the basis for a better understanding of system performance. Therefore developments in communication theory may lead to the improvement of systems. Study Programme 133A(III) deals with communication theory. Report 196 shows some applications. A practical application discussed by the Study Group, is the ARQ-system, described in Recommendation 342. The Study Group uses the binary information unit (bit) as a standard for comparing the performance of telegraph systems (Recommendation 166), and the normalized signal-to-noise ratio for comparing radiotelegraph channels (Report 195).

8. Cooperation with the C.C.I.T.T. resulted in Recommendation 335 (telephony), Recommendations 342 and 345 (telegraphy) and Recommendation 344 (phototelegraphy). This cooperation is continued by studies laid down in Study Programmes 186(III) (efficiency factor) and 3B(III) (automatic phasing).

RESOLUTION 1 *

OPTIMUM USE THE RADIO-FREQUENCY SPECTRUM

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that the available information on the wanted-to-unwanted signal protection ratios and the operating sensitivities of receiving systems needs further refinement for each of the services, to permit the most efficient planning of the use of the radio-frequency spectrum;

(b) that a larger number of simultaneous users of the spectrum must be accommodated in the future;

(c) that the accommodation of these additional users, without serious deterioration of those services in use at present, will require careful consideration of all the many technical factors involved in the simultaneous operation of potentially interfering systems;

UNANIMOUSLY DECIDES

1. that an International Group of Experts of the C.C.I.R.**, which would be representative of the Study Groups interested in this problem, shall be established, to prepare a report on definitions and procedures which would, when made available to the various Study Groups of the C.C.I.R., be expected to lead to improved information on:
- the required signal-to-interference protection ratios;
- the minimum field strengths required for various classes of emission;

which would permit the optimum use of the radio-frequency spectrum by the maximum number of simultaneous users;

2. that the co-ordination of the work of the Group should be undertaken by Study Group III;

3. that, as far as possible, the work of the Group should be conducted by correspondence.

Note. – The Director, C.C.I.R. is invited to bring this Resolution to the attention of the U.R.S.I. for information.

* This Resolution relates to Recommendations 2 and 3 of the Administrative Radio Conference, Geneva, 1959.

** The following Administrations: U.S.A., (Dr. K.A. NORTON, Chairman), France, Japan, Netherlands, F.R. of Germany, United Kingdom, the U.S.S.R. and the I.F.R.B. have already indicated their willingness to form part of this Group.

QUESTION 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 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 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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* Questions 1, 2 and 3(III).

STUDY PROGRAMME 3A(III) *

FACTORS AFFECTING THE QUALITY OF PERFORMANCE OF COMPLETE SYSTEMS OF THE FIXED SERVICES

Signal-to-noise and signal-to-interference protection ratios for fading signals, bandwidth and adjacent channel spacing

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that Question 3(III) establishes a permanent study of questions relating to the desired conditions of performance to be fulfilled by the fixed services;

(b) that the conditions for satisfactory performance of a system must take account of the need to receive signals propagated via the ionosphere, which are subject to fading and multipath effects and are accompanied by radio noise and interference;

(c) that studies requiring signal-to-noise and signal-to-interference protection ratios are closely related, and that determination of necessary adjacent channel spacings requires, in addition, consideration of frequency stability and bandwidth of the systems;

(d) that there are a number of different techniques and systems in use in the radiotelegraph and radiotelephone services and, while it is essential to consider the most advanced state of the radio art, it is also necessary to give special study to conventional systems, either affecting integration of land-line and radio services, or of concern to the I.F.R.B.;

UNANIMOUSLY DECIDES to carry out the following studies:

1. Classes of service

The studies concern the following classes of service in regular use in the fixed services, but should also give due regard to new techniques and systems, including those under development, for application to the fixed services:

1.1 *Radiotelephony*

1.1.1 Types of emission: A3, A3A, A3B, F3 **;

1.2 *Radiotelegraphy*

1.2.1 Types of emission: A1, A2, A7, F1;

1.2.2 Telegraph speeds:

- A1, A2, hand speed 8 and 24 bauds, machine speed 50 and 120 bauds;
- A7, multichannel VF telegraphy, 50 to 200 bauds per channel;
- F1, 50 to 600 bauds;

1.2.3 Codes:

- 5-unit start-stop;
- 5-unit synchronous;
- synchronous error-detecting and correcting systems using two-condition signalling codes other than the International Alphabet No. 2;
- other systems using more than two signalling conditions;

1.3 *Facsimile, phototelegraphy; Hellschreiber*

1.3.1 Types of emission: A4, F4.

* This Study Programme, which replaces Study Programmes 44, 45, 49 and 50 and Questions 82, 129 and 131, was previously designated Study Programme 128(III).

** F3 above 30 Mc/s only, with reference to ionospheric-scatter applications.

2. Minimum conditions required for satisfactory service

2.1 Acceptable criteria and values for:

2.1.1 *intelligibility* over radiotelephone circuits *;

2.1.2 *error rate* for characters and elements over radiotelegraph circuits (*efficiency factor* for ARQ circuits);

2.1.3 *legibility* of copy over facsimile (phototelegraphy) and Hellschreiber circuits;

- what is the maximum duration and percentage of the time during which performance inferior to the standard values can be tolerated;

2.2 Performance of the system as a function of:

- signal-to-noise and signal-to-interference (co-channel) ratios;
- required signal-to-noise and signal-to-interference (co-channel) protection ratios for the acceptable standard values of intelligibility, error rate (efficiency factor on ARQ circuits), or legibility, for the various services **, considering:

2.2.1 Signal fading, taking account not only of the amplitude distribution, but also of the autocorrelation function and the distribution of duration of the fades;

2.2.2 Diversity (space, frequency, or time) techniques:

- noise reducers,
- coding including the use of error-correcting; codes or ARQ ***,
- use of more than two signalling conditions, and
- optimum modulation and detection techniques ****,

2.2.3 Multipath effects;

2.2.4 Interference effects of radio noise of various types, such as atmospheric, impulsive, or Gaussian noise, as described by the wave form and amplitude distribution of the instantaneous values of the noise,

- the resulting interference effects on actual reception, taking account of the method of detection, and of filtering prior to and following detection;

2.2.5 Interference effects of co-channel signals representing the various classes of emission, taking account of the spectral and statistical (fading) characteristics of the interfering signal;

2.2.6 Monthly mean signal-to-noise ratios and signal-to-interference ratios, required for circuits of various lengths and directions, for the acceptable standard values of circuit performance (§ 2.1), to be met during the specified percentage of the time, taking into account,

- the distribution within an hour of the mean values of the short-term (fading) distributions of signals and noise,
- the distribution, within a month or season, for a given hour of the hourly mean values of the signal strengths and atmospheric noise levels (Report 322) *****,

* For the various grades – just usable, operator to operator (order wire);
– marginally commercial;
– good commercial.

** For radiotelephone services, the signal-to-noise ratio required in the audio band must be specified, and from this the signal-to-noise ratio required in the radio-frequency band is established.

*** It would be useful to compare the systems using the various telegraph codes, including those of § 1.2.3, in terms of undetected or uncorrected error rate for a given 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 character as an error only. It is provisionally suggested that the ratio of error rates should be expressed for two circuit conditions only, namely, when the system under test is subjected to an average of one undetected or uncorrected error per 1000 characters, and per 10 000 characters.

**** A special study is needed comparing the different systems used for voice-frequency telegraphy on radio circuits; this is dealt with in Study Programme 43A(III).

***** The monthly mean values of atmospheric noise for various time blocks, and information on the distribution of values within the month, is given in Report 322; with regard to monthly mean values of signal strength, and distribution of hourly values within the month, until such time as C.C.I.R. adopts information on this subject, other standard references may be used, such as U.S. National Bureau of Standards Circular No. 462.

ANNEX

MINIMUM PROTECTION RATIOS AND FREQUENCY SEPARATION UNDER STABLE CONDITIONS

Wanted signal		Interfering signal																							
Type of service		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																								
A1	50 bauds (printer)																								
A1	120 bauds (recorder)																								
F1	50 bauds (printer)																								
F1	120 bauds (recorder)																								
F1	200 bauds (printer ARQ)																								
F4	phototelegraphy																								
A3A	SSB																								
A3	DSB (commercial)																								

Note. – Column 1 gives the limiting values in db of signal-to-interference ratio, 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, 6 or 30 db higher than the wanted signal.

this study is intended to lead to revisions or replacement of Recommendations 240, 339 and 340.

2.3 Minimum bandwidth required for satisfactory transmission and reception of the intelligence, in a complete system (this is not the question of " bandwidth necessarily occupied ", involving the capability of the transmitting system to avoid radiation outside the band needed for communication, which is included in Study Programme 181(I)).

3. Determination of adjacent channel signal-to-interference protection ratios, and frequency separations between various classes of service, considering

3.1 the use of effective receiving band-pass filters no wider than necessary for satisfactory reception (§ 2.3 above, and Recommendations 237, 330 and 332);

3.2 the bandwidth occupied by the interfering transmission;

3.3 the frequency tolerance and stability of the wanted and unwanted signals;

3.4 the studies of § 2.2 above relating to co-channel signal-to-interference protection ratios.

Note. – The results of this study should be presented in the form indicated in the Annex. The results are intended to lead to revision of Recommendation 240.

STUDY PROGRAMME 3B(III)

RADIOTELEGRAPH CIRCUITS USED IN AUTOMATIC SWITCHED-NETWORKS

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that a high value of the efficiency factor is required for radiotelegraph circuits used in automatic switched-networks;

(b) that, on such circuits, the duration of possible interruptions should be kept to a minimum;

(c) that it is desirable, when ARQ is used on such circuits, to use a phasing procedure that restores correct phase as soon as possible;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the determination of useful out-of-phase criteria;

2. rearrangement of the ARQ-procedure to give more rapid phasing;

3. the establishment of a procedure for phasing, in which the sequence of phasing is fixed for both the master and slave stations;

4. the development of a suitable indicator for the efficiency factor * of a radiotelegraph circuit.

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* See Study Programme 186(III).

QUESTION 43(III)

VOICE-FREQUENCY TELEGRAPHY ON RADIO CIRCUITS

(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 C.C.I.T.T. Study Group IX.

STUDY PROGRAMME 43A(III) *

VOICE-FREQUENCY (CARRIER) TELEGRAPHY ON RADIO CIRCUITS

The C.C.I.R., (Geneva, 1951 – London, 1953 – Los Angeles, 1959)

CONSIDERING

(a) that different methods are now in use for voice-frequency telegraphy on radio circuits operating below 30 Mc/s subject to fading, noise and interference,

- either using equipment normally designed for land-line working and suitably adapted for radio;
- or using equipment especially designed for radio working (see for example Docs. 29 and 195 of Geneva, 1951; Docs. 5, 205 and 273 of London, 1953; and Doc. 422 of Warsaw, 1956, MADFAS system);

(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 voice-frequency oscillator, without taking into account all the factors of the equipment (see more particularly Doc. 273 of London, 1953);

(c) that the study of Question 43(III) is to be continued, in conjunction with the C.C.I.T.T., to obtain, if possible, unification of at least some of the component elements of voice-frequency equipment used on wire and radio;

(d) that experience in reception of voice-frequency telegraphy over radio circuits has shown the importance of correct design of the limiters, the filters and the diversity combining circuits; and that, from these considerations and the special conditions for combined voice-frequency telegraphy channels employing diversity operation, it appears that frequency-modulated voice-frequency telegraphy equipments for use on radio circuits, may differ substantially from voice-frequency land-line equipment; they may, therefore, have to be designed and constructed with their special purpose in mind;

UNANIMOUSLY DECIDES that the following studies should be carried out:

comparisons of the different systems used to transmit and receive voice-frequency telegraphy on radio circuits subject to the effects of fading, noise and interference, with a view to standardizing their characteristics, taking into account the following techniques and factors:

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* This Study Programme, which replaces Study Programme 46, was previously designated Study Programme 129(III).

- frequency-shift keying of one voice-frequency oscillator;
- transmitting mark and space by the two-tone method;
- other modulation systems, e. g. phase modulation;
- reception by discriminator or separate filters;
- influence of modulation index $= \frac{\text{frequency shift (c/s)}}{\text{telegraph speed (bauds)}}$

on the error rate, and channel spacing.

QUESTION 74(III) *

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 at 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 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 at frequencies below about 30 Mc/s?

QUESTION 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 organizations, of the directivity of antennae realized at great distances (taking full advantage of existing transmissions), by any suitable method, for example, by use of mechanically or electrically steered antennae.

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* This Question replaces Question 46.

** This Question replaces Question 48.

STUDY PROGRAMME 81A(III) *

IMPROVEMENT OBTAINABLE FROM THE USE OF DIRECTIONAL ANTENNAE

The C.C.I.R., (London, 1953 – Warsaw, 1956 – Los Angeles, 1959)

CONSIDERING

(a) that Study Programme 3A(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 162 shows median value 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;

(c) that it is also important to know the discrimination given by the antenna, when the wanted station or the interfering station, or both, are at much shorter range;

(d) that it appears practicable to obtain some reduction of interference by using a null method at the receiver;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of the signal power gain in the main lobe provided by practical directional antennae used under actual propagation conditions, relative to a half-wave horizontal dipole ** at the height of the centre of the directional antenna; the median value and cumulative distribution with time of the values of gain during short periods (as, for example, less than an hour), should be observed; observing periods should be suitably distributed and the data studied on a statistical basis, so as to show dependence of results on time of day and season for normal propagation conditions, and the effect of especially critical propagation conditions such as encountered near time of sunrise and sunset, and at times of failure of the operating frequency near the MUF, and at times of ionospheric disturbances;

2. determination of the signal power gain in directions outside the main lobe and/or values of discrimination provided by the antenna between the wanted and interfering signals. The data should include the variations with time, referred to in § 1 above, and should specify directions or the appropriate arcs shown in Fig. 1 of Recommendation 162;

3. the effects of the antenna height in increasing the number of hours of useful transmission and in the reduction of interference;

4. the usefulness of a null method of minimizing the interference. The data required to evaluate the usefulness might consist of:

4.1 logs of commercial receiving stations, showing outages due solely to interference and the relative azimuth bearing of interfering stations;

4.2 experimental data on the use of directional antenna systems and antennae with adjustable directions of null, under conditions where interference is experienced.

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* This Study Programme, which replaces Study Programme 85, was previously designated Study Programme 130(III).

** The median values of the gain can also be expressed relative to the isotropic antenna.

STUDY PROGRAMME 81B(III) *

DIRECTIVITY OF ANTENNAE FOR FIXED SERVICES USING IONOSPHERIC-SCATTER PROPAGATION

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that systems are at present in service using ionospheric-scatter propagation, at frequencies above 30 Mc/s and that extension of use of this mode of propagation may be expected in the international fixed services;

(b) that it is desirable to establish the preferred characteristics of such systems needed to facilitate their international connection, and that it is particularly important to have similar or matched directivity of the antennae at opposite terminals of the circuit;

(c) that antenna directivity, including the characteristics of radiation pattern, gain, beamwidth and direction of the main lobe or lobes, significantly affects transmission loss, and the possibility of occurrence of multipath propagation and interference to and from other services;

UNANIMOUSLY DECIDES that the following studies should be carried out:

studies of the desirable characteristics of the directivity of transmitting and receiving antennae for international fixed services, using ionospheric-scatter propagation above 30 Mc/s, including gain, beamwidth and direction of the main lobe or lobes, and tolerances for the radiation pattern outside the main lobe, taking into account:

- dependence on propagation characteristics of the scattering medium, including dependence on scattering angle, size and inhomogeneity of the scattering region;
- effects of meteoric ionization, and the techniques of beam slewing and beam splitting, and how these may depend on season and time of day;
- operating frequency;
- diversity;
- polarization;
- multipath propagation, in relation to the modulation technique used;
- interference to and from other services.

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* This Study Programme was previsouly designated Study Programme 131(III).

QUESTION 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, 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 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 utilizing 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, which 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 liable to interfere with each other and with other services operating on the same or neighbouring frequencies;

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 to enable two systems to be interconnected, and what values should be specified?

QUESTION 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;

(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. has suggested further study in Doc. 14 of Warsaw, 1956;

UNANIMOUSLY RECOMMENDS that the following question should be studied:

1. the relation between permissible delay and residual uncertainty and its dependence on bandwidth utilization;

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 133A(III) **

COMMUNICATION THEORY

The C.C.I.R., (Geneva, 1951 – London, 1953 – Warsaw, 1956 – Geneva, 1963)

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, some at least of which were not designed in the light of phenomena peculiar to radio propagation, are making the best use of the occupied bandwidth;

** This Question replaces Question 44.

* This Study Programme replaces Study Programme 86.

(e) that, to assess the effectiveness of any error-detecting or error-correcting codes over radio circuits, it is essential that realistic error statistics be known for these radio circuits;

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 comparison of the various existing systems of modulation from the point of view of the bandwidth occupied in relation to the amount of information transmitted in a given time for a given power; *

2. that experimental determination of error statistics be made for operating radio circuits. On the 3 out of 7 ARQ systems, this can conveniently be done by counting and printing out the errors on " idle alpha " characters, while the system is in full operation. The result of these experiments will be a table, showing the frequency of occurrence of m errors in a sequence of n digits ($m = 0, 1, 2, 3 \ldots$ and $n = 7, 14, 21 \ldots$). Where this is possible, it may be useful to give information on the occurrence of the different types of error);

3. that experimental determination of the relative frequencies of occurrence of m errors be extended to values of n other than multiples of 7. This experiment may require a separate experimental channel. The suggested range of values for n is between about 10 and 100, with particular emphasis put on 15, 31, 63 and 127;

4. the study, in conjunction with the U.R.S.I., of the methods of communication theory that are best suited for practical application.

Note. – The statistical information asked for under § 2 and 3 should, where possible, state the conditions of the channel: signal-to-noise ratio, fading characteristics, special noise or channel disturbances, interference from other stations, etc.

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* Relative to this study, it is useful to consider for radiotelephony, the determination of the relationship 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:
- in many cases, the noise power is distributed uniformly over the audio-frequency spectrum, while speech power is distributed unevenly over the spectrum;
- 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.

QUESTION 180(III)

USE OF INTERMITTENT COMMUNICATION IN RADIOTELEGRAPHY

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that the method of intermittent communication is coming into use, particularly for circuits using meteoric ionization;

(b) that intermittent communication often enables the mean telegraph speed to be increased considerably, for a given quality of service, when the signals and interference at the receiver are random in character;

(c) that insufficient data are so far available concerning the fields in which it would be opportune to apply the principle of intermittent communication;

UNANIMOUSLY DECIDES that the following question should be studied:

1. under what conditions is the use of intermittent communication advantageous in radiotelegraphy;
2. what advantages, as regards telegraph speed, can be expected from the use of intermittent communication under various conditions, as compared with the usual uninterrupted method;
3. what is the most rational course to be followed in the construction of equipment for the use of intermittent communication under various conditions?

QUESTION 181(III) *

INFLUENCE ON LONG-DISTANCE HIGH-FREQUENCY COMMUNICATION USING FREQUENCY-SHIFT KEYING OF FREQUENCY DEVIATIONS ASSOCIATED WITH PASSAGE THROUGH THE IONOSPHERE

The C.C.I.R., (Warsaw, 1956 – Los Angeles, 1959)

CONSIDERING

(a) that Recommendation 246, § 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 frequency deviations, associated with passage through the ionosphere, has shown that the resultant frequency variations may reach values of a few cycles per second, while instantaneous deviations may reach much higher values (see Documents of the VIth Plenary Assembly, Geneva, 1951, Vol. II, page 79; Doc. 213 of Warsaw, 1956; Doc. 133 of Los Angeles, 1959 and Report 111);

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 frequency deviations?

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* This Question replaces Question 139.

QUESTION 182(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., (Los Angeles, 1959)

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 a.f.c. (automatic frequency control), to adjust the receiver oscillator frequency in sympathy with frequency variations of the transmitted signal;

(b) that such a.f.c. 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 Recommendation 233, and is approaching a value which could provide sufficient inherent stability to enable a.f.c. to be dispensed with;

(d) that frequency deviations, caused by the passage through the ionosphere, are not likely to influence significantly the operation of SSB, ISB, and telegraph systems;

UNANIMOUSLY DECIDES that the following question should be studied:

what frequency stabilities are necessary for SSB, ISB and telegraph operation in fixed HF systems, range 4000–30 000 kc/s, to make a.f.c. unnecessary, and how can these be achieved?

QUESTION 183(III) **

FREQUENCY-SHIFT KEYING

The C.C.I.R., (Stockholm, 1948 – Los Angeles, 1959)

CONSIDERING

(a) that frequency-shift keying is employed in radiotelegraphy for the fixed services and it has also been extended to the mobile services;

(b) that it is desirable to standardize 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:

c.a the overlap of marking and spacing signals due to multipath propagation (in this respect a small deviation is preferable);

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* This Question replaces Question 167.

** This Question replaces Question 20.

c.b the possible advantage of frequency diversity for reception (an advantage which increases with deviation);

c.c economy of bandwidth and the consequent necessity for controlling the shape of the transmitted signals;

c.d instability of frequency, which is one reason for the relatively large deviation employed in many existing equipments;

c.e the choice of receiving systems, whether with separate filters or with frequency discriminator;

UNANIMOUSLY DECIDES that the following question should 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:
- the frequency spectrum resulting from the keying operation;
- the degree of frequency diversity desired;
- economy of bandwidth;
- instability of frequencies;

2. compilation of a standard terminology regarding the characteristics of systems employing frequency-shift keying.

STUDY PROGRAMME 183A(III) *

FREQUENCY-SHIFT KEYING

The C.C.I.R., (Geneva, 1951 – London, 1953 – Los Angeles, 1959)

CONSIDERING

(a) that frequency-shift keying is employed in radiotelegraphy for the fixed services and has also been extended to mobile services;

(b) that it is desirable to standardize 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 2 and 27 Mc/s;

2. the determination, in each particular case, of recommended values of frequency shift for emissions using frequencies below 2 Mc/s.

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* This Study Programme, which replaces Study Programme 41, was previously designated Study Programme 133(III).

STUDY PROGRAMME 183B(III) *

FOUR-FREQUENCY DIPLEX SYSTEMS

The C.C.I.R., (Warsaw, 1956 – Los Angeles, 1959)

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 desirable to standardize 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:
- 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;

UNANIMOUSLY DECIDES that the following study should be carried out:

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 operations.

QUESTION 232(III) **

FACSIMILE TRANSMISSION OF DOCUMENTARY MATTER OVER COMBINED RADIO AND METALLIC CIRCUITS

The C.C.I.R., (London, 1953 – Geneva, 1963)

CONSIDERING

(a) that increasing use is being made of facsimile telegraphy for the transmission of documentary matter;

(b) that it is desirable to standardize the characterictics of the facsimile system employed for this purpose;

UNANIMOUSLY DECIDES that the following question should be studied:

what are the requirements, imposed by the use of radio, on the characteristics of systems for the transmission by facsimile of:
- telegrams in the public service,
- business documents,
- documents of large size, such as meteorological charts?

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* This Study Programme, which replaces Study Programme 83, was previously designated Study Programme 134 (III).

** This Question replaces Question 94.

QUESTION 233(III)

USE OF COMMON-FREQUENCY SYSTEMS ON INTERNATIONAL RADIOTELEPHONE CIRCUITS

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that relief of the present congestion of the HF (decametric) band is a matter of urgency;

(b) that, in certain cases, the use of the same frequency for both directions of transmission (in combination with the use of VODAS equipment), may result in important economies in spectrum utilization on international radiotelephone circuits;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the characteristics to be specified for international radiotelephone systems using the principles of common-frequency operation;

2. what should be the minimum difference in level at the input to the receiver between the received signal from the distant station, and signals from the nearby transmitting station, to avoid interference between the wanted signal and that from the nearby transmitter operating on the same frequency;

3. to what extent will the use of transmitting and receiving antennae, with different transmission characteristics, reduce the possibilities of application of this technique;,

4. to what extent will the possibilities of application of this technique be reduced by the presence of different noise levels at the receiving locations;

5. what other factors should be taken into account when planning such systems, for example:
- non-linearities in the transmitting and receiving equipment,
- carrier-filter bandwidth,
- frequency stability of the equipment?

QUESTION 280(III)

USE OF DIRECTIONAL ANTENNAE IN THE BAND 4 TO 27·5 Mc/s

Limitation of radiation outside the direction necessary for the service

THE INTERNATIONAL FREQUENCY TEGISTRATION BOARD,

IN VIEW OF the request by the Panel of Experts in Recommendation No. 38 of its Final Report, Geneva, 1963, and AFTER CONSIDERING:

(a) that there is serious congestion in the frequency bands between 4 and 27·5 Mc/s;

(b) that there is a need to adopt methods and regulations for the solution of the frequency problems with which Administrations are confronted in the use of these bands;

(c) that occupation of the radio-frequency spectrum is represented, not only in time and band-width, but also in the spatial distribution of the radiated power;

(d) that this latter distribution can be effectively controlled by the use of directional antennae;

(e) that the intent of Articles 12 and 14 of the Radio Regulations, Geneva, 1959, would seem to justify further explicit requirements for the use of directional antennae in the bands between 4 and 27·5 Mc/s, as well as for quantitative limitation of the intensity of radiation in directions other than that required for the service;

AND IN VIEW OF No. 180 of the International Telecommunication Convention, Geneva, 1959;

DECIDES to submit the following urgent question to the C.C.I.R.:

what are reasonable standards for the directivity of antennae in the various types of radio services, and for various distances, in the bands between 4 and 27·5 Mc/s, including the width of the main beam and the allowable intensity of radiation (effective radiated power) in directions of azimuth outside the main beam (such standards should reflect due regard for practical considerations of construction and cost)?

QUESTION 281(III)

AUTOMATIC CONTROL OF THE OUTPUT POWER OF HF TRANSMITTERS

THE INTERNATIONAL FREQUENCY REGISTRATION BOARD,

IN VIEW OF the request of the Panel of Experts in Recommendation No. 38 of its Final Report, Geneva, 1963, and AFTER CONSIDERING:

(a) that No. 694 of the Radio Regulations, Geneva, 1959, requires that all stations shall radiate only as much power as is necessary to ensure a satisfactory service;

(b) that nevertheless, for a considerable part of the time, stations using frequencies in the bands between 4 and 27·5 Mc/s, radiate powers considerably in excess of those necessary to ensure a satisfactory service;

(c) that manually operated methods of adjusting the power of transmitters are not fully adequate to meet No. 694 of the Radio Regulations;

(d) that the use of automatic control of the output power of transmitters would assist in reducing the congestion in the HF spectrum;

AND IN VIEW OF No. 180 of the International Telecommunication Convention, Geneva, 1959;

DECIDES to submit the following urgent question to the C.C.I.R.:

what are the most suitable methods for automatically controlling the output power of radio transmitters operated in the HF bands to ensure, as far as is practicable, that the radiated power is no greater than is necessary to ensure a satisfactory service?

STUDY PROGRAMME 186(III) *

EFFICIENCY FACTOR

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that the efficiency factor, as defined in the List of definitions of essential telecommunication terms (Part I, 1961, No. 33.23) (see also Recommendation 345), is very useful to define and determine the quality of a communication using automatic error-correction;

(b) that the efficiency factor will be of use in the operation of radiotelegraph telex circuits with fully-automatic switching; *

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. use of the efficiency factor for theoretical studies on point-to-point circuits; the measurements should be effected in the following manner for theoretical studies on point-to-point circuits:

- duration of traffic observations for a measurement: 15 min.;
- a count of the number of telegraph signals repeated in the course of these 15 min.;
- a count of the number of errors during these 15 min. (number of telegraph signals wrongly translated);
- a count of the number of telegraph signals received in the course of these 15 min.;
- an indication should be given of the type of telegraph apparatus used and, when applicable, of the error-correcting system;
- an indication of the modulation rate;
- an indication of the maximum commercial speed, in words per minute, at that modulation rate;
- an indication of the average quality of reception during the measurement (the quality to be shown by means of one of the codes recommended by the C.C.I.R., SINPO or SINPFEMO code, or by a measurement of the average field-strength during the observation);
- an indication of the date and time at which the observation was made;
- repetition of these measurement periods of 15 min over a whole day, on a given frequency, during the hours when this frequency is normally used, to take account of the influence of propagation conditions;

2. study of the continuous measurement of the efficiency factor on circuits used with fully-automatic operation and study of its employment on such circuits.

Measurement of the efficiency factor itself is fairly simple, once agreement has been reached on the value of two (or possibly one) time-constants, referring respectively to the time interval t_1, during which the efficiency factor should exceed a certain limit, before a new call can be set up, and the time interval t_2 during which the channel efficiency should be less than some other limit, before an existing call should be interrupted. (The C.C.I.T.T. is considering fixing one limit only for the efficiency factor: 80%).

It is agreed that the time intervals t_1 and t_2 should be much shorter than the value of 15 min. proposed in § 1 and the following values are under consideration by the C.C.I.T.T.:

$$t_1 = 20 \text{ s and } t_2 = 60 \text{ s}$$

The question of the continuous evaluation of the efficiency factor and its employment to remove the circuit from operation and to return it to operation should be studied in collaboration with the C.C.I.T.T.

* This Study Programme, which together with Study Programme 3B(III) replaces Study Programme 132, does not arise from any Question under study.

It is suggested that Administrations should try to find an answer to the following question (in view of the urgency of the matter, possibly before the IIIrd Plenary Assembly of the C.C.I.T.T.):

- is the one value of 80% for the efficiency factor suitable, or would it be better to have two values;
- are the suggested values for the time intervals acceptable, or are other values to be preferred?

STUDY PROGRAMME 187(III) *

IDENTIFICATION OF THE CARRIER FREQUENCY RELATIVE TO THE ASSIGNED FREQUENCY OF AN EMISSION

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that in certain classes of emission, notably single-sideband and suppressed or reduced carrier types, the carrier frequency is not in the centre of the assigned frequency band and does not therefore coincide with the assigned frequency;

(b) that the exchange of operating information, between the terminals of a radio circuit, is facilitated if there is a simple method of identifying the carrier frequency of such an emission;

(c) that the assigned frequency forms a convenient reference, relative to which the carrier frequency may be located;

UNANIMOUSLY DECIDES that the following studies should be carried out:

investigation of the application of the method of carrier frequency identification (see Report 202) and assessment of the advantages to be gained by the use of such a method.

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* This Study Programme does not refer to any Question under study.

LIST OF DOCUMENTS OF THE Xth PLENARY ASSEMBLY CONCERNING STUDY GROUP III

Doc.	Origin	Title	Reference	Other Study Groups concerned
3	Chairman, Study Group III	Report by the Chairman, Study Group III (Dr. H. C. A. Van DUUPEN)	—	—
88	Netherlands	The use of radio circuits in association with 5-unit start-stop telegraph apparatus	Rec. 242 Rep. 108	—
118	United Kingdom	Use of radio circuits in association with 5-unit start-stop telegraph apparatus	Rep. 108	—
121	Netherlands	Terms related to ARQ-systems	Rec. 242 Res. 34	XIV
122	United Kingdom	The use of automatic error-correction of telegraph signals transmitted over radio circuits – Errors during automatic rephasing when using the systems of Report 108	S.P. 128 Rep. 108	—
129	C.C.I.R. Secretariat	Bibliographic references in the volumes of the C.C.I.R.	—	I–XIV
146	Netherlands	Performance of telegraph systems and receivers	Rec. 234 Rep. 105	II
153	C.C.I.R. Secretariat	Refinement of I.F.R.B. technical standards	—	I, II, V, VI, X, XII, XIII
164	,, ,,	Effect of noise on telegraph transmission	Rep. of CCITT W.P.	IX
178	,, ,,	Transmission of facsimile and phototelegraph signals over radio circuits	Rec. 243 & 244	—
191	,, ,,	High-frequency directional antennae – Replies to C.C.I.R. Circular AC/55	Circ. AC/55	X, XII
201	,, ,,	Voice-frequency telegraphy over radio circuits	Q. 43	—
202	,, ,,	Quality index and efficiency factor	S.P. 132 Rep. 42	—
203	,, ,,	Telegraph distortion and error rate	S.P. 132	—
225	India	Some observations in long-distance HF communication using FSK, due to passage through the ionosphere	Q. 181	—
226	,,	A suggestion for increasing the speed of transmission of printed language on a teleprinter circuit by use of phonetic alphabet	S.P. 86	—
227	,,	A suggestion for increasing the transmission rate in a teleprinter circuit without increasing the bandwidth and baud speed	S.P. 86	—
228	,,	Helical rhombics	S.P. 130	—
233	Australia	Improvement obtainable from the use of directional antennae	S.P. 130	—

Doc.	Origin	Title	Reference	Other Study Groups concerned
234	Australia	Proposed variations to Recommendation 242	S.P. 128	—
237	India	Information regarding high-frequency directional antennae used by radiocommunication services in India	Circ. AC/55	X, XII
271	U.R.S.I.	Long-distance directivity of HF antennae	Circ. AC/55	VI, X
285	Study Group III	Summary record of the first meeting	—	—
363	Study Group III	Telegraphic distortion, quality index, error-rate, efficiency factor	Draft Rep.	—
364	Study Group III	Factor affecting quality of performance of complete systems of the fixed services	Draft Rep. S.P. 128	— —
368	Study Group III	Voice-frequency (carrier) telegraphy on radio circuits	Rep. S.P. 129	—
369	Study Group III	Amendment to Annex 3/5 to Doc. 3	(Doc. 3)	—
370	Sub-Group III–C	Bibliographic references in the volumes of the C.C.I.R. – Suggested answer to Doc. 129	(Doc. 129)	—
417	Study Group III	Summary record of the second meeting	—	—
447	Sub-Group III–C	Bandwidth and signal-to-noise ratios in complete systems	Draft Rep. S.P. 128	—
479	Sub-Group III–B	Automatic error-correcting system for telegraph signals transmitted over radio links	Draft Rec. S.P. 128	XIV
480	Sub-Group III–B	Radiotelegraph circuits used in automatic switched networks	Draft S.P.	—
502	Study Group III	Resolution in response to Recommendations 2 and 3 to the C.C.I.R. adopted at Geneva in 1959 by the Administrative Radio Conference – Optimum use of the radio spectrum	Rec. 2 and 3 to C.C.I.R.	—
523	Study Group III	Efficiency factor	Draft S.P.	—
524	Study Group III	Frequency stability required for single-sideband, independent-sideband and telegraph systems to make the use of automatic frequency control superfluous	Draft Rec. Q. 182	—
549	Sub-Group III–A	High-frequency directional antennae	(Doc. 191)	—
607	Study Group III	Summary record of the third and last meeting	—	—
620	Study Group III	Proposed small amendment to Recommendation 241	Rec. 241	—
644	Study Group III	International group of experts set up by Resolution 1 – Summary record of the first meeting	Res. 1	—
2128	Drafting Committee	Intercontinental radiotelephone systems and use of radio links in international telephone circuits	Rec. 335	—
2129	,, ,,	Principles of the devices used for achieving privacy of radiotelephone conversations	Rec. 336	—
2130	,, ,,	Channel separation	Rec. 337	—

Doc.	Origin	Title	Reference	Other Study Groups concerned
2131	Drafting Committee	Bandwidth required at a telegraph or telephone receiver output	Rec. 338	—
2132	,, ,,	Bandwidths and signal-to-noise ratios in complete systems	Rec. 339	—
2133	,, ,,	Facsimile transmission of meteorological charts over radio circuits	Rec. 343	—
2134	,, ,,	Standardization of phototelegraph systems for use on combined radio and metallic circuits	Rec. 344	—
2135	,, ,,	Four-frequency diplex systems	Rec. 346	—
2136	,, ,,	Classification of multi-channel radiotelegraph systems for long-range circuits operating on frequencies below about 30 Mc/s and designation of the channels in these systems	Rec. 347	—
2137	,, ,,	Arrangement of channels in multi-channel single-sideband and independent-sideband transmitters for long-range circuits operating at frequencies below 30 Mc/s	Rec. 348	—
2138	,, ,,	Facsimile transmission of documentary matter over combined radio and metallic circuits	Q. 232	—
2139	,, ,,	Use of common-frequency systems on international radiotelephone circuits	Q. 233	—
2140	,, ,,	Communication theory	S.P. 133A	—
2141	,, ,,	Identification of carrier frequency relative to the assigned frequency of an emission	S.P. 187	—
2142	,, ,,	Some aspects of the application of communication theory	Rep. 196	—
2143	,, ,,	Arrangement of voice-frequency frequency-shift telegraph channels on radio circuits	Rep. 199	—
2144	,, ,,	Remote control signals for facsimile transmissions	Rep. 201	—
2145	,, ,,	Identification of carrier frequency relative to the assigned frequency of an emission	Rep. 202	—
2146	,, ,,	Multi-path propagation on high frequency radio circuits	Rep. 203	—
2147	,, ,,	Factor affecting quality of performance of complete systems of the fixed services	Rep. 197	—
2148	,, ,,	Voice-frequency (carrier) telegraphy on radio circuits	Rep. 198	—
2149	,, ,,	Telegraphic distortion, error-rate	Rep. 200	—
2301	,, ,,	Optimum use of the radio-frequency spectrum	Res. 1	—
2302	,, ,,	Fading allowances for the various classes of service	Rec. 340	—

Doc.	Origin	Title	Reference	Other Study Groups concerned
2303	Drafting Committee	Bandwidth and signal-to-noise ratios in complete systems	Rep. 195	—
2304	,, ,,	Automatic error-correcting system for telegraph signals transmitted over radio links	Rec. 342	—
2305	,, ,,	Radiotelegraph circuits used in automatic switched networks	S.P. 3B	—
2306	,, ,,	Frequency stability required for single-sideband, independent-sideband and telegraph systems to make the use of automatic frequency control superfluous	Rec. 349	—
2307	,, ,,	Telegraphic distortion	Rec. 345	—
2308	,, ,,	Efficiency factor	S.P. 186	—
2393	,, ,,	Small amendment to Recommendation 241	Rec. 341	—

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RECOMMENDATIONS OF SECTION D: MOBILE SERVICES

RECOMMENDATION 45

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

(Question 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 76

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

(Question 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 minimize 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 1)	Net operate time (Note 2)	Net release time (Note 3)
– 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 4)*, 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 ms 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 5)*, 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 ms is generally suitable.

Note 1. – 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 2. – 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 3. – 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 4. – 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 5. – 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 77 *

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

(Question 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 two-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.T.T. 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 echo suppressors or other devices on domestic or international circuits frequently;

5. that, for 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 218 *

PREVENTION OF INTERFERENCE TO RADIO RECEPTION ON SHIPS **

(Question 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 (1960, Chapter IV, Regulation 9), 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;

(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 minimized at its source (see also No. 959 of the Radio Regulations, Geneva, 1959);

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 antennae 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 antennae 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 earth terminal of the receiver;

5. that, frame or loop antennae 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;

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* This Recommendation replaces Recommendation 78. Certain references to the Radio Regulations have been inserted subsequently.

** 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 45.

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:

9.1 the electrical ignition systems of internal combustion engines, including those which may be installed in lifeboats, should be fitted with suppressors;

9.2 the navigational instruments and associated equipment, which are installed in the neighbourhood of the receiving antennae or the radio receiving room should, if necessary, be fitted with suppressors, be screened, and the screen effectively earthed;

10. that cables in the vicinity of the receiving antennae 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 effectively earthed;

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 (stay that are subject to considerable tension can more conveniently be bonded);

16. that, for 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 minimize 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 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 (see Art. 36 of the Radio Regulations, Geneva, 1959);

* This Recommendation replaces Recommendation 125. Certain references to the Radio Regulations have been inserted subsequently.

(b) that the alarm signal should be such as to:
- provide reliable operation of automatic alarm equipment;
- provide a distinctive signal, which is readily recognized aurally, when received on a loudspeaker or headphones;
- be capable of being received through interference from speech transmissions, through other kinds of interference, and through noise;
- avoid false responses when received either aurally or by automatic means;
- 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 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 which participated in Study Programme 29 (Geneva, 1951), are sufficiently conclusive to determine the 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 radiotelegraphy, normally transmitted on the frequency 500 kc/s (see Nos. 1475 and 1476, and Appendix 20, § 1 of the Radio Regulations, Geneva, 1959; and Chapter IV, Regulation 10 of the Convention for the Safety of Life at Sea, London, 1960);

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 s. 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 ms;

1.2 the tolerance of the frequency of each tone shall be $\pm$ 1·5%; the tolerance on the duration of each tone shall be $\pm$ 50 ms; the interval between successive tones shall not exceed 50 ms; 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 s 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 fulfill 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 $\pm$ 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, under conditions of intermittent interference caused by atmospheric 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 atmospheric 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 fulfill 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 224 *

TESTING OF 500 kc/s RADIOTELEGRAPH AUTO-ALARM RECEIVING EQUIPMENT ON BOARD SHIPS

(Question 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 antenna) are always in good working order on board ships at sea;

UNANIMOUSLY RECOMMENDS

in addition to the requirements of Chapter IV of the International Convention for the Safety of Life at Sea (London, 1960);

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 10 of the said Convention;

* This Recommendation terminates the study of Question 108. The references to the International Convention for the Safety-of-life at sea, London, 1960, have been inserted subsequently.

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 antenna 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 antenna 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.

RECOMMENDATION 257 *

SELECTIVE CALLING DEVICES FOR USE IN THE INTERNATIONAL VHF (METRIC) MARITIME MOBILE RADIOTELEPHONE SERVICE

(Question 271(XIII))

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that selective calling from coast stations to ship stations would expedite handling of traffic, particularly in public correspondence services;

(b) that a selective calling system is faster and more positive than calling by voice;

(c) that it overcomes the disadvantage and annoyance caused by vessels being required to listen to all calls;

(d) that it permits concentration of aural watches on the safety and calling channel 156·80 Mc/s;

(e) that a selective calling system is not subject to language difficulties;

UNANIMOUSLY RECOMMENDS

1. that a selective calling system for the international VHF maritime mobile radiotelephone service be standardized as soon as possible;

2. that this selective calling system should have an international numbering system for such public correspondence services;

3. that the system and the numbering plan should be capable of providing a sufficient number of individual non-conflicting codes;

4. that the bandwidth required for the transmission of the code signals should not exceed the maximum permissible emission bandwidth specified by regulations governing the maritime services;

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* The reference to the Radio Regulations has been inserted subsequently.

5. that the time required to select and transmit the code signal should be of the shortest possible duration consistent with reliable operation;

6. that the system should be capable of satisfactory operation, with signal-to-noise ratios at least equivalent to the minimum acceptable for satisfactory two-way speech transmission;

7. that the individual signalling combinations must be sufficient for adequately identifying ships using selective signalling, considering that it might be possible to repeat codes in sufficiently separated geographic areas, taking into account ships' itineraries;

8. that the selective signalling, at any given coast station, should not be limited to vessels regularly using that coast station. The numbering system should be planned so as to make this unnecessary;

9. that the number code, assigned to a ship, should be distinctive and should be permanently associated with that ship;

10. that the call should not be prefixed by a long dash or other special signal, to attract attention of vessels not fitted with a selective calling device, as such calls should be made, preferably, on the frequency of the common calling and safety channel 156·80 Mc/s;

11. that the attention of Administrations should be drawn to the desirability of their reaching agreement upon the channel, or channels, that should be used for selective calling. Attention should also be drawn to Note 8 of Annex 1 of the Agreement on the international VHF maritime mobile radiotelephone service (The Hague, 1957) (see also Nos. 1214, 1361 and 1362 of the Radio Regulations, Geneva, 1959).

RECOMMENDATION 258 *

SINGLE-SIDEBAND AERONAUTICAL AND MARITIME MOBILE RADIOTELEPHONE EQUIPMENTS

(Question 162)

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that the main advantages of single-sideband working (SBB), as compared with double-sideband (DSB), for mobile radiotelephony, are as follows:

a.a reduction of bandwidth required per channel;

a.b increase in signal-to-noise ratio or, alternatively, reduction in transmitter power (and hence antenna voltage), for the same signal-to-noise ratio, improvements dependent upon the degree of carrier suppression;

a.c reduction of the type of distortion that is due to selective fading;

a.d reduction of interference, particularly that due to beat notes, between carriers dependent on the degree of carrier suppression;

a.e reduction of interference, due to cross-modulation between adjacent channel transmissions;

(b) that the disadvantages of SSB compared with DSB for mobile radiotelephony, are as follows:

* This Recommendation terminates the study of Question 162. The references to the Radio Regulations have been inserted subsequently.

b.a more rigorous requirements for transmitter and receiver frequency stability;

b.b greater complexity of apparatus;

b.c higher prices of the equipment;

b.d higher maintenance costs for the equipment;

b.e impracticability of conversion of existing mobile DSB equipments for SSB operation;

b.f Doppler effects, that are significant for very high-speed mobile units;

(c) that the MF-radiotelephony bands, used in the maritime services (i. e. world-wide 1605 to 2850 kc/s and additionally, in Region 1, 3155 to 3800 kc/s):

c.a include the international calling and distress frequency 2182 kc/s;

c.b are shared with fixed services;

c.c are used by many low tonnage ships, some compulsorily and others voluntarily fitted exclusively with DSB MF-radiotelephony equipments;

(d) that the parts of the HF bands (i. e. 4000 kc/s and 23 000 kc/s for mobile maritime and 2850 kc/s to 24 000 kc/s for aeronautical use), allocated to the respective services;

d.a do not include any international distress frequency;

d.b are exclusively allocated to these services;

(e) that in the maritime mobile services, the advantages of SSB operation predominate over the disadvantages to a greater extent in the HF than in the MF band;

(f) that, in the maritime mobile services, in the interests of safety of life at sea, the introduction of SSB operation should not be allowed to discourage the extension of voluntary fitting of DSB MF-radiotelephony equipment;

UNANIMOUSLY RECOMMENDS

1. for the maritime mobile services (see also Appendices 15 and 17 to the Radio Regulations, Geneva, 1959, and Recommendation No. 28 of the Administration Radio Conference, Geneva, 1959);

1.1 that SSB operation be introduced as far as operationally required in the MF and HF radiotelephony bands;

1.2 that coast stations be prepared to communicate with DSB and SSB shipborne equipment;

1.3 that for SSB equipment the following technical characteristics be employed:

1.3.1 for an interim period the degree of carrier reduction should be 16 to 26 db below the peak envelope power and every endeavour should be made to achieve a carrier suppression of at least 40 db as soon as possible;

1.3.2 the carrier frequency of the transmitters should be maintained within the following tolerances:

1.3.2.1 for coast stations ± 20 c/s;

1.3.2.2 for ship stations the short-term limits (of the order of 15 min.) should be ± 40 c/s *;

1.3.2.3 for ship stations long-term limits of ± 350 c/s (in the 8, 12, 16 and 22 Mc/s bands) and ± 100 c/s (in the 2 and 4 Mc/s bands) should be permitted for an interim period and every endeavour should be made to achieve limits of ± 100 c/s as soon as possible in all bands;

1.3.3 the carrier frequency stability of SSB receivers should be maintained within the following tolerances:

1.3.3.1 for coast stations ± 20 c/s;

1.3.3.2 for ship stations the short-term limits should be ± 40 c/s *;

* This value may be maintained either manually or by other means.

1.3.3.3 if spot frequency (i. e. fixed frequency pre-tuned) shipborne receivers are used, long-term limits of ± 350 c/s should be permitted for an interim period and every endeavour should be made to achieve limits of ± 100 c/s as soon as possible;

1.3.4 the upper sideband should be used (see Appendix 15, Section B and Appendix 17 of the Radio Regulations, Geneva, 1959);

1.3.5 the channel arrangements should be such, that two SSB channels are accommodated within each existing DSB channel and the bandwidth of the SSB emissions should be kept within such limits as will permit this to be done (it is proposed that the precise arrangement of these SSB channels should be further discussed at the Administrative Radio Conference);

1.3.6 the transmitter audio-frequency band should be 350 to 2700 c/s, with a permitted amplitude variation of 6 db;

1.3.7 the unwanted frequency modulation of the SSB carrier should be sufficiently low to prevent harmful distortion;

1.3.8 in the MF maritime mobile radiotelephony bands, SSB ship stations should be able to insert a carrier at a level sufficient to permit satisfactory reception by DSB receivers when communicating with DSB stations;

1.3.9 in the particular case of transmissions on the radiotelephone calling and distress frequency 2182 kc/s, all transmissions should be made either by DSB, or by SSB, with carrier insertion sufficient to permit satisfactory reception by DSB receivers;

1.4 that the attention of Administrations should be drawn to the fact that, there would be technical and operational advantages in designating certain frequencies for international common use for ship-shore and inter-ship working;

2. that for the aeronautical mobile service, the Director, C.C.I.R. should:

2.1 formally acquaint the I.C.A.O. of the interest of the C.C.I.R. in the study of SSB working in the aeronautical and maritime mobile services;

2.2 invite the I.C.A.O. to advise the C.C.I.R. of any technical or operational problems on which they would like the assistance of the C.C.I.R.;

2.3 offer to keep the I.C.A.O. informed of progress made by the C.C.I.R. in the study of the application of SSB working in the maritime mobile services;

2.4 request the I.C.A.O. to keep the C.C.I.R. informed of progress made by the I.C.A.O. in the study of the application of SSB working in the aeronautical mobile services.

RECOMMENDATION 422 *

PULSE TRANSMISSION FOR RADIO DIRECTION-FINDING

(Question 61)

The C.C.I.R., (London, 1953 – Geneva, 1963)

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 pulse transmissions occupy wide bandwidths;

UNANIMOUSLY RECOMMENDS

that the use of pulse transmissions for radio direction-finding at frequencies below 20 000 kc/s is generally undesirable.

ANNEX

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

1. observational errors introduced by the operator;
2. instrumental errors, including polarization 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;
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° for a continuous-wave emission and about 2° 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°, pulse 1·7°.

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* This Recommendation replaces Recommendation 126.

RECOMMENDATION 423 *

USE OF 8364 kc/s FOR RADIO DIRECTION-FINDING

(Question 21)

The C.C.I.R., (Geneva, 1951 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) Nos. 994, 997 and 1179 of the Radio Regulations, Geneva, 1959;

(b) that land stations will, when the appropriate portions of Article 32, Section V of the Radio Regulations, Geneva, 1959, 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 12 and 13 of Chapter IV of the Safety of Life at Sea Convention (London, 1960) indicate minimum specifications for automatic distress transmitters;

(d) that tests and operational experience have shown that radio direction-finding at 8364 kc/s may be a valuable aid (in conjunction with direction-finding at 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;

(f) that HF (decametric) radio direction-finding requires apparatus as free as possible from local site error and polarization 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 standardized 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;

UNANIMOUSLY 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 m, 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 antenna system should be as free as possible from wave polarization 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;

* This Recommendation replaces Recommendation 252.

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 at 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 United Kingdom, given in Doc. 39 (France), 43 and 99 (U.S.A.) and 44 (United Kingdom) of Geneva, 1951, 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, to give as great accuracy of fix as possible, several widely-spaced and interconnected direction-finding stations should be employed (see Annex);

10. that the attention of Administrations concerned should be drawn to the advantage of their studying further:

10.1 the most suitable type of network for providing rapid communication between direction-finding stations and plotting centres;

10.2 the most suitable way in which information should be exchanged between different stations or networks (e. g. use of " Q " code);

10.3 the best way to evaluate the most probable fix (position) from bearings supplied by the direction-finding stations;

11. 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 AT 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°.

At distances less than 1200 km the error progressively increases with decrease of distance to values of the order of 5° to 10°; at small distances, less than about 100 km, the error may be even greater than 10°.

The above figures refer to the arithmetic mean of bearings spread over an interval of not more than about 10 min.

RECOMMENDATION 424 *

BEARING AND POSITION CLASSIFICATION FOR DIRECTION-FINDING

(Question 159)

The C.C.I.R., (Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that the procedure specified in Appendix 23, Section II, §§ 6, 7 and 8, of the Radio Regulations, Geneva, 1959, refers particularly to the maritime mobile radio direction-finding service at frequencies below 3000 kc/s;

(b) that there would be advantages in adopting an internationally agreed system for classifying the accuracy of bearings and positions for all frequency bands;

(c) that there would be advantages in adopting an internationally agreed type of signal for direction-finding purposes;

UNANIMOUSLY RECOMMENDS

1. that a common system of classification of bearings and positions should be used in all frequency bands;

2. that the accuracy of bearings should be classified as follows:

" Class A ": Probability of less than 1 in 20 that the error exceeds 2°;
" Class B ": Probability of less than 1 in 20 that the error exceeds 5°;
" Class C ": Probability of less than 1 in 20 that the error exceeds 10°;
" Class D ": Bearings whose accuracy is less than Class C;

3. that the accuracy of positions, determined from direction-finding bearings, should be expressed as Class N, where N is the error, or amount of uncertainty, in nautical miles, such that the chance that N is exceeded is 1 in 20;

4. that Report 93, and the references below, should be used as a guide in determining the accuracy of bearings and positions by the objective (statistical) method and the subjective (observational) method, and the Annex to the Report should be used as a guide to the accuracy of bearings to be expected from HF Adcock direction-finders;

5. that signals for direction-finding purposes should include long dashes, each of at least 5 s duration, but, where necessary, the direction-finding station should also be permitted to specify the type and duration of the signal.

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* This Recommendation replaces Recommendation 253.

RECOMMENDATION 425 *

TECHNICAL CHARACTERISTICS OF FREQUENCY-MODULATION VHF (METRIC) MARITIME MOBILE EQUIPMENTS

(Questions 107, 161 and 164)

The C.C.I.R., (Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that Nos. 1359 to 1379 inclusive and Appendix 18 of the Radio Regulations, Geneva, 1959, stipulate the general procedure for the world-wide use by the international maritime mobile service in the band 156–174 Mc/s;

(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 at the frequency 156·8 Mc/s and other channels specified in Appendix 18 of the Radio Regulations, Geneva, 1959, 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 to expedite the international use of such equipments;

(e) that, in the informal agreement on standardization 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 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;

(g) that the International Maritime VHF Radiotelephone Conference (The Hague, 1957), had agreed among other matters, upon a frequency allocation table using 4·6 Mc/s separation for duplex operation in the VHF international maritime mobile radiotelephone service;

UNANIMOUSLY RECOMMENDS **

1. that the following characteristics for frequency-modulated VHF (metric) radiotelephone equipments for the international maritime mobile services operating at 156·8 Mc/s and other channels specified in Appendix 18 to the Radio Regulations, Geneva, 1959, should be adopted by Administrations;

1.1 that, 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;

1.2 that all receivers should be capable of receiving satisfactorily emissions having a maximum deviation of $\pm$ 15 kc/s;

2. that vertical polarization should be used;

* This Recommendation replaces Recommendation 254.

** See also Appendices 3, 4 and 19 to the Radio Regulations, Geneva, 1959.

3. that, 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.);

4. that the equipment should be designed for a frequency separation between adjacent channels of 50 kc/s;

5. that the frequency separation between the transmitting and receiving frequencies for duplex working should be 4·6 Mc/s;

6. that further study is required of means of selective calling. For this purpose reference is made to Question 271(XIII), Report 320 and Resolution 19;

7. other essential parameters;

7.1 frequency modulation with a pre-emphasis of 6 db/octave should be used (phase modulation) with subsequent de-emphasis in the receiver;

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;

7.3 spurious emissions:

7.3.1 the mean power of spurious emissions due to harmonics of the carrier frequency should not exceed 25 μW measured at the antenna terminals of the transmitter when loaded with a resistance equal to the nominal antenna impedance;

7.3.2 the mean power of spurious emissions falling in any other international VHF maritime mobile channel due to products of modulation should not exceed 10 μW, measured at the antenna terminals of the transmitter or receiver when loaded with a resistance equal to the nominal antenna impedance;

7.3.3 the mean power output of any other spurious emission on any discrete frequency within the international VHF maritime mobile band should not exceed 2·5 μW, measured at the antenna terminals of the transmitter or receiver when loaded with a resistance equal to the nominal antenna impedance;

7.3.4 in cases where Administrations permit exceptionally the use of higher powered transmitters, proportionate increases in the level of these spurious emissions may be permitted.

7.4 the audio-frequency bandwidth should be limited to 3000 c/s;

7.5 the frequency tolerance of the transmitter should not exceed 0·002%;

7.6 to minimize interference, special attention should be paid to the following receiver characteristics:

- stability,
- selectivity,
- receiver radiation,
- intermodulation;

8. equipments should be designed so that frequency changes between assigned channels can be carried out rapidly, e. g., within a few seconds;

9. that care should be taken in the choice of intermediate frequencies for VHF receivers to avoid interference from other services and, in particular, care should be taken to avoid interference from other maritime mobile services, especially those in the 500 kc/s and 2 Mc/s bands.

RECOMMENDATION 426 *

SPURIOUS EMISSIONS FROM FREQUENCY-MODULATED VHF (METRIC) MARITIME MOBILE EQUIPMENT

(Question 161)

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that spurious emissions from frequency-modulated VHF maritime mobile equipments are likely to cause interference in the international VHF maritime mobile radiotelephone channels if they are not adequately suppressed;

(b) that such spurious emissions may be caused by:
- harmonics of oscillators of transmitters and receivers,
- modulation products falling into other channels,
- intermodulation products produced at receiving stations or generated at transmitting stations,
- intermodulation products caused by non-linear elements near the VHF transmitting or receiving stations, especially when signals from two transmitters with a frequency spacing of 4·6 Mc/s are present,
- parasitic oscillations,
- transmitter noise;

UNANIMOUSLY RECOMMENDS

1. that for transmitters of the order of 20 W:

1.1 the mean power of any spurious emission due to products of modulation and falling in any international VHF maritime mobile channel (other than the channel of the fundamental emission), should not exceed 10 μW measured at the antenna terminals of the transmitter or receiver when loaded with a resistance equal to the nominal antenna impedance;

1.2 the mean power of any other spurious emission on any discrete frequency within the international VHF maritime mobile bands should not exceed 2·5 μW, measured at the antenna terminals of the transmitter or receiver when loaded with a resistance equal to the nominal antenna impedance;

2. that where Administrations permit, exceptionally, the use of higher powered transmitters, proportionate increases in the level of these spurious emissions may be permitted.

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* This Recommendation replaces Recommendation 255 and Report 113, and terminates the study of Question 161.

RECOMMENDATION 427 *

INTERFERENCE DUE TO INTERMODULATION PRODUCTS IN THE VHF (METRIC) MARITIME MOBILE RADIOTELEPHONE SERVICE

(Question 164)

The C.C.I.R., (Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that intermodulation products may cause serious interference in the operation of the VHF mobile maritime radiotelephone service;

(b) that intermodulation products may be generated and radiated at receiving stations and transmitting stations, in the radio equipment itself or at external points (such as antenna systems), where there is electrical non-linearity;

(c) that practical measures can be taken to minimize the generation of such intermodulation products and to mitigate their harmful effects;

UNANIMOUSLY RECOMMENDS

1. that Recommendation 218, particularly §§ 3, 4 and 15, should be followed for the purpose of minimizing the generation of intermodulation products at points on ships external to the receiver;

2. that antennae, rigging, stays and structures, likely to cause intermodulation products, should be maintained in such condition as to minimize the generation of intermodulation products;

3. that care should be taken, in the design and development of receivers, to minimize the possibility of interference due to the generation of intermodulation products in the receivers themselves;

4. that the range of interference, due to radiated intermodulation products, should be limited to sea areas that are not normally navigated by ships and to shore areas that are clear of coast receiving stations;

5. that the siting of coast stations should take into account the factors mentioned in § 4 above (see also No. 695 of the Radio Regulations, Geneva, 1959);

6. that frequency assignments in the VHF mobile maritime radiotelephone band should, as far as possible, take into account the possibility of interference from intermodulation products (see also No. 695 of the Radio Regulations, Geneva, 1959);

7. that where the service area permits, coast stations should use directive antennae (see also No. 695 of the Radio Regulations, Geneva, 1959);

8. that care should be taken in the use of the single-frequency channels to minimize interference, due to intermodulation products, to the common calling and safety channel of 156·80 Mc/s and to the other channels specified in Appendix 18 to the Radio Regulations, Geneva, 1959 (see also No. 1363 of the Radio Regulations, Geneva, 1959);

9. that frequency assignments to other services should, as far as possible, take into account the possibility of interference to the VHF mobile maritime radiotelephone service due to the generation of intermodulation products; in particular, powerful emissions from stations near coastal areas and with frequencies differing by about 4·6 Mc/s from one another, should be avoided if possible.

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* This Recommendation replaces Recommendation 256.

RECOMMENDATION 428

DIRECTION-FINDING BY SHIPS IN THE 2 Mc/s BAND

(Question 206(XIII))

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that, according to the Convention for the Safety of Life at Sea, London, 1960, the medium frequency radiotelephony calling and distress frequency of 2182 kc/s will become of increasing importance to the safety of life at sea;

(b) that, in most distress cases, merchant ships and fishing vessels and other surface craft participate in search and rescue;

(c) that in addition to ships between 500 and 1600 tons gross tonnage, which are already required to be fitted with medium frequency radiotelephone equipment if they do not carry medium frequency radiotelegraph equipment, ships between 300 and 500 tons gross tonnage will also be required to fit such equipment, in accordance with Chapter IV, Regulation 4 of the Convention for the Safety of Life at Sea, London, 1960;

(d) that a large number of ships of more than 1600 tons gross tonnage (which are compulsorily fitted with medium frequency radiotelegraph equipment), are voluntarily fitted with medium frequency radiotelephone equipment and that the number of such ships is increasing;

(e) that the majority of deep sea fishing vessels are fitted voluntarily with medium frequency radiotelephone equipment;

(f) that an increasing number of ships are being fitted with direction-finding equipment capable of taking bearings in the 2 Mc/s band;

(g) that direction finding and especially homing by ships is important in cases of distress;

(h) that Recommendation 31 of the Convention for the Safety of Life at Sea conference, London, 1960, drew the attention of contracting governments to the studies being undertaken under Question 206 (XIII) by the C.C.I.R.;

(i) that technical studies in several countries have shown:

i.a that direction-finding, or at least homing, is usually possible in the 2 Mc/s band on many ships;

i.b that compared with the problems of direction-finding by ships in the lower parts of the medium frequency band, the main cause of error in direction-finding in the 2 Mc/s band is re-radiation from various parts of the ships super-structures, masts, downleads, halyards, stays, derricks, etc., and from other antennae;

i.c that errors caused by re-radiation effects, however, should be constant if the disposition and electrical conditions of the re-radiators are constant and that such errors can be taken into account by calibrating the direction-finder;

i.d that direction-finding and homing is easier on board small ships than on larger ones, because an increase in the size of ships and their super-structures, masts, etc., as given in *i.b*, leads to an increase of disturbing resonance effects;

i.e that a reliable direction-finder calibration can be more readily obtained if it is restricted to a specific frequency such as 2182 kc/s, instead of a wide frequency band;

i.f that even where omnidirectional direction-finding, even on a specific frequency is difficult or impossible (such as on board large vessels with strong re-radiation effects), homing will nearly always be possible;

UNANIMOUSLY RECOMMENDS

1. that the following technical measures and precautions should be observed when installing direction-finders capable of taking bearings in the 2 Mc/s band:

1.1 the antenna system, including the sense antenna, of the direction-finder should be erected as far as possible away from any re-radiators;

1.2 the direction-finder antenna system should, preferably, be installed on the fore-and-aft line of the ship;

1.3 if the direction-finder antenna system is fitted on a mast, it should, preferably, be installed symmetrically on top of the mast and not to one side of it;

1.4 the effects caused by re-radiating antenna wires can be minimized by providing properly located isolating switches for the antennae;

1.5 re-radiation from the rigging (e. g. stays, wire ropes, etc.) should be reduced by the insertion of insulators such that the resonant frequency of the longest portions is above the highest frequency used for direction-finding;

1.6 the formation of " closed loops ", e. g. by the rigging, should be avoided by inserting insulators at appropriate points;

1.7 to avoid electrically-doubtful connections, the connecting points of movable parts of the rigging, and connections between masts and derricks, wire ropes, etc., should be short-circuited as far as possible;

2. that the following measures and precautions should be observed in the calibration of direction-finders for the 2 Mc/s band:

2.1 the rigging, downleads, derricks, halyards, etc., should be in their sea-going positions;

2.2 any antennae that affect the direction-finder should, preferably, be isolated and other antennae which cannot be isolated (for example, because of operational requirements), should be in the same conditions as they will be when bearings are being taken at sea; the condition and electrical arrangement of all antennae should be noted on the direction-finder calibration charts;

2.3 calibration should be carried out in an area well clear of the shore and of other ships. If a shore-based transmitter is used, calibration should be carried out on a line passing through that station and crossing the coast-line approximately at right angles. The transmitting antenna should radiate vertically polarized waves from a single element, and care should be taken to avoid re-radiation from any object in the vicinity. The distance between the transmitting antenna and the direction-finder should be great enough to avoid the calibration being affected by the induction field of the transmitting antenna;

2.4 care should be taken to ensure that the direction-finder gives the correct sense on all bearings and frequencies concerned;

2.5 the direction-finder calibration should, as a general rule, cover the full 360 degrees and, as far as possible, should be made at sufficiently small bearing intervals (say, in steps of a few degrees), to detect any sudden changes in the calibration curve (for example, re-entrant portions where two or more different corrections exist for the same indicated bearing);

2.6 calibration at 2182 kc/s should be carried out at a frequency as near as possible to 2182 kc/s, special attention being paid to No. 1325 of the Radio Regulations, Geneva, 1959, and to the avoidance of interference to established operations in adjacent channels;

3. that the calibration should be checked periodically, especially if the condition of the rigging, etc., has been altered since the last calibration;

4. that on board ships equipped with a direction-finder, the frequency range of which includes the 2 Mc/s band, a calibration should be made to determine if the direction-finder could be used without modification for omnidirectional direction-finding, or at least for homing on the frequency of 2182 kc/s;

5. that when Administrations encourage the use of direction-finders on board ship, capable of operating in the 2 Mc/s band, or at least on the international radiotelegraphy distress and calling frequency of 2182 kc/s, they should also encourage the provision of suitable facilities for the calibration of such direction-finder equipment;

6. that the Director, C.C.I.R. should be invited to bring this Recommendation to the attention of the I.M.C.O. Reference is made to Recommendation 31 of the Convention for the Safety of Life at Sea, London, 1960;

7. that Administrations should bring the above Recommendations to the attention of those responsible for the provision, installation, and maintenance of direction-finders on ships;

8. that Administrations should continue the study of Question 206(XIII).

ANNEX

When the above precautions and technical measures have been taken, under good conditions an accuracy of about $\pm 2^{\circ}$ can be attained in taking bearings in the 2 Mc/s band by reception of " ground " waves on board ships of less than about 800 tons gross tonnage. In unfavourable conditions, for example, when the ship is pitching and rolling, an accuracy of about $\pm 5^{\circ}$ can be obtained. On larger ships, the accuracy may be worse, but in most cases it should usually be possible to use the direction-finder for homing purposes on 2182 kc/s. Bearings taken by reception of skywaves, although variable in azimuth and sharpness, are useful for homing into the ground wave range by utilizing their average value.

RECOMMENDATION 429 *

INTERFERENCE LEVEL ON THE RADIOTELEGRAPH DISTRESS FREQUENCY

(Study Programme 171)

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that the Safety of Life at Sea Conference, London, 1960, adopted the following Recommendation (No. 27):

" The Conference, recognizing that at present there is a tendency to increase the maximum power of radiotelegraph installations, and this may lead to an increase in the interference level of the radiotelegraph distress frequency, which may considerably impair the use of this frequency for safety purposes, recommends that the International Telecommunication Union should be invited by the Organization—(i. e. Intergovernmental Maritime Consultative Organization)—to consider what measures can be taken to prevent such an increase in the interference level ";

* This Recommendation concludes the study of Study Programme 171.

(b) the provisions of the relevant Radio Regulations, Geneva, 1959;

(c) the experience of coast station radio operators and ships' radio officers;

UNANIMOUSLY RECOMMENDS

1. that the following measures should be taken to reduce interference at 500 kc/s;

1.1 messages prefixed by the Safety Signal, TTT, should be sent on a working frequency after an initial announcement on 500 kc/s, in accordance with Nos. 1107 and 1492 of the Radio Regulations, Geneva, 1959;

1.2 coast stations should use their working frequencies to reply to calls from ships on 500 kc/s, in accordance with Nos. 1116 and 1117 of the Radio Regulations, Geneva, 1959;

1.3 coast stations making calls to ships on 500 kc/s should request ships to reply on their working frequencies, as permitted by Nos. 1023 and 1116 of the Radio Regulations, Geneva, 1959;

1.4 No. 1092 of the Radio Regulations, Geneva, 1959, which forbids " CQ " calls to be made in congested areas, should be enforced by Administrations;

1.5 greater use should be made of the facilities provided under No. 972 of the Radio Regulations, Geneva, 1959, for reducing power at ship stations, and coast stations as far as practicable should use the minimum necessary power, particularly at night, in accordance with No. 694 of the Radio Regulations, Geneva, 1959;

1.6 steps should be taken by Administrations to prevent unnecessary signalling on 500 kc/s, particularly during distress, in accordance with Nos. 693, 1107 to 1113 inclusive, and 1445 of the Radio Regulations, Geneva, 1959;

1.7 for Class A2 emissions on 500 kc/s the note frequencies used by various stations should, as far as practicable, be spread over the range 450 to 1350 c/s;

1.8 prolonged calling on 500 kc/s by ships endeavouring to establish contact with distant coast stations should be avoided by greater use of HF channels or by relaying of messages;

1.9 in areas where considerable use is made of 500 kc/s for calls and replies, the calling frequencies assigned to coast stations should be spread over the band 497 to 503 kc/s in accordance with No. 1115 of the Radio Regulations, Geneva, 1959;

1.10 in Regions 1 and 3, the frequency of 512 kc/s may be used as a supplementary frequency for calls and replies when 500 kc/s is being used for distress, in accordance with Nos. 1125 to 1129 inclusive of the Radio Regulations, Geneva, 1959.

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REPORTS OF SECTION D: MOBILE SERVICES

REPORT 93 *

HF (DECAMETRIC) AND VHF (METRIC) DIRECTION-FINDING

(Question 159)

(Warsaw, 1956)

1. Introduction

Two documents, 67 (United States of America) and 232 (United Kingdom), were submitted to the VIIIth Plenary Assembly in response to Question 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 United Kingdom document expresses bearing accuracies in the form of errors that are exceeded on only 1 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:

- type of direction finding (DF) equipment, for example, Adcock type,
- type of site,
- frequency,
- range and signal strength,
- ionospheric conditions, particularly diurnal variations,
- amount of interference,
- number of bearings taken,
- skill of the operator.

By day, the error which is exceeded on only 1 occasion in 20 (referred to subsequently as the 95% error), lies between about 3° and 10° 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°. At distances less than 500 to 1600 km (depending on ionospheric conditions), the error progressively increases, and may rise to as large as 10° to 20° 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°, but in the U.S.A. it has been found that the 95% error is usually about 12° on transmissions from aircraft. The difference is probably due mainly to the effects of differences

* This Report was adopted unanimously.

of siting, since with refinements in siting, the 95% error is reduced to about 4° 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°.

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. 232 of Warsaw, 1956.

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. proposed 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° 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° 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° of arc of bearing swing,
(6) insufficient observation time.

The United Kingdom proposed 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°,
Class B: Probability of less than 1 in 20 that the error exceeds 5°,
Class C: Probability of less than 1 in 20 that the error exceeds 10°,
Class D: Bearings whose accuracy is less than that of Class C.

8. Classification of VHF (metric) bearings

It was considered that time alone prevents the classification of VHF bearings taken on transmissions from aircraft and it is not possible for the operator to classify bearings. But the United Kingdom 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 United Kingdom 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 important, 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:

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 United Kingdom 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 Organization on all the aeronautical aspects of VHF direction finding and position finding.

12. 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: – HF Adcock direction finder
– Daylight
– 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 min	Single snap bearing	Mean of 10 bearings taken in 5 min	Single snap bearing	Mean of 10 bearings taken in 5 min
Very good	7	6	6	5	6	4
Good, average	10	9	8	7	7	6

REPORT 317 *

PUBLICATION OF SERVICE CODES IN USE IN THE INTERNATIONAL TELEGRAPH SERVICE

(Resolution 33)

(Warsaw, 1956 – Geneva, 1963)

1. In conformity with the C.C.I.T. proposal (Doc. 471 of Warsaw, 1956), the separate volume of codes to be published by the Secretary-General should contain the following documents:

1.1 Appendix 13, Section II to the Radio Regulations, Geneva, 1959: Miscellaneous abbreviations and signals.

1.2 Appendix 16 to the Radio Regulations, Geneva, 1959.

1.3 Appendix 14 to the Radio Regulations, Geneva, 1959: SINPO Code.

1.4 Appendix 14 to the Radio Regulations, Geneva, 1959: SINPFEMO Code.

1.5 The Cable and Wireless Ltd. 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 Appendix 13, Section I to the Radio Regulations, Geneva, 1959: Q-code.

1.9 The Cable and Wireless Ltd. Service Code.

1.10 The Cable and Wireless Ltd. 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 under § 1.1, viz:

SLT Ship Letter Telegram
OL Ocean Letter

2.2 The documents summarized under §§ 1.7 to 1.10 inclusive are to be included in the code book in part only, as indicated below (see § 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 Organization). 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 § 7.3).

3. Appendix 2 to Doc. 471 of Warsaw, 1956 (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.

* This Report, which replaces Report 90, was adopted unanimously.

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. 471 of Warsaw, 1956 (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 the 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. 471 of Warsaw, 1956 (Cable and Wireless Ltd., Z-code)

6.1 This code, as stated in the last paragraph of § 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 accepted 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. 471 of Warsaw, 1956 (Arrangement of material within the code book)

7.1 In § 2 of Appendix 7 of Doc. 471 of Warsaw, 1956, the C.C.I.T. suggested that the book be divided into three main sections.

7.2 Referring to § 2.3 of this Report, the C.C.I.R. accepted 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. 471 of Warsaw, 1956), 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 (§§ 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 § 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. proposed that the C.C.I.T. suggestion concerning the title (page 4, Doc. 471 of Warsaw, 1956) should be amended as follows:

" Codes and Abbreviations for the International Telecommunication Services, published by the International Telecommunication Union. "

9. Unification

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 (see Opinion 20).

REPORT 318 *

MARINE IDENTIFICATION DEVICES

(Question 158)

(Warsaw, 1956 – Geneva, 1963)

1. General

Two documents, 53 (United Kingdom) and 71 (United States of America), were submitted to the VIIIth Plenary Assembly in answer to Question 105 on the identification of a response on a marine radar display.

This Report summarizes 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 the 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 §§ 3 and 4.

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* This Report, which replaces Report 92, was adopted unanimous.

3. Summary of Doc. 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 normal direction-finding (bearing only), would not normally be sufficient. There is less likelihood of confusion in harbour radar identification, because ships would be identifying 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. 71 (United States of America)

4.1 Doc. 71 (United States) of Warsaw, 1956, 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 document cited as Annex 3. In summary it is observed that:

4.1.1 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 (IFF, 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.

4.1.2 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 PPI 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 to realize a simplified version of this method.

4.1.3 The use of a radar beacon system of the IFF 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 energizing 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.

4.1.4 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 counter-part 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.

4.1.5 The number of vessels involved poses a technical difficulty in adapting an IFF system for marine use, if each vessel were to have a distinct identifying code.

4.1.6 A system of the IFF 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,
- DF identification using radar antennae,
- suggestions other than identification.

For further details on such types of devices, see Annex 3 to Doc. 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 manœuvres, 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 manœuvre 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 beacuse 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 for the C.C.I.R. to obtain from responsible shipping and administrative authorities, their views on the navigational requirements that should be met by radar identification devices. However, at the IXth Plenary Assembly, Los Angeles, 1959, the responsible authorities had not, in fact, advised the C.C.I.R. of any operational requirements for such devices and consequently the studies were terminated.

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REPORT 319 *

CHARACTERISTICS OF EQUIPMENT AND PRINCIPLES GOVERNING THE ALLOCATION OF FREQUENCY CHANNELS IN THE VHF (METRIC) AND UHF (DECIMETRIC) LAND MOBILE SERVICES

(Question 163(XIII))

(Geneva, 1963)

1. Contributions relating to Question 163 (XIII) have been received as follows:

1.1 *Documents of Los Angeles, 1959:*

Docs. XIII/4 (New Zealand), XIII/2 and XIII/11 (F. R. of Germany), XIII/30 (Japan), XIII/32 (United Kingdom) and 180 (Sweden).

1.2 *Documents of Geneva, 1963:*

Docs. XIII/1 (F. P. R. of Yugoslavia), XIII/4 (Greece), XIII/10 and 259 (P. R. of Poland), XIII/24 (F. R. of Germany) and 222 (Australia).

2. The technical information contained in these contributions is given in the Annex to this Report. These data are arranged in the table in the order of the geographical relationship of countries. It appears from this information that it is difficult at present to reach complete international standardization of the performance characteristics of land mobile equipment operating in the VHF and UHF bands. However, it is desirable that countries with common border areas should reach agreement on some common characteristics, which would be helpful in planning for the land mobile services.

3. Some information concerning interference between mobile services and broadcasting services is given in the Final Acts of the Special Regional Conference, Geneva, 1960.

4. Resolution 20 invites Administrations to continue to send details of performance specifications and also to send details of practices for the allocation of channels in the VHF and UHF land mobile services in operation in their respective countries to the C.C.I.R. for circulation.

5. The study of Question 163 (XIII) should be continued.

* This Report, which replaces Report 114, was adopted unanimously.

ANNEX I

SUMMARY OF SPECIFICATION FOR LAND MOBILE EQUIPMENTS

Doc.(1)	Country	Public or private	Frequencies: Bands (Mc/s)	Frequencies: Separation of transmit and receive frequencies	Frequencies: Channel separation (kc/s)	Transmitter characteristics: RF power (max.) W(2)	Frequency tolerance (±) (2)	Classes of emission	Max. deviation (±kc/s)	Occupied bandwidth (kc/s) (3)	Spurious emissions
1	2	3	4	5	6	7	8	9	10	11	12
180 (L.A.)	Sweden	Public	75·2–87·5	5·0	25	100 (e.r.p.)	10×10^{-6}(B) 20×10^{-6}(M)	A3 and F3	5	6 or 15·2	0·2 μW
		Private	31·7–41·0 } 70–87·5 } 156–174	4·6 and 8·0	50		100×10^{-6}	A3 and F3	15	6 or 36	−60 db
XIII/2 XIII/11 (L.A.)	Federal Republic of Germany	Public and private	156–174 156–174	4·5 4·5	50 50	80 (B) 20 (M) 10	2·5 kc/s 2·5 kc/s	F3 F3	15 15	40 40	
XIII/24 (G)		Private	146–156	7	20	6	0·8 kc/s (B) 1·6 kc/s (M)	F3	4	14	20/2 μW (4)
XIII/32 (L.A.)	United Kingdom	Private	71·5–88 } 156–174 }	5·0 to 13·5	25	25 (e.r.p.)	1·5 kc/s (B) 3·0 kc/s (M)	A3 or F3	5	6 or 16	2·5 μW
		Public	156–174	4·5	50	100 (B) 25 (M)	2·0 kc/s (B) 3·0 kc/s (M)	F3	15	36	2·5 μW
XIII/10 and 259 (G)	People's Republic of Poland	Private	33–35 44–46 150–156		50	80 (B) 20 (M)	50×10^{-6} 50×10^{-6} 20×10^{-6}	F3	15	42	−60 db
			300–308 336–344		50	80 (B) 15 (M)	10×10^{-6}	F3	12	30	−60 db
XIII/1 (G)	F.S.R. of Yugoslavia	Private	31·7–41		100	20	15×10^{-6}	F3	15	36	−30 db
XIII/4 (G)	Greece	Private	68–87·5		66	50 (B) 20 (M)	3 kc/s	F3	15	36	−70 db
XIII/30 (L.A.)	Japan	Public and private	54–68 148–162	2–4·5	30 40	50	20×10^{-6}	F3	10 12	26 30	−80 db
222 (G)	Australia	Private	29·7–52 54–70		25	50 (B) 25 (M)	20×10^{-6} (B and M)	A3 and F3	5	6 or 16	Less than 2·5 μW 50 kc/s from carrier
			70–85 92–94		30						
			148–174		30		10×10^{-6}(B) 20×10^{-6}(M)				Less than 2·5 μW 60 kc/s from carrier
XIII/4 (L.A.)	New Zealand	Public and private	100	1·0	50						

Doc.(1)	Receiver characteristics: Sensitivity (e.m.f.) μV	Sensitivity: For a signal-to-noise ratio of (db)	Selectivity (db)	Frequency tolerance (±) (2)	Spurious responses (db)	Antennae	Remarks
1	13	13	14	15	16	17	18
180 (L.A.)			−80 at 25 kc/s	10×10^{-6}(B) 20×10^{-6}	−70	Max. height 50 m	Receiver selectivity with two-signal test.
							Receiver not specified
XIII/2 XIII/11 (L.A.)						Vertical polarization	Receiver not specified
XIII/24 (G)	1	20	9 db/kc/s between 6 and 80 db			Vertical polarization	
XIII/32 (L.A.)	5	10	−70 at 25 kc/s	1·5 kc/s (B) 3·0 kc/s (M)	−70		The RF power is specified in each individual licence. Receiver selectivity with two-signal test
	2	20	−70 at 50 kc/s	2·0 kc/s (B) 3·0 kc/s (M)	−70		
XIII/10 and 259 (G)	2	20	−70 at 50 kc/s	50×10^{-6} 50×10^{-6}	−70		Receiver selectivity with two-signal test
	2	20	−70 at 50 kc/s	20×10^{-6} 10×10^{-6}	−70		
XIII/1 (G)	1	10	−80 at 100 kc/s	50×10^{-6}	−50		
XIII/4 (G)	1 0·5	12(B) 12(M)	−86 at 60 kc/s	3 kc/s	−70		
XIII/30 (L.A.)	2	20	−70 db at 50 kc/s	20×10^{-6}	−80		
222 (G)	1	10	−80 at 25 kc/s		−80 at 25 kc/s	Vertical polarization	
	1·5	10	−76 at 30 kc/s		−76 at 30 kc/s		
	2·5	10	−72 at 26 kc/s		−72 at 26 kc/s		
XIII/4 (L.A.)							

(1) L. A. = Los Angeles, 1959; G = Geneva, 1963.
(2) B = base station; M = mobile station.
(3) In some cases, the bandwidth is specified at the 20 db points.
(4) The first figure refers to the harmonic emissions only, the second figure refers to the other spurious emissions.

REPORT 320 *

SELECTIVE CALLING DEVICES FOR THE INTERNATIONAL MARITIME MOBILE RADIOTELEPHONE SERVICES

(Question 160 and Study Programme 168)

(Geneva, 1963)

1. Study Programme 271A(XIII) states that Recommendation 257 does not give a full reply to Question 160 (Warsaw, 1956) and the trials of selective calling systems, described in Los Angeles Docs. XIII/10, XIII/18, XIII/26 and Doc. 189, should be carried out with a view to coming to a decision on the type of system that should be adopted internationally.

   The Administrations of the Federal Republic of Germany and the U.S.A. have carried out comparative tests. Reference is made to Docs. 229 and 235 of Geneva, 1963.

2. Study Group XIII has studied in great detail, during the session of the Xth Plenary Assembly, the results of these tests and has also taken into consideration Docs. XIII/6, 8, 9, 11, 15, 19 and 21 of Geneva, 1963.

3. Study Group XIII has come to the conclusion that it is important that the principal operational and technical characteristics of a world-wide maritime selective calling system should be standardized as soon as possible.

   No decision can be taken at present regarding the selective calling system to be adopted on a world-wide basis and further tests including tests under practical operating conditions should be made by Administrations.

   Account was taken of the fact that different national selective calling systems, already in operation on a limited scale, may expand in the absence of early international agreement and, for economic reasons, preclude international standardization.

   To expedite agreement on a world-wide basis, the studies must be continued without delay and attention is drawn to Resolution 19.

4. The discussions during the Xth Plenary Assembly have made it clear that all selective calling systems tested by the Administrations of the Federal Republic of Germany (Doc. 229) and the U.S.A. (Doc. 235) are capable of operating at VHF–(F3 operation).

5. Question 271(XIII) and Study Programme 271A(XIII) require the determination of the technical characteristics for a selective calling device for use in the maritime VHF band only. However, the view has been expressed in Docs. XIII/8, 15 and 21 of Geneva, 1963, that it would be advantageous for the world-wide selective calling system to be suitable also for operation in the maritime MF and HF bands, having regard to the probable additional requirement for SSB, operating in accordance with Recommendation 258.

6. The tests, to be carried out by Administrations in accordance with Resolution 19 have, therefore, to include the operation of selective calling systems, using classes of emission F3 at VHF and A3, A3H, A3J at MF and HF. Interference, atmospherics and fading may impair the reliable operation of any system. Tests should, therefore, take account of these factors.

7. With A3J emissions, the frequency of the tones received may differ from those transmitted by the coast stations, since the reintroduced carrier of the receiver on board ship may not exactly

* This Report was adopted unanimously.

match the corresponding frequency of the suppressed carrier of the coast station transmitter. This may be to the disadvantage of any selective calling system, which depends for its operation on circuits which are very frequency-selective.

Consequently, doubt has been expressed during the discussions whether or not a selective calling system depending on highly frequency-selective elements such as vibrating reed relays will operate reliably on class A3J emissions in accordance with Recommendation 258.

8. The duration of the selective calling signal is of importance.

A signal of long duration or with many signal elements may be more vulnerable to mutilation by fading (e. g. sudden drop of field-strength), interference or atmospherics, than a short signal or one with fewer signal elements.

9. A system with a constant number of signal elements for each code might have an advantage over a similar system with a variable number of signal elements, if the design of the automatic receiving selector for the former system includes a device to count the number of signal elements, thus providing additional protection against false calls.

10. The requirements of the tests to be carried out by Administrations according to Resolution 19, may be summarized as follows:

10.1 As far as possible, the tests should be extended to the classes of emission:

F3 in the maritime VHF band,

A3, A3H, A3J in the maritime MF and HF bands.

10.2 Tests should also be carried out under practical operating conditions, including the effects of fading, interference or atmospherics, and the reports should contain information with regard to:

10.2.1 Reliability tests (ratio of calls received to calls transmitted), for high and low field-strengths;

10.2.2 Immunity against false calls (ratio of false calls received to calls transmitted), caused by such phenomena as speech modulation, intermodulation, etc.;

10.2.3 An indication of the complexity of the different receiving selectors, such as number of tubes, transistors, relays, and frequency-selective elements; also whether any components used are special or critical, especially as regards adjustment and maintenance;

10.2.4 An indication of the relative cost of typical equipments tested should, as far as possible, be given.

11. Doc. XIII/19 (U.S.A.) of Los Angeles, 1959, contains a contribution on the subject of a numbering system for selective signalling in the maritime mobile services.

From the discussions during the Xth Plenary Assembly, the conclusion was reached that a selective calling system, with a capability of approximately 60 000 individual signalling combinations, would be adequate.

Ships normally engaged on international voyages should, where required, be allocated one individual code permanently assigned to that ship and this code should not be given to any other ship to which the same calling channel has been assigned. Allocation of codes to ships normally engaged on voyages of a domestic nature could be done on a shared basis.

On the assumption that the international selective calling system to be adopted will contain approximately 60 000 individual combinations, a decision will be required on the division of the number of codes, to be allocated:

- individually to ships engaged on international voyages;
- on a shared basis to ships on domestic voyages.

(A possible division could be 45 000 for ships on international voyages, and 15 000 for ships on voyages of a domestic nature.)

The allocation of individual codes to ships engaged in international voyages could be best done by the I.T.U. in the form of " blocks " of a relatively small number of codes to individual Administrations.

An additional " block of codes " would be allocated to an Administration when its previous " block " was nearly exhausted.

If, eventually, all codes were allocated, a second channel for selective calling could be brought into use, thus doubling the number of codes available. Another designator to indicate the channel could then be added to the code numbering and another equal number of code combinations would be added to the system.

A detailed consideration of the allocation plan and numbering system, including operational procedures in different frequency bands, can only take place after an international selective calling system has been adopted.

12. An examination of the patent situation, with respect both to the systems and the selective calling equipments, shall be included in the report of the International Working Party to be set up in accordance with Resolution 19.

STUDY GROUP XIII

(Mobile Services)

Terms of reference :

To study technical and operating questions concerning the aeronautical, maritime, land mobile, radiolocation and radionavigation services (except services that involve the use of earth satellites which, at present, are the concern of Study Group IV).

Chairman : Mr. G. H. M. GLEADLE (United Kingdom)
Vice-Chairman : Mr. J. SØBERG (Norway)

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP XIII

1. Former Resolution 33 : Publication of service codes in use in the international radiotelegraph service

Action has been taken in § 1 and § 2 of former Resolution 33. Opinion 21 has been adopted concerning the operational necessity for the unification of codes. Report 317 is a more up-to-date version of Report 90.

2. Question 158 and former Resolution 61 : Marine identification devices

Question 158, former Resolution 61 and Recommendation 222 have been deleted as there is no operational requirement evident. Report 92, § 6, has been amended accordingly, and appears as Report 318.

3. Question 160 and Study Programme 168 : Selective calling devices for use in the international maritime mobile radiotelephone service

The results of extensive tests of the selective calling systems for VHF-FM services in the U.S.A. and the Federal Republic of Germany were discussed. Several other systems in use in other countries were also examined. It was agreed that tests of selective calling systems should be carried out also on the HF and MF maritime services and with double-sideband and single-sideband amplitude-modulation. The Question 160 and Study Programme 168 have, therefore, been revised and bear the numbers Question 271(XIII) and Study Programme 271A(XIII) and Report 320 prepared on the discussions. Resolution 19 was adopted for setting up an International Working Party (Chairman: Mr. Broersma, Netherlands), to examine the results of the tests at MF and HF and, if possible, to prepare a draft Recommendation on an international selective calling system for the maritime service.

4. Question 161 : Spurious emissions from frequency-modulated maritime mobile equipment

The substance of Report 113 and Recommendation 255 have been combined into Recommendation 426 and Question 161 has been terminated.

5. Question 163(XIII) and former Resolution 60 : Characteristics of equipments and principles governing the allocation of channels in the VHF and UHF land mobile services

The technical specifications for land mobile equipment, which were submitted by various Administrations, have been added to Report 114, which appears as Report 319, and an addition made to former Resolution 60 (now renumbered Resolution 20), asking Administrations to furnish technical and operational information on any agreements concerning the operation of land-mobile services in border areas. It is hoped to work towards a measure of international standardization:

– to limit mutual interference between land-mobile services of adjacent countries;
– to permit the operation of common land-mobile services.

6. Question 206 (XIII) : Direction-finding by ships in the 2 Mc/s band

Recommendation 428 has been adopted on the provision and calibration of equipments in ships for taking bearings and for " homing ". This is especially important in cases of distress and will be of interest to the I.M.C.O. The Question has been retained for further study.

7. Study Programme 171 : Interference level on the radiotelegraph distress frequency

This study was referred to the I.T.U. by the Conference on the Safety of Life at Sea, London, 1960. Recommendation 429 has been adopted and Study Programme 171 terminated.

8. New Questions and Resolutions

Question 274(XIII): Facsimile transmission of meteorological charts for reception by ships.

Question 272(XIII): Signal-to-interference protection ratios and minimum field-strengths required in the mobile services.

Question 273(XIII): Use of classes of emission A2H and A3H on the distress frequencies 500 kc/s and 2182 kc/s respectively.

Opinion 22: Emergency position-indicating radio beacons.

9. Cancelled Recommendations

The following Recommendations have been cancelled, because their substance has been incorporated in the Radio Regulations, or implemented in other ways, or because they are redundant. Suitable notes have been inserted in the Complete List of Recommendations.

Recommendation 124: Watch on the radiotelephony distress-frequency of 2182 kc/s.

Recommendation 222: Inter-ship radar identification.

Recommendation 250: Signals MAYDAY and PAN.

Recommendation 251: Addition to Appendix 9 of the Radio Regulations.

10. Amended Recommendations

Recommendation 126 (Pulse transmission for radio direction-finding), has been recast into a more appropriate form without altering its substance and it appears as Recommendation 422.

Recommendation 254 (Technical characteristics of VHF-FM maritime equipments), has had a new section added to it concerning the choice of intermediate frequencies for receivers. It now appears as Recommendation 425.

All Recommendations were amended where necessary to bring various references, etc., up-to-date.

11. Recommendations and Resolutions of the Administrative Radio Conference, Geneva, 1959

Preliminary consideration was given to the question of whether the C.C.I.R. should take up the study of Recommendations Nos. 18, 22, 26, 27, 30, and Resolutions Nos. 8 and 12 of the Administrative Radio Conference, Geneva, 1959. No decision was taken, however, as Administrations needed more time to consider the matter.

12. Terms of reference of Study Group XIII

The terms of reference were revised, as indicated on page 177.

OPINION 20 *

PUBLICATION OF THE "CODES AND ABBREVIATIONS FOR THE INTERNATIONAL TELECOMMUNICATION SERVICES" BY THE INTERNATIONAL TELECOMMUNICATION UNION

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that under the supervision of the C.C.I.T.T., with the cooperation of the C.C.I.R., the first edition of the " Codes and Abbreviations for the International Telecommunications Services, published by the International Telecommunication Union " was issued in 1958;

(b) that a second edition of this book is in the course of preparation and will be published in 1963;

(c) that Administrations have not expressed a need for the unification of codes;

IS UNANIMOUSLY OF THE OPINION

1. that under the supervision of the C.C.I.T.T., in cooperation with the C.C.I.R., the publication mentioned in § *(a)*, should be kept up-to-date;

2. that after the second edition has been published, Administrations should express their views as to whether there is an operational need for the unification of codes;

3. that if Administrations consider that there is an operational need for the unification of codes, the C.C.I.T.T. should be asked to assume the supervision and responsibility for investigating the extent to which unification might be possible. The C.C.I.R. should cooperate as necessary with the C.C.I.T.T.

RESOLUTION 19

SELECTIVE CALLING DEVICES FOR USE IN THE INTERNATIONAL MARITIME MOBILE RADIOTELEPHONE SERVICE

(Study Programme 271A (XIII))

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) Question 271(XIII), Study Programme 271A(XIII), Recommendation 257 and Report 320;

(b) that the results of a limited series of tests, carried out by the Administrations of the Federal Republic of Germany and the United States of America, are given in Docs. 229 and 235 of Geneva, 1963;

(c) that the tests of the selective calling systems, as mentioned in Study Programme 271A(XIII), § 1, have not been sufficient to enable a decision to be reached as to the system that should be adopted internationally;

(d) that Docs. XIII/8, XIII/15 and XIII/21 of Geneva, 1963, express the view that the selective calling system to be adopted should be suitable for operation in all maritime mobile radiotelephone bands (VHF, HF and MF), and be capable of working with single-sideband systems;

(e) that it is important to standardize, with the least possible delay, the principal operational and technical characteristics of an international maritime selective calling system;

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* This Opinion replaces Resolution 33.

UNANIMOUSLY DECIDES

1. that Administrations should carry out further tests, including practical tests under operational conditions, to determine the suitability of the selective calling systems on all maritime radiotelephone services (VHF, HF and MF), with special regard to the tests proposed in § 10 of Report 320;

2. that an International Working Party should be formed to prepare a comprehensive but brief report based on the tests mentioned in § 1;

3. that the following Administrations and International Organizations should be invited to participate in this International Working Party;

   Netherlands (Chairman),
   Belgium,
   United States of America,
   France,
   Japan,
   Federal Republic of Germany,
   United Kingdom,
   Union of Soviet Socialist Republics,
   Comité International Radio Maritime,
   International Chamber of Shipping;

4. that the tests mentioned in § 1 should be completed and the results sent to the Chairman of the International Working Party and to the Chairman, Study Group XIII, by July, 1964;

5. that the Chairman of the International Working Party should convene a meeting to prepare a Report and, if possible, a draft Recommendation, for circulation to participants in the work of Study Group XIII, by November, 1964;

6. that Study Group XIII should hold an Interim Meeting about March, 1965, to prepare a draft Report and a draft Recommendation, for circulation to Administrations for their consideration with a view to subsequent adoption by the C.C.I.R.

QUESTION 271 (XIII) *

SELECTIVE CALLING DEVICES FOR USE IN THE INTERNATIONAL MARITIME MOBILE RADIOTELEPHONE SERVICES

The C.C.I.R., (Warsaw, 1956 – Geneva, 1963)

CONSIDERING

(a) Recommendation 425, in answer to Question 107, concerning VHF (metric) FM 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, HF and MF maritime mobile radiotelephone services;

(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 with normal modulation;

(f) that the signal transmitting and receiving units should be capable of operating with the radio transmitting and receiving equipments commonly available in ships;

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* This Question replaces Question 160.

(g) that the transmission of a complete call number should be accomplished in as short a time as possible;

(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 a world-wide selective calling system in the VHF, HF and MF maritime mobile radiotelephone services, and to what extent, and for what purposes can selective calling be used with advantage;

2. what are the advantages and disadvantages in the use of the same selective calling system in all three (VHF, HF and MF) maritime radiotelephone bands;

3. 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 § 1 of this Question;

4. what are the essential technical characteristics of selective calling devices on which international agreement is required (see Report 320);

5. what selective calling systems are there which fulfil the operational and technical requirements in answer to §§ 3 and 4?

STUDY PROGRAMME 271A (XIII) *

SELECTIVE CALLING DEVICES FOR USE IN THE INTERNATIONAL MARITIME MOBILE RADIOTELEPHONE SERVICES

The C.C.I.R., (Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that Recommendation 257 does not give a full reply to Question 160;

(b) that the essential technical characteristics of a selective calling system to be agreed upon need further study, in accordance with Resolution 19 and Report 320;

(c) that it is desirable to standardize the main operating and technical characteristics;

UNANIMOUSLY DECIDES that the following study should be carried out:

1. trials of selective calling systems, with a view to coming to a decision on the type of system that should be adopted internationally;

2. consideration of the number of individual code combinations required and the principles to be adopted in their allocation. In this connection, attention is drawn to Doc. XIII/19 of Los Angeles, 1959;

3. determination of technical characteristics of the selective calling signal, in particular:

3.1 tone frequency or frequencies;
3.2 radio-frequency deviation in frequency-modulated systems and percentage modulation in amplitude-modulated systems;
3.3 composition and duration of signal;
3.4 transmission sequences;
3.5 tolerances on the above parameters;
3.6 any other parameters requiring international standardization;

4. degree of immunity of the systems from false operation and degree of their response to wanted signals.

Note – See also §§ 6 and 10 of Report 320.

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* This Study Programme replaces Study Programme 168.

QUESTION 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 to minimize 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 standardize 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?

RESOLUTION 20 *

CHARACTERISTICS OF EQUIPMENTS AND PRINCIPLES GOVERNING THE ALLOCATION OF CHANNELS IN THE VHF (METRIC) AND UHF (DECIMETRIC) LAND MOBILE SERVICES

(Question 163 (XIII))

The C.C.I.R., (Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that land mobile services of various kinds are growing rapidly;

(b) that in border areas difficulties may arise between the services of different Administrations;

(c) that it would be advantageous if there were a sufficient measure of agreement, where necessary, between Administrations on the characteristics of equipments and on the principles adopted in the planning for land mobile services;

UNANIMOUSLY DECIDES

1. that Administrations should consult together as necessary to resolve any difficulties concerning their land mobile services and for the purpose of improving such services;

2. that those Administrations which are interested in the provision of common land mobile services should consult together and should advise the C.C.I.R. of any technical and operational problems that require international study;

3. that Administrations should continue to submit technical specifications of land mobile equipment used in their respective countries to the Chairman of Study Group XIII and the Director, C.C.I.R. for circulation;

4. that Administrations should submit information on practices adopted for the allocation of channels in the VHF and UHF land mobile services to the Chairman of Study Group XIII and the Director, C.C.I.R. for circulation;

5. that Administrations, which have reached agreement with adjacent countries on the operation of land mobile services in border areas, should submit to the C.C.I.R., technical and operational details of the agreement to assist other Administrations with similar problems.

* This Resolution replaces Resolution 60.

QUESTION 206(XIII)

DIRECTION-FINDING BY SHIPS IN THE 2 Mc/s BAND

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that the use of radiotelephony by ships in the 2 Mc/s band is increasing;

(b) that an increasing number of ships are being fitted with direction-finding equipment capable of taking bearings in the 2 Mc/s band;

(c) that the taking of accurate bearings, and especially " homing ", by ships is important in cases of distress;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what special technical measures and precautions should be taken in the design and the installation of 2 Mc/s direction-finding equipment for use on board ships for taking bearings, or at least for " homing ";

2. what is the order of accuracy to be expected from 2 Mc/s direction-finding equipments on board ships, particularly on the international distress frequency of 2182 kc/s?

OPINION 21

EMERGENCY POSITION-INDICATING RADIO BEACONS

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) Recommendation 48 of the Convention for the Safety of Life at Sea, London, 1960, and Chapter 9 of the Report of the 7th session of the I.C.A.O. Communication Division (Doc. 8226-COM/552);

(b) the discussions that took place in May-June 1962 in the Inter-Agency Working Group on the Coordination of Safety at Sea and in the Air;

(c) the letter from I.C.A.O. in Doc. 393 of Geneva, 1963;

(d) the letter from I.M.C.O. in Doc. 393 of Geneva, 1963;

IS UNANIMOUSLY OF THE OPINION

that the following questions should be addressed to both I.C.A.O. and I.M.C.O.:

1. are the beacons intended for homing only or for both alerting and homing;

2. what class of stations (e. g. aircraft, ship, coast or aeronautical), are expected to receive the transmissions from the beacons;

3. up to what distances must the beacon signals be receivable?

QUESTION 272 (XIII)

SIGNAL-TO-INTERFERENCE PROTECTION RATIOS AND MINIMUM FIELD-STRENGTHS REQUIRED IN THE MOBILE SERVICES

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that full effect should be given to the studies which the Administrative Radio Conference, Geneva, 1959, in its Recommendation No. 3, invited the C.C.I.R. to continue for all services;

(b) that for certain kinds of mobile services, partial data relating to interference protection ratios and minimum field strengths required, exist in documents of some Conferences of the I.T.U., for example, in the Final Acts of the International Administrative Aeronautical Radio Conference, Geneva, 1948-1949 and of the Special Regional Conference, Geneva, 1960;

(c) that such documents, however, do not constitute a complete and consistent set of data relating to all kinds of mobile services operating in all frequency ranges, particularly with respect to VHF mobile services;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the signal-to-interference protection ratios which define the threshold of harmful interference for the several mobile services;

2. what are the signal-to-noise ratios and the minimum field-strengths required for satisfactory reception of the different classes of emission in the several mobile services;

3. what are the appropriate fading allowances in the several mobile services?

Note 1. – The above studies should be continued simultaneously and with the same urgency.

Note 2. – Particular attention should be given to those studies which will assist the further refinement of the technical standards used by the International Frequency Registration Board.

Note 3. – The above-mentioned studies should be carried on permanently and recommendations and possible revisions be published as soon as practicable.

QUESTION 273 (XIII)

USE OF CLASSES OF EMISSION A2H AND A3H ON THE DISTRESS FREQUENCIES 500 kc/s AND 2182 kc/s RESPECTIVELY

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that, for distress and safety purposes, the Convention for the Safety of Life at Sea (SOLAS) prescribes the use of classes of emission as assigned by the Radio Regulations, Geneva, 1959 (SOLAS (London, 1960), Chapter IV, Reg. 9*e*, 9*h*(i), 12*b*, 12*f*, 13*c*, 13*f*, 15*b* and 15*f*);

(b) that for distress and safety purposes, the Radio Regulations, Geneva, 1959, prescribe for ships and survival craft:
- Class A2 emission on 500 kc/s (see Nos. 973, 974, 994, 995 and 1134);
- Class A3 emission on 2182 kc/s (see Nos. 983, 984, 994, 996 and 1337);

(c) that, to the maximum extent possible, amplitude-modulation systems should use single-sideband (SSB) emissions having characteristics in accordance with the relevant C.C.I.R. Recommendations (No. 670 of the Radio Regulations, Geneva, 1959), and that SSB operation be introduced as far as operationally required for radiotelephony in band 6 and band 7 (Recommendation No. 28 of the Administrative Radio Conference, Geneva, 1959);

(d) that in several countries, new marine transmitters are being designed which make use of SSB techniques;

(e) that SSB transmitters may easily and economically be adapted for Class A2H and Class A3H emission;

(f) that until SSB emission is universally adopted in the MF maritime mobile service, there will be a need for communications between DSB and SSB stations;

UNANIMOUSLY DECIDES that the following question should be studied:

1. is Class A2H emission on 500 kc/s as effective as Class A2 for alarm, distress, urgency and safety signals to be received by stations equipped for DSB reception by aural means or automatic receiving equipment;

2. is Class A3H emission on 2182 kc/s as effective as Class A3 for alarm, distress, urgency and safety signals to be received by stations equipped for DSB reception by aural means or automatic receiving equipment?

QUESTION 274 (XIII)

FACSIMILE TRANSMISSION OF METEOROLOGICAL CHARTS FOR RECEPTION BY SHIPS

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that meteorological charts are being transmitted extensively over radio circuits;

(b) that the transmissions concerned are mainly intended for exchange of meteorological information in the fixed services;

(c) that Chapter V, Regulation 4*b*(ii), of the Convention for the Safety of Life at Sea, London, 1960, requests contracting Governments to encourage the transmission of suitable facsimile weather charts;

(d) that ships need to receive suitable meteorological charts;

(e) that an increasing number of ships is being fitted with equipment for receiving meteorological charts;

(f) that the World Meteorological Organization (W.M.O.), in collaboration with the C.C.I.T.T., has standardized the equipment used for international meteorological transmissions (see Recommendations 60 and 61 of the Commission for Synoptic Meteorology, W.M.O. – No. 122. R.P. 50);

(g) that the W.M.O. standards provide for various drum-speeds and indices of co-operation; the choice, which depends on the type of charts transmitted, is left at present to the discretion of meteorological services;

(h) that it is desirable to adopt a uniform practice for all facsimile transmissions of meteorological charts intended for ships;

(i) that certain characteristics, concerning meteorological facsimile transmissions by radio, are contained in Recommendation 343;

UNANIMOUSLY DECIDES that the following question should be studied jointly with the W.M.O.:

what steps should be taken to establish a uniform practice for facsimile transmissions of meteorological charts intended for reception by ships?

Note. – The Director, C.C.I.R. is invited to bring this Question to the attention of the I.M.C.O.

QUESTION 282 (XIII)

USE OF A CONTROL TONE FOR AUTOMATIC GAIN CONTROL OF RECEIVERS IN SINGLE-SIDEBAND RADIOTELEPHONE SYSTEMS OPERATING IN THE HF MARITIME MOBILE BANDS

THE INTERNATIONAL FREQUENCY REGISTRATION BOARD,

IN VIEW OF the request by the Panel of Experts in Recommendation No. 38 of its Final Report, Geneva, 1963, and AFTER CONSIDERING:

(a) that Recommendation 258 requires that a reduction in carrier-level to at least 40 db below peak envelope power should be achieved as soon as possible on single-sideband radiotelephone systems operating in the HF maritime mobile band;

(b) that this reduction in carrier power is desirable from the point of view of the economic use of the radio-frequency spectrum, but virtually excludes the use of the residual carrier for automatic gain control;

(c) that although automatic gain control can be obtained from the speech modulation, such modulation is not always present;

AND IN VIEW OF No. 180 of the International Telecommunication Convention, Geneva, 1959;

DECIDES to submit the following urgent question to the C.C.I.R.:

1. what arrangements should be adopted in single-sideband radiotelephone systems in the HF maritime mobile service, which use a carrier reduction of at least 40 db in accordance with Recommendation 258, to control the gain of the receiver in the absence of speech modulation;

2. if the arrangements adopted employ an audio-frequency control tone, what characteristics of the tone and of the equipment should be standardized, bearing in mind the necessity for the service to operate on a world-wide basis?

LIST OF DOCUMENTS OF THE Xth PLENARY ASSEMBLY CONCERNING STUDY GROUP XIII

Doc.	Origin	Title	Reference	Other Study Groups concerned
13	Chairman, Study Group XIII	Report by Chairman of Study Group XIII (Mr. G.H.M. Gleadle)	—	—
18	Belgium	Interference caused to FM reception by AM and FM VHF mobile stations	—	II
120	Federal Republic of Germany	Direction-finding by ships in the 2 Mc/s band	Q. 206	—
129	C.C.I.R. Secretariat	Bibliographic references in the volumes of the C.C.I.R.	—	I–XIV
141	Belgium	Interference to FM reception by emissions from VHF (metric) mobile AM- and FM-stations	Q. 178 Q. 163	II
153	C.C.I.R. Secretariat	Refinement of I.F.R.B. technical standards	—	I, II, III, V, VI, X, XII
169	Sweden	Use of classes of emission A2H and A3H on the distress frequencies 500 kc/s and 2182 kc/s respectively	Draft. Q.	—
177	Sweden	Comparison of reception of classes of emission A3H and A3 on receivers designed for A3 reception	—	—
179	Federal Republic of Germany	Direction-finding by ships in the 2 Mc/s band	Q. 206	—
222	Australia	Specification for radio equipment employed in privately-operated land and harbour mobile radiotelephone services	Res. 60	—
229	Federal Republic of Germany	Selective calling devices for use in the international VHF (metric) maritime mobile radiotelephone service	S.P. 168	—
235	United States of America	Tests of maritime radiotelephone selective calling devices	Q. 160 S.P. 168 Rec. 257 and 258	—
240	I.M.C.O.	Emergency position-indicating radio beacons (Correspondence between I.M.C.O. and I.T.U.)	—	—
259	P.R. of Poland	Corrigendum to Doc. XIII/10 – Technical characteristics of the equipment used in Poland for the land mobile services	Res. 60	—
265	Study Group XIII	Amendment to Recommendation 251	—	—
305	”	Draft text submitted by Study Group XIII to the Drafting Committee – Amendment to Recomendation 254	Draft Rec.	—
306	”	Spurious emissions from frequency-modulated VHF (metric) maritime mobile equipment	Draft Rec. Q. 161	—
310	”	Summary record of the first meeting	—	—
354	”	Interference level on the radiotelegraph distress frequency	Draft Rec.	—

Doc.	Origin	Title	Reference	Other Study Groups concerned
367	Study Group XIII	Direction-finding by ships in the 2 Mc/s band	Draft Rec. Q. 206	—
385	”	Publication of the “ codes and abbreviations for the international telecommunication services ” published by the International Telecommunication Union	Draft Res.	—
386	”	Amendment to Report 92	Draft Rep.	—
390	”	Facsimile transmission of meteorological charts for ships	Draft Q.	—
391	”	Signal-to-interference protection ratios and minimum field-strengths required in the mobile services	Draft Q.	—
392	”	Use of classes of emission A2H and A3H on the distress frequencies 500 kc/s and 2182 kc/s respectively	Draft Q.	—
393	”	Emergency positioning indicating radio beacons	Draft Res.	—
449	”	Summary record of the second meeting	—	—
460	”	Selective calling devices for use in the international maritime mobile radiotelephone service	Draft Res. S.P. 168	—
482	”	Amendment to Resolution 60	Draft Res.	—
493	”	Proposed revision of the documents of Study Group XIII	—	—
503	”	Selective calling devices for the international mobile radiotelephone services	Draft Rep.	—
507	”	Selective calling devices for use in the international maritime mobile radiotelephone services	Draft Q.	—
508	”	Selective calling devices for use in the international maritime mobile radiotelephone services	Draft S.P.	—
518	”	Summary record of the third meeting	—	—
563	”	Summary record of the fourth meeting	—	—
632	”	Summary record of the fifth and last meeting	—	—
2121	Drafting Committee	Technical characteristics of frequency-modulation VHF (metric) maritime mobile equipments	Rec. 425	—
2122	”	Spurious emissions from frequency-modulated VHF (metric) maritime mobile equipment	Rec. 426	—
2178	”	Amendment to Recommendation 251	—	—
2179	”	Interference level on the radiotelegraph distress frequency	Rec. 429	—
2180	”	Direction-finding by ships in the 2 Mc/s band	Rec. 428	—
2181	”	Publication of the “ codes and abbreviations for the international telecommunication services ” published by the International Telecommunication Union	Op. 20	—

Doc.	Origin	Title	Reference	Other Study Groups concerned
2182	Drafting Committee	Amendment to Report 92	Rep. 318	—
2183	”	Signal-to-interference protection ratios and minimum field strengths required in the mobile services	Q. 272	—
2184	”	Use of classes of emission A2H and A3H on the distress frequencies 500 kc/s and 2182 kc/s respectively	Q. 273	—
2185	”	Emergency positioning-indicating radio beacons	Op. 22	—
2189	”	Facsimile transmission of meteorological charts for reception in ships	Q. 274	—
2190	”	Selective calling devices for use in the international maritime mobile radiotelephone service	Res. 19	—
2346	”	Selective calling devices for the international mobile radiotelephone services	Rep. 320	—
2347	”	Selective calling devices for use in the international maritime mobile radiotelephone services	S.P. 271A	—
2348	”	Selective calling devices for use in the international maritime mobile radiotelephone services	Q. 271	—
2349	”	Characteristics of equipment and principles governing the allocation of channels in the VHF (metric) and UHF (decimetric) land mobile services	Res. 20	—
2351	”	Characteristics of equipment and principles governing the allocation of frequency channels in the VHF (metric) and UHF (decimetric) land mobile services	Rep. 319	—
2359	”	Revision of the documents of Study Group XIII	Rec. 422, 423, 424, 427 Rep. 317 Res. 20	—

RECOMMENDATIONS OF SECTION H: STANDARD-FREQUENCIES AND TIME-SIGNALS

RECOMMENDATION 374 *

STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS

(Question 140 (VII))

(Geneva, 1951 – London, 1953 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that the Administrative Radio Conference, Geneva, 1959, allocated the frequency bands 20 kc/s $\pm$ 0·05 kc/s, 2·5 Mc/s $\pm$ 5 kc/s (2·5 Mc/s $\pm$ 2 kc/s in Region 1), 5 Mc/s $\pm$ 5 kc/s, 10 Mc/s $\pm$ 5 kc/s, 15 Mc/s $\pm$ 10 kc/s, 20 Mc/s $\pm$ 10 kc/s and 25 Mc/s $\pm$ 10 kc/s, requesting the C.C.I.R. to study the question of establishing and operating a world-wide standard-frequency and time-signal service;

(b) that additional standard-frequencies and time-signals are emitted in the bands 4 to 9;

(c) the provisions of Article 44, Section IV, of the Radio Regulations, Geneva, 1959;

UNANIMOUSLY RECOMMENDS

1. that the standard-frequency and time pulses at each transmitting station should be generated from the same oscillator;

2. that the frequency should be maintained constant each year with reference to atomic frequency standards, but be offset to keep the time pulses in close agreement with UT2; the offset to be used each year will be that adopted by the B.I.H. after consultation with the observatories concerned. This offset is expressed in the time scale in which the frequency of caesium has the value:

$$f(\mathrm{Cs}) = 9\,192\,631\,770 \text{ c/s} \;**$$

3. that the time-signals should consist of impulses repeated at intervals of one second and maintained within approximately 100 ms of universal time UT2. Changes in the phase of the pulses should be exactly 50 ms and should be made simultaneously by the stations concerned;

4. that frequency deviations at each transmitting station should not exceed 5×10^{-10};

5. that the measured values of frequencies and time-signals should be published promptly and advance notification should be given of major adjustments of emissions.

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* This Recommendation replaces Recommendation 319.

** See U.R.S.I. Resolution 1 (1960).

RECOMMENDATION 375 *

STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS IN ADDITIONAL FREQUENCY BANDS

(Question 249 (VII))

The C.C.I.R., (Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that intercontinental frequency synchronization has already been achieved by the use of the frequency-stable emissions operating in band 4;

(b) that for many purposes a world-wide time (epoch) synchronization with an accuracy greater than 1 ms is required;

(c) that synchronization to 1 μs may be extended to ranges greater than 2000 km by means of pulsed ground-wave signals;

(d) that line-of-sight transmissions in band 8, and predominantly ground-wave signals in band 5, provide a stable means of distributing time-signals and standard-frequencies on a more local basis;

UNANIMOUSLY RECOMMENDS

1. that existing studies of phase stability, over paths in bands 4 and 5, should be continued and information on the results and methods of measurement disseminated as widely as possible;

2. that the ultimate stability and precision of pulsed ground-wave navigation systems, should be studied as fully as possible with the aim of establishing intercontinental and possibly world-wide time synchronization;

3. that appropriate stations, existing in bands 5 and 6, should be employed as much as possible for distributing standard-frequencies by precise control of their carrier frequencies;

4. that existing broadcasting stations, in bands 8 and 9, such as FM and television, should be employed as much as possible for distribution of standard-frequency and time-signals which can be added to, or make use of, the existing modulation without interference to the normal programme;

5. that a band of 200 kc/s, in the upper part of band 8, would appear to be suitable for an effective line-of-sight standard-frequency and time-signal service.

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* This Recommendation replaces Recommendation 320.

RECOMMENDATION 376 *

AVOIDANCE OF EXTERNAL INTERFERENCE WITH EMISSIONS OF THE STANDARD-FREQUENCY SERVICE IN THE BANDS ALLOCATED TO THAT SERVICE

(Question 140 (VII))

The C.C.I.R., (Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) the importance and increasing use of standard-frequency and time-signal emissions in the allocated bands;

(b) that interference reduces the usefulness of the standard-frequency and time-signal service to a serious degree;

(c) that, despite the efforts made by Administrations and the I.F.R.B. to clear the standard-frequency bands, some registered users, and many unnotified emissions, remain in these bands, which continue to cause interference with the standard-frequency services;

UNANIMOUSLY RECOMMENDS

1. that to avoid external interference, Administrations and, if necessary, the I.F.R.B. should continue their efforts to clear the standard-frequency bands;

2. that, in the territory under its jurisdiction, each Administration should make every effort to prevent all users of the radio-frequency spectrum from operating other stations in the standard-frequency bands, capable of causing harmful interference to the standard-frequency service;

3. that national monitoring stations should carry out a regular search for external interfering stations in the standard-frequency bands and should make every effort to identify each interfering station, if necessary with international co-operation;

4. that in each case of external interference the users of standard-frequency emissions should request the monitoring service of their own country to identify the interfering station;

5. that, in cases of external interference with the standard-frequency service, Administrations should apply the provisions of Articles 14, 15 and 16, of the Radio Regulations, Geneva, 1959, and, if desired, should send a copy of relevant correspondence to the I.F.R.B.;

6. that, when interference is observed in the standard-frequency bands, even if the source cannot definitely be identified, representatives of Administrations, participating in the work of C.C.I.R. Study Group VII, should exchange information from users of standard-frequency and time-signal transmissions and from the monitoring service. This may later permit identification of the interfering station.

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* This Recommendation replaces Recommendation 321.

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REPORTS OF SECTION H: STANDARD-FREQUENCIES AND TIME-SIGNALS

REPORT 267 *

STANDARD-FREQUENCIES AND TIME-SIGNALS

(Question 140 (VII))

(Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

This Report outlines the work of Study Group VII in the interval between the IXth and the Xth Plenary Assemblies.

Further consideration has been given to the problem of meeting the need for time-signals based on a uniform time scale, as well as for the time-signals related to universal time, without increasing the number of transmissions. Interference is still a pressing problem, but proposals have been considered which might lead to an amelioration in the more seriously affected areas. Demands for increasing precision posed many technical questions, and useful discussions ensued. Much interest centred on the employment of VLF for phase comparison of high accuracy. The various Study Programmes indicate how Study Group VII should proceed with its future work.

Recommendation 374 concerning standard-frequency and time-signal emissions has been revised with a view to providing, on the same emission, for the needs of users who require uniform frequency and those who require time information. It is recommended, that the emitted frequencies shall be maintained constant throughout each year by reference to atomic standards but offset in frequency so that the time pulses remain within approximately 100 ms of UT2. This tolerance should ensure that changes in the adopted frequency offset and the 50 ms adjustments in the phase of the time pulses will be required only occasionally.

Study Group VII has noted with satisfaction that, in accordance with Resolution 53, of the C.C.I.R., the Administrative Radio Conference, Geneva, 1959, has allocated the frequency 20 kc/s $\pm$ 0·05 kc/s in band 4 for an international standard-frequency and time-signal service. Particulars of the first station, WWVL, to be registered on this frequency are given in Table I, together with the characteristics of the other stations known to be operating regular standard-frequency and time-signal services. An experimental Japanese emission, with very low radiated power, is also being emitted on 20 kc/s.

Figs. 1 and 2 are two schedules giving, where appropriate, the daily and hourly pattern of emission and modulation. The extent of the problem of mutual interference which exists in many areas may be clearly seen from these diagrams: it is particularly severe in Western Europe and the Far East. Report 269 contains proposals for the reduction of this interference, involving a degree of regional time sharing and a reduction in the periods of audio-frequency modulation. It is hoped that Administrations will make mutual adjustment of their emission schedules and thereby attempt to secure better use of the standard-frequency services for all users. Resolution 14 indicates the procedure to be followed to avoid the possibility of interference from any new standard-frequency stations and indicates that the information referred to in this Resolution should be published in the fortnightly Notifications of the General Secretariat and distributed directly to the participants in the work of Study Group VII.

Stations operating regular services at controlled frequencies outside the allocated bands are given in Table II. It should be noted that all the U.S. Navy transmitters in band 4 are now precisely frequency-controlled and participate in the international coordination of time and frequency, which now extends to many stations listed in both Annexes and also to the stations operating

* This Report, which replaces Report 166, was adopted unanimously.

the Loran-C transmissions at 100 kc/s on the East Coast of the United States. Recommendation 375 places emphasis on the study of such pulsed navigational systems for long-range time synchronization.

The disadvantage that the allocated frequencies between 2·5 Mc/s and 25 Mc/s are subject to considerable propagation irregularities (Report 271), and the success already achieved with transmissions in band 4 has led to Question 249(VII), which asks for recommendations for the distribution of standard-frequencies and time-signals above 30 Mc/s and below about 100 kc/s. It should be noted that stations in the Republic of South Africa and Sweden are now operating in the upper part of band 8.

In addition to the mutual interference discussed above, effective use of the services is impaired by other transmissions. Interference continues even though the efforts of Administrations and of the I.F.R.B. have effected a considerable clearance of registered transmitters. Recommendation 376 urges Administrations to clear the bands by monitoring and, if possible, identify interfering stations as well as by applying Articles 14, 15 and 16 of the Radio Regulations, Geneva, 1959. In 1962, the I.F.R.B. sent a new circular letter on this subject to Administrations and is in course of analyzing the results of a special monitoring programme which was carried out in cooperation with Administrations, with a view to approaching Administrations believed to be responsible for the out-of-band transmissions.

Increasing use is being made of band 4 on account of its wide coverage and the high phase stability of the received signals. Comparisons with locally generated signals can be made readily to about 1 μs corresponding to a frequency error of about 1 part in 10^{11} in a period of 24 hours. For a comparison time of 1 hour, the frequency precision may be limited by diurnal variations to the order of 1 part in 10^9. Information on transmitting and receiving stations is given in Report 268, together with supplementary information on typical recording methods.

In band 7, measurements reported have shown that in a measuring time of a few minutes, precision of several parts in 10^9 is possible during the day (one hop E-layer propagation), and several parts in 10^8 during the night (multi-hop F-layer propagation). Second-to-second accuracy of the time-signals as received does not seem to be better than 0·5 ms. In bands 8 and 9, extensive experimental and theoretical studies summarized in Report 271 have shown that the instability introduced by propagation is at least one order less than the instability of the best oscillators currently available.

The Working Group of Study Group VI, entrusted with the study of Resolution 7, has suggested that use be made of standard-frequency emissions in a field-strength measurement programme. The time sharing plan for these emissions examined by Study Group VII (Report 269) would provide a favourable background for carrying out such measurements. Those interested in the measurements are advised to apply direct to the standard-frequency stations for any information they may require. Study Programme 140B(VII) concerning the use of single-sideband emissions would appear to provide a possible solution to this problem.

The increasing precision required in the distribution of time-signals emphasizes the need for further study (see Study Programme 250A(VII) and Report 270), of the ways in which this might be done within the present bands or in reduced bandwidth.

In the course of examination of the documents submitted, it was found that the use could be foreseen of artificial satellites for an accurate distribution of standard-frequencies and time-signals. Study Programme 249A(VII) raises the question of what factors would have to be considered for the implementation of such a system. The Study Group learned with interest that Telstar I had been used in August 1962 to relate clocks in the U.S.A. and United Kingdom with an accuracy of about 1 μs.

Question 251(VII) has been introduced to investigate timing code formats and methods of distribution by radio transmission. As an example, a fast timing code giving time of year with millisecond resolution once per second, has been emitted experimentally by WWV for over a year. This has been used in the U.S.A. in connection with space telemetry work. It is hoped that Administrations will contribute to the formulation of standards for the formats and distribution of timing codes.

Study Programme 250B(VII) has been introduced as a result of the increasing precision in many fields of frequency measurement. This proposes a close examination of the various factors, some hitherto insignificant, which contribute to the instability of frequency-standards, and the adoption of criteria for the specification of performance; proposals leading to agreements for terminology are also required.

Some of the work of U.R.S.I. is closely related to improvements in standards and measurement techniques and in determining errors introduced in propagation of standard-frequencies and time-signals. For example, U.R.S.I. Resolution 2 (1960), asked that an intensive effort be made to determine the limitations in accuracy in distributing and inter-comparing frequency standards by means of transmissions in band 4. Although such matters were in part discussed at the C.C.I.R. Interim Meeting, advantages are foreseen in arranging some discussions of this type in collaboration with U.R.S.I. It is hoped that, at future Interim Meetings, it will be possible also to arrange one or two meetings with the representatives of U.R.S.I.

TABLE I

Characteristics of standard-frequency and time-signal emissions in the allocated bands, at April, 1963

Station			Antenna(e)		Number of simultaneous transmissions	Period of operation		Standard-frequencies used		Duration of emission		Accuracy of frequency and time intervals (2) (parts in 10^9)	Method of adjustment of time-signal
Call sign	Approximate location	Latitude Longitude	Type	Carrier power (kW)		Days/ week	Hours/ day	Carrier (Mc/s)	Modulation (c/s)	Time-signal (min)	Audio-modulation (min)		
ATA	New Delhi India	28° 34′ N 77° 19′ E	Horizontal dipole	2	1	5	5	10	1; 1000	continuous	4 in each 15	±20	Steering by the frequency
FFH	Paris France	48° 59′ N 02° 29′ E	Radiating tower	0·3	1	2	8½	2·5	1; 440; 1000	10 in each 20	10 in each 20	±2	Steps of 50 ms
HBN(1)	Neuchatel Switzerland	46° 58′ N 06° 57′ E	Horizontal dipole	0·5	1	7	24	5	1	5 in each 10	nil	±0·1	Steps of 50 ms
IAM	Rome Italy	41° 52′ N 12° 27′ E	Vertical λ/4	1	1	6	1	5	1; 1000	10 in each 15	4 in each 15	±5	Steps of 50 ms
IBF	Turin Italy	45° 03′ N 07° 40′ E	Horizontal dipole	0·3	1	6	1⅓	5	1; 1000	35 in each 60	5 in each 60	±5	Steps of 50 ms
JJY(1)	Tokyo Japan	35° 42′ N 139° 31′ E	Vertical λ/2 dipoles; (λ/2 dipole, top-loaded for 2·5 Mc/s)	2	3–4	7	24	2·5; 5; 10; 15	1; 1000	continuous	4 in each 5; (nil at 15 Mc/s)	±5	Steps of 50 ms
LOL(1)	Buenos Aires Argentina	34° 37′ S 58° 21′ W		2	3	6	5	5; 10; 15	1; 440; 1000	4 in each 60	4 in each 5	±20	Steps of 50 ms
MSF(1)	Rugby United Kingdom	52° 22′ N 01° 11′ W	Horizontal quadrant dipoles; (vertical monopole, 2·5 Mc/s)	0·5	3	7	24	2·5; 5; 10	1	5 in each 10	nil	±0·1	Steps of 50 ms
OMA	Prague Czechoslovak S.R.	50° 07′ N 14° 35′ E	T	1	1	7	24	2·5	1; 1000	15 in each 30	4 in each 15	±1	Steps of 50 ms
RWM-RES	Moscow U.S.S.R.	56° 37′ N 36° 36′ E		20	1	7	19	5; 10; 15	1; 1000	10 in each 120(3)	5¼ hours/day(4)	±5	Multiples of 10 ms
WWV(1)	Washington D.C. U.S.A.	39° 00′ N 76° 51′ W	Vertical λ/2 dipoles; (vertical λ/4 for 2·5 Mc/s)	0·1 to 9	6	7	24	2·5; 5; 10; 15; 20; 25	1; 440; 600	continuous (5)	2 in each 5	±0·1	Steps of 50 ms
WWVH(1)	Hawaii U.S.A.	20° 46′ N 156° 28′ W	Vertical λ/2 dipoles; (vertical λ/4 for 5 Mc/s)	2	3	7	23½	5; 10; 15	1; 440; 600	continuous	3 in each 5	±1	Steps of 50 ms
WWVL(1)	Boulder U.S.A.	40° 02′ N 105° 27′ W	Top-loaded vertical	10(6)	1	7	24	0·02	nil	nil	nil	±0·05	nil
ZLFS	Lower Hutt New Zealand	41° 14′ S 174° 55′ E		0·3	1	1	3	2·5	nil	nil	nil	±50	nil
ZUO(1)	Olifantsfontein Republic of South Africa	25° 58′ S 28° 14′ E	Horizontal quadrant dipole	4	1	7	24	5	1	continuous	nil	±1	Steps of 50 ms
ZUO(1)	Johannesburg Republic of South Africa	26° 11′ S 28° 04′ E	Horizontal dipole	0·25	1	7	24	10	1	continuous	nil	±1	Steps of 50 ms

Notes to Table I

The daily transmission schedule and hourly modulation schedule is given, where appropriate, in the form of Figs. 1 and 2 supplemented by the following notes:

(1) These stations have indicated their participation in the international coordination of time and frequency. The time signals remain within about 100 ms of UT2, and the frequency is maintained as constant as possible by reference to atomic or molecular standards, and at the offset from the nominal value announced for each year by the Bureau international de l'Heure.

(2) Measured with respect to the announced offset in frequency.

(3) Time signals are radiated according to the following programme:

Minutes past odd hour	*Transmission*
45–46	Call sign
46–50	Seconds, preliminary signal
50–55	No modulation
55–60	Seconds
60–61	Call sign
61–66	Rhythmic signals, 61 per minute

The signals at 06, 08, 10 and 12 hours are transmitted by modulated carrier (A2 signals). At all other times, telegraphic (A1) signals are emitted.

RWM-RES does not operate from 0607 to 1345 UT on the first and third Wednesday of each month.

(4) From 0500 to 0807 UT on 5 Mc/s and from 0830 to 1207 UT on 15 Mc/s, excluding periods of time-signal transmissions.

(5) In addition to other timing signals and time announcements, a special timing code is radiated 10 times per hour. Consisting of 36 bit, 100 pulse/sec. binary-coded decimal code, it gives the second, minute, hour and day of year. A complete time frame lasts one second and the code is broadcast for one minute in each 5-minute period, except the first after the hour. The code contains 100 c/s, 10 c/s and 1 c/s markers, which are locked to the frequency and time-signals.

(6) Later in 1963, the new station at Fort Collins, Colorado, will radiate 1 kW.

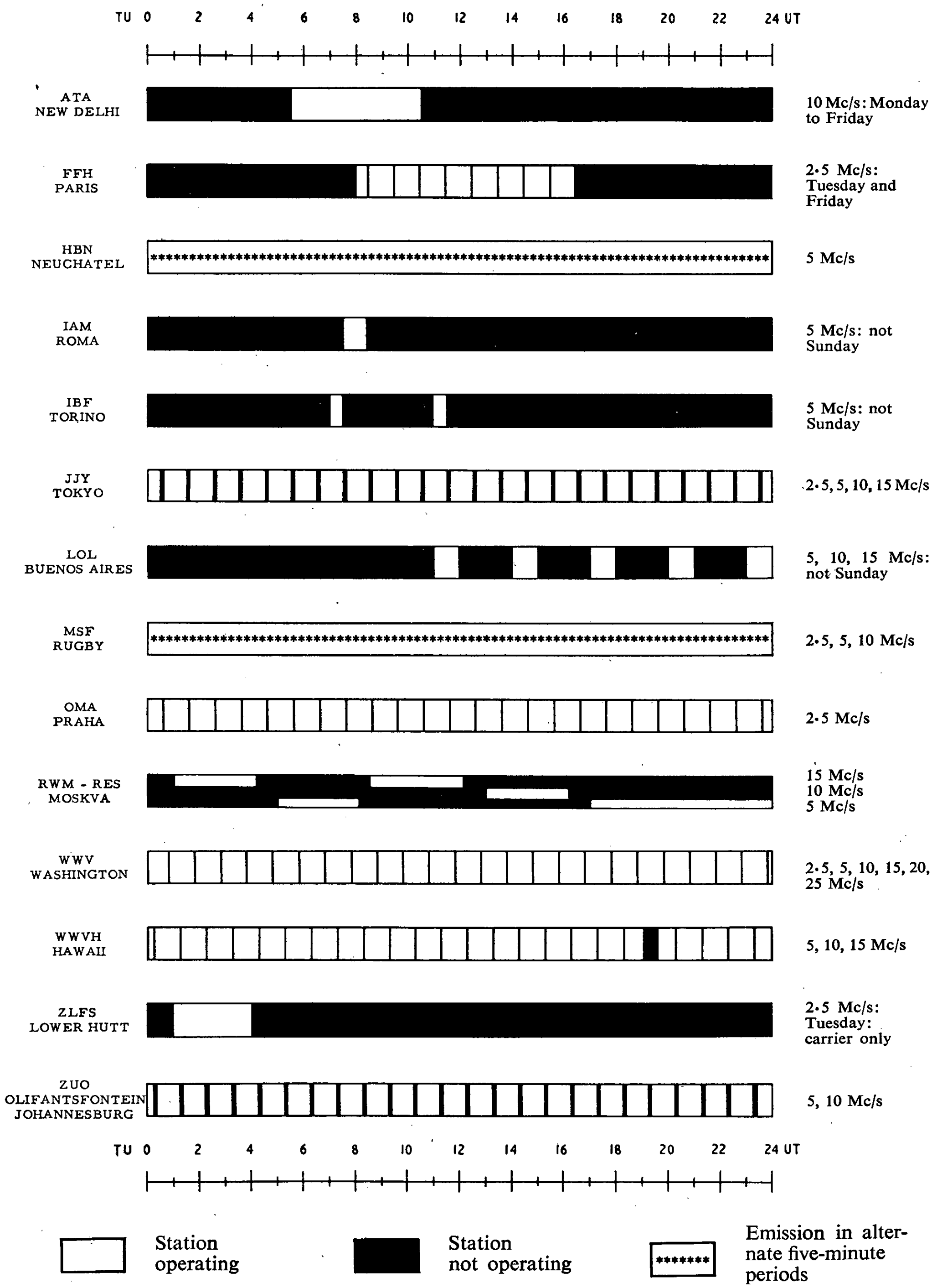
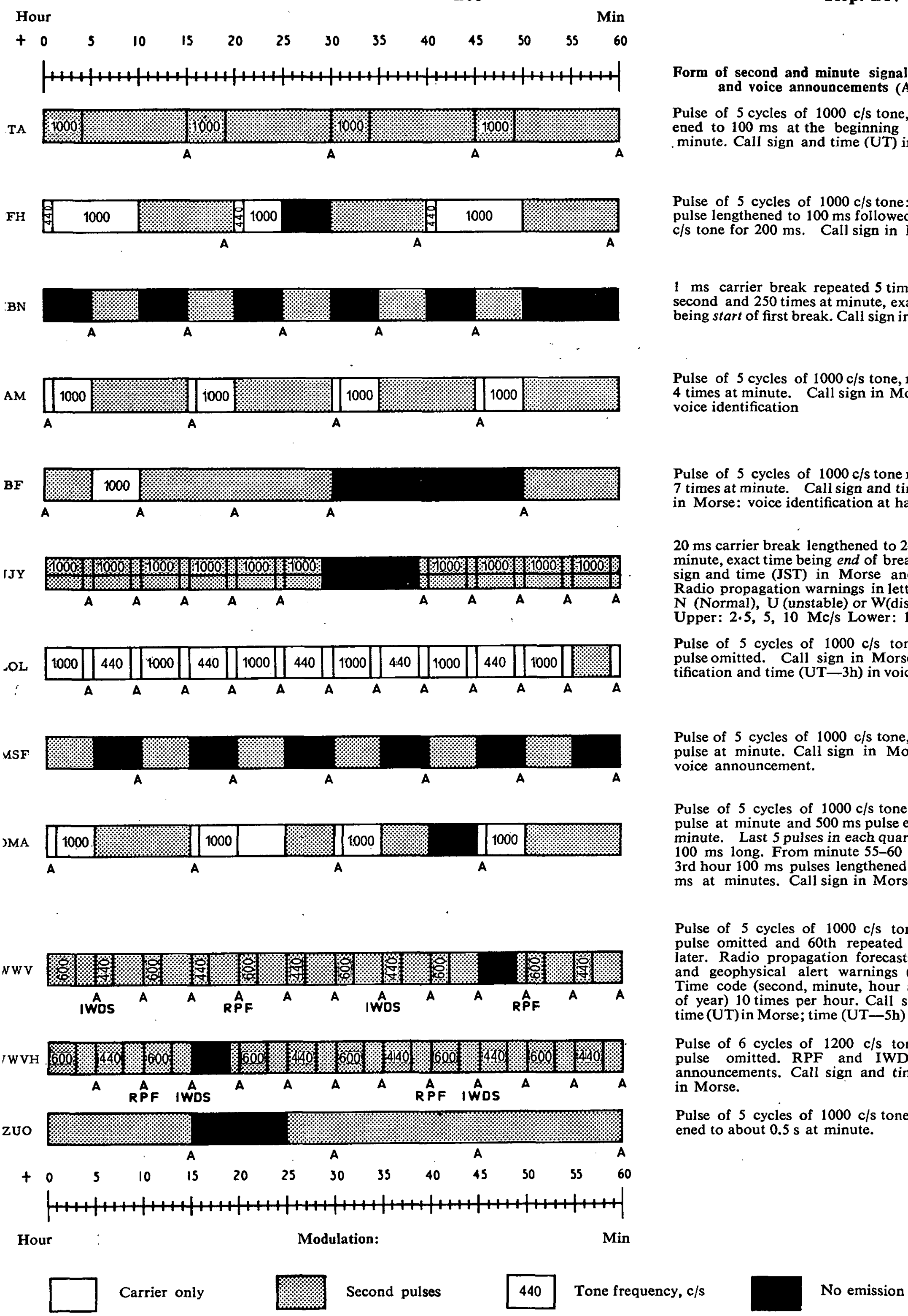


FIGURE 1

Daily emission schedule



Form of second and minute signals morse and voice announcements (A)

Pulse of 5 cycles of 1000 c/s tone, lengthened to 100 ms at the beginning of each minute. Call sign and time (UT) in Morse

Pulse of 5 cycles of 1000 c/s tone: minute pulse lengthened to 100 ms followed by 440 c/s tone for 200 ms. Call sign in Morse.

1 ms carrier break repeated 5 times every second and 250 times at minute, exact time being *start* of first break. Call sign in Morse.

Pulse of 5 cycles of 1000 c/s tone, repeated 4 times at minute. Call sign in Morse and voice identification

Pulse of 5 cycles of 1000 c/s tone repeated 7 times at minute. Call sign and time (UT) in Morse: voice identification at half-hour.

20 ms carrier break lengthened to 200 ms at minute, exact time being *end* of break. Call sign and time (JST) in Morse and voice. Radio propagation warnings in letter code: N (Normal), U (unstable) or W(disturbed). Upper: 2·5, 5, 10 Mc/s Lower: 15 Mc/s.

Pulse of 5 cycles of 1000 c/s tone, 59th pulse omitted. Call sign in Morse: identification and time (UT—3h) in voice.

Pulse of 5 cycles of 1000 c/s tone, 100 ms pulse at minute. Call sign in Morse and voice announcement.

Pulse of 5 cycles of 1000 c/s tone, 100 ms pulse at minute and 500 ms pulse every 5th minute. Last 5 pulses in each quarter hour 100 ms long. From minute 55–60 in every 3rd hour 100 ms pulses lengthened to 500 ms at minutes. Call sign in Morse.

Pulse of 5 cycles of 1000 c/s tone, 59th pulse omitted and 60th repeated 100 ms later. Radio propagation forecasts (RPF) and geophysical alert warnings (IWDS). Time code (second, minute, hour and day of year) 10 times per hour. Call sign and time (UT) in Morse; time (UT—5h) in voice.

Pulse of 6 cycles of 1200 c/s tone, 59th pulse omitted. RPF and IWDS code announcements. Call sign and time (UT) in Morse.

Pulse of 5 cycles of 1000 c/s tone, lengthened to about 0.5 s at minute.

FIGURE 2

Hourly modulation schedule

TABLE II

Characteristics of standard-frequency and time-signal emissions in additional bands, at April, 1963

Station			Antenna(e)		Number of simultaneous transmissions	Period of operation		Standard-frequencies used		Duration of emission		Accuracy of frequency and time intervals(2) (parts in 10⁹)	Method of adjustment of time-signal
Call sign	Approximate location	Latitude Longitude	Type	Carrier power (kW)		Days/week	Hours/day	Carrier (kc/s)	Modulation (c/s)	Time-signal (min)	Audio-modulation (min)		
CHU(1)	Ottawa Canada	45° 18′ N 75° 45′ W	Folded dipoles and rhombic	0·3; 3; 5	3	7	24	3330; 7335; 14 670	1(5)	continuous	nil	±5	Steps of 50 ms
DCF77	Mainflingen F.R. of Germany	50° 01′ N 09° 00′ E	Omni-directional	12	1	6(6)	6(7)	77·5	1; 200; 440	(8)	(9)	(10)	Steps of 50 ms
	Droitwich United Kingdom	52° 16′ N 02° 09′ W	T	150	1	7	18–20	200	nil	nil	A3 broadcast continuously	±10	nil
GBR(1)	Rugby United Kingdom	52° 22′ N 01° 11′ W	Omni-directional	300 40(3)	1	7	22(11)	16	1(12)	4×5(13) per day	nil	±0·1	Steps of 50 ms
MSF(1)	Rugby United Kingdom	52° 22′ N 01° 11′ W	Omni-directional	10	1	7	1(14)	60	1(15)	5 in each 10	nil	±0·1	Steps of 50 ms
Loran-C	Carolina Beach N.C. U.S.A.	34° 04′ N 77° 55′ W	Omni-directional	300	1	7	24	100	20(16)	continuous	nil	±0·05	Steps of 50 ms
NAA(1)	Cutler, Maine, U.S.A.	44° 39′ N 67° 17′ W	Omni-directional	2000 1000(3)	1	7	24	14·7	nil	nil	nil	±0·05	nil
NBA(1)	Balboa Panama Canal Zone, U.S.A.	09° 04′ N 79° 39′ W	Omni-directional	300 30(3)	1	7	24(17)	18	1(12)	continuous	nil	±0·05	Steps of 50 ms
NPG/NLK (1)	Jim Creek Washington U.S.A.	48° 12′ N 121° 55′ W	Omni-directional	1200 250(3)	1	7	24	18·6	nil	nil	nil	±0·05	nil
NPM(1)	Lualualei Hawaii, U.S.A.	21° 25′ N 158° 09′ W	Omni-directional	1000 100(3)	1	7	24(18)	19·8	nil	nil	nil	±0·05	nil
NSS(1)	Annapolis Maryland U.S.A.	38° 59′ N 76° 27′ W	Omni-directional	1000 100(3)	1	7	24	22·3	nil	nil	nil	±0·05	nil
OMA	Podebrady CzechoslovakSR	50° 08′ N 15° 08′ E	T	5	1	7	24	50	1(12)	23 hours per day(19)	nil	±1	Steps of 50 ms
RWM-RES	Moscow U.S.S.R.	55° 45′ N 37° 33′ E		20	1	7	21(20)	100	1	40 in each 120	nil	±5	Multiples of 10 ms
SAZ	Enköping Sweden	59° 35′ N 17° 08′ E	Yagi (12 db)	0·1 (ERP)	1	7	24	100 000	nil	nil	nil	±5	nil
SAJ	Stockholm Sweden	59° 20′ N 18° 03′ E	Omni-directional	0·06 (ERP)	1	1(21)	2(22)	150 000	nil	nil	10(23)	±1	nil
WWVB(1)	Boulder U.S.A.	39° 59′ N 105° 16′ W	Omni-directional	2; 0·002 (4)	1	7	23(24)	60	nil	nil	nil	±0·05	nil
ZUO	Johannesburg Republic of South Africa	26° 11′ S 28° 04′ E	Omni-directional	0·05	1	7	24	100 000	1; 100 000	continuous	nil	±1	Steps of 50 ms

Notes to Table II

(1) These stations have indicated their participation in the international coordination of time and frequency. The time-signals remain within about 100 ms of UT2, and the frequency is maintained as constant as possible by reference to atomic or molecular standards, and at the offset from the nominal value announced each year by the Bureau international de l'Heure.

(2) Measured with respect to the announced offset in frequency.

(3) Figures give the estimated *radiated* power.

(4) Later in 1963, the new station at Fort Collins, Colorado, will radiate 7 kW.

(5) Pulses of 200 cycles of 1000 c/s tone: the first pulse in each minute is prolonged.

(6) Monday to Saturday.

(7) Transmission extends essentially from 0645 to 1035 and 1900 to 0010 UT (1 November – 28 February) and from 1900 to 0210 UT (1 March – 31 October).

(8) International type A1 telegraphy time-signals from the Deutsche Hydrographische Institut from 0700 to 0710, 1000 to 1010, 1900 to 1910, 1930 to 1940, 2000 to 2010 UT and during the minutes 00 to 10 of each hour until the end of transmission (see (7)).

A1 telegraphy time-signals (carrier with second-pulses) from the Physikalisch-Technische Bundesanstalt from 0728 to 0735, 1028 to 1035, 1911 to 1929, 1941 to 1959 UT and during the minutes 57 to 59 of each hour until the end of the transmission (see (7)).

Carrier with pulses every 2 minutes from the Physikalisch-Technische Bundesanstalt from 0645 to 0659 and 0736 to 0959 UT.

(9) Carrier modulated with 440 c/s tone from 0711 to 0727 and with 200 c/s tone from 1011 to 1027 UT.

(10) The frequency of the controlling oscillator varies by some parts in 10^{10} and increasing slowly at the rate of about 1 part in 10^9 in one month.

(11) Maintenance period from 1300 to 1430 UT each day.

(12) A1 telegraphy signals.

(13) From 0255 to 0300, 0855 to 0900, 1455 to 1500 and 2055 to 2100 UT.

(14) From 1430 to 1530 UT.

(15) Pulses of 5 cycles of 1000 c/s tone: first pulse in each minute lengthened to 100 ms.

(16) Time pulses occur in groups of 8, one millisecond apart; 20 groups per second.

(17) Except from 1300 to 2100 UT on Wednesday.

(18) Except from 1800 to 2300 UT on Wednesday.

(19) From 1000 to 1100 UT, transmission without keying except for call-sign OMA at the beginning of each quarter-hour.

(20) Transmission is interrupted from 0007 to 0100, 1207 to 1300 and 1607 to 1700 UT each day and from 0607 to 1345 UT on the first and third Wednesday of each month.

(21) Each Friday.

(22) From 0930 to 1130 UT.

(23) 5 minutes at the beginning and 5 minutes at the end of the transmission for identification purposes only.

(24) Interruption from 1430 to 1530 UT.

REPORT 268 *

STABILIZED FREQUENCY EMISSIONS AND MONITORING FACILITIES IN BANDS 4 AND 5

(Recommendation 375 and Question 249 (VII))

(Geneva, 1963)

1. Introduction

The following Tables provide information for those interested in the measurement of the received phase of frequency-stabilized emissions in bands 4 and 5, with respect to local frequency standards.

Table I lists frequency-stabilized transmissions, with some operating characteristics. Table II lists laboratories measuring the received phase of emissions with respect to local frequency standards.

2. Description of methods

2.1 *Beat frequency recording*

The incoming carrier is mixed with a locally generated signal of the same nominal frequency. The beat frequency of the resultant, represents the relative phase shift of the received signal with respect to the local standard.

2.2 *Photographs of oscillograms*

The incoming carrier modulates the beam intensity of an oscilloscope, whose linear sweep is triggered by a signal derived from the local frequency standard. With proper amplitude adjustments, an incoming signal would produce alternate dashes and spaces of equal length, if noise were not present. The relative lateral motion of the dashes represents a phase shift of the received carrier with respect to the local standard and is recorded on an oscilloscope camera with the motion of the film at 90° to the oscilloscope sweep.

2.3 *Servo*

A servo system is used to bring a locally generated signal of the same nominal frequency into a constant phase relationship with respect to the received carrier. The relative phase shift of the received carrier, with respect to the local standard, is represented by the angular rotation of the phase shifter shaft, which is usually recorded on a mechanical counter and a chart recorder.

For further information on different methods of phase comparisons, reference is made to Doc. VII/5 of Geneva, 1962.

* This Report was adopted unanimously.

TABLE I

Stabilized carrier emissions in bands 4 and 5

Station call sign and approximate location	Carrier frequency (kc/s)	Carrier power (kW)		Transmission schedule		Frequency accuracy (parts in 10^9)
		to antenna	radiated	days/week	hours/day	
DCF77 Mainflingen, F.R. of Germany	77·5	12		6	10	±0·5
CYZ40 Ottawa, Canada	80			7	24	—
GBR Rugby, United Kingdom	16	300	40	7	22	±0·5
MSF Rugby, United Kingdom	60	10		7	1	±0·5
JG2AR Tokyo, Japan	20	3		5	2	±5
NAA Cutler, Maine, U.S.A.	14·7	2000	1000	7	24	±0·05
NBA Balboa, Canal Zone, U.S.A.	18	300	30	7	24	±0·05
NPG/NLK Jim Creek, Washington, U.S.A.	18·6	1200	250	7	24	±0·05
NPM Lualualei, Hawaii, U.S.A.	19·8	1000	100	7	24	±0·05
NSS Annapolis, Maryland, U.S.A.	22·3	1000	100	7	24	±0·05
OMA Podebrady, Czechoslovak S.R.	50	5		7	24	±1
RWM–RES Moscow, U.S.S.R.	100	20		7	21	±5
WWVB Boulder, Colorado, U.S.A.	60	50	7	7	23	±0·05
WWVL Boulder, Colorado, U.S.A.	20	50	1	7	24	±0·05

TABLE II

Laboratories measuring the received phase of emissions in bands 4 and 5

Address	Stations monitored	Method
Australia		
C.S.I.R.O. National Standards Laboratory, Sydney, New South Wales	GBR, NBA	Servo
Mount Stromlo Observatory, Canberra, Australian Capital Territory	GBR	Beat frequency recording
P.M.G. Research Laboratories, Melbourne, Victoria	GBR, NPM	Servo
Weapons Research Establishment, Salisbury, South Australia	GBR, NBA	Beat frequency recording
Belgium		
Free University of Brussels, Brussels	GBR, NAA	Oscilloscope photography
Canada		
National Research Council, Physics Department, Ottawa	CYZ 40, GBR MSF, NBA	Beat frequency recording (Atomic frequency standard)
France		
C.N.E.T., 196, rue de Paris Bagneux (Seine)	GBR, NAA, NBA NPM, NPG/NLK, NSS	Servo (atomic frequency standard)
India		
National Physical Laboratory, New Delhi		
Italy		
Istituto Superiore P. & T., Viale Trastevere, Roma	GBR	Oscilloscope
« Istituto Elettrotecnico Nazionale » Corso M. D'Azeglio, 42, Torino	GBR, NBA	Servo
Japan		
Tokyo Astronomical Observatory, Mitaka, Tokyo	GBR, NBA	Beat frequency recording
Radio Research Laboratories, Koganei, Tokyo	NPM	Servo (atomic frequency standard)
New Zealand		
Dominion Physical Laboratory, Lower Hutt	GBR	Beat frequency recording
F.R. of Germany		
Fernmeldetechnisches Zentralamt, Darmstadt	DCF 77, MSF, NAA, NBA	Beat frequency recording
Physikalisch-Technische-Bundesanstalt Braunschweig	DCF 77, GBR, NBA	Beat frequency recording (atomic frequency standard)

Address	Stations monitored	Method
Sweden		
Research Institute of National Defense, Stockholm	GBR, NBA, NPM	Servo (atomic frequency standard)
Switzerland		
Observatoire Cantonal, Neuchâtel	GBR, NAA, NBA, NSS	Oscilloscope photography (atomic frequency standard)
Republic of South Africa		
Union Observatory, Johannesburg		
United Kingdom		
National Physical Laboratory, Teddington	GBR, MSF, NBA	Beat frequency recording and servo (atomic frequency standard)
Post Office Research Station, Dollis Hill, London	NBA	Servo (atomic frequency standard)
Royal Greenwich Observatory, Herstmonceux	GBR, NBA	Servo
United States of America		
Harvard University, Cambridge, Massachusetts	GBR, NBA and others	Oscilloscope photography (atomic frequency standard)
U.S. National Bureau of Standards, Boulder, Colorado	GBR, MSF, NBA, WWVB, WWVL	Servo (atomic frequency standard)
U.S. Naval Observatory, Washington, D.C.	GBR, NAA, NBA, NPG/NLK, NPM, NSS	Servo (atomic frequency standard)
U.S. Naval Observatory Sub-Station, Richmond, Florida	GBR, NAA, NBA NPG/NLK, NPM, NSS	Servo (atomic frequency standard)
U.S. Naval Research Laboratories, Anacostia, Maryland, Code 5424	GBR, NAA, NBA NPG/NLK, NPM, NSS	Servo (atomic frequency standard)

REPORT 269 *

REDUCTION OF MUTUAL INTERFERENCE BETWEEN STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS

(Question 140(VII))

(Geneva, 1963)

The degree of mutual interference between standard-frequency and time-signal emissions continues to impair the value of the services on the allocated frequencies. In recent years, the participation of an increasing number of stations in the international system of time and frequency coordination, while it is to be welcomed, has raised difficulties in identifying and using synchronized signals from several stations in a geographically small area, where the times of arrival of the signals are separated by only one or two milliseconds. The situation in Western Europe, where these conditions exist, has been simplified by the decision of HBN and MSF to coordinate their respective emission schedules. A programme of time-sharing has been agreed, each station emitting time-signals in alternate 5-minute periods, the last 5-minute period in each hour being left free for the reception of the time-signal emissions of RWM-RES (5 Mc/s). It would be advantageous if OMA (2·5 Mc/s) could also bring its modulation programme into accord with the new MSF schedule; a unified standard-frequency and time-signal service would thus be secured over a large area of Western Europe.

The presence of continuous tone modulation on a number of emissions constitutes a prolific source of interference with time-signal reception. By its nature, the tone modulation is limited essentially to applications requiring only low accuracy and it seems very desirable to restrict the extent of such modulation. HBN and MSF have already eliminated all periods of tone modulation from their schedules. IAM (5 Mc/s) has reduced the number of audio-frequencies used from three to one (1000 c/s) and the total period of modulation from 40 to 16 minutes per hour. IBF (5 Mc/s) also intends to suppress all but 1000 c/s modulation and this will be limited to 5 minutes per hour. The periods of tone modulation on FFH (2·5 Mc/s) will also be modified or reduced, if this will contribute to a reduction of mutual interference on this frequency.

Other approaches to the problem of the coexistence of several standard-frequency stations are being made. Thus WWV, in addition to reducing progressively the time devoted to tone modulation has also, for the past three years, introduced a gap of 40 ms in the continuous modulation in which the time-signals have been inserted. This technique has also been investigated in Japan by means of special emissions using JJY (10 Mc/s), the length of the gap being increased to 85 ms to permit reception of the time-signals from any other synchronized station free of interference from the tone modulation [1]. This system allows the simultaneous emission of both tone and pulse modulation without serious detriment to either, but it also requires the use of rather more complex equipment at the receiving station if the time information is to be extracted satisfactorily.

An alternative to time-sharing is frequency-sharing, and Study Programme 140B(VII) calls for examination of the possibilities of single-sideband operation of standard-frequency transmitters. This mode of operation is in use for a number of the WWV frequencies and also by IAM (5 Mc/s) and offers the possibility of reducing interference between two stations by using,

* This Report was adopted unanimously.

respectively, the upper and lower sidebands. Again it is apparent, that such a scheme would demand more advanced receiving equipment for best results.

The Xth Plenary Assembly, C.C.I.R., afforded an opportunity for an exchange of views between Administrations, but it should be emphasized that bi-lateral or multi-lateral negotiations between organizations operating standard-frequency services may lead to a more direct solution of the interference problems in restricted regions. If the Chairman and Vice-Chairman of C.C.I.R. Study Group VII, the Director, C.C.I.R. and the I.F.R.B. are kept informed of such negotiations, it will enable them to assist and expedite the work of reducing interference.

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1. C.C.I.R. Doc. 147 of Geneva, 1963.

REPORT 270 *

FREQUENCY SPECTRUM CONSERVATION FOR HIGH PRECISION TIME-SIGNALS

(Study Programme 250A(VII))

(Geneva, 1963)

There is a need for increasingly greater precision in the distribution of time-signals. The bandwidth occupied by a system of distribution can be expected to increase to the allowable maximum by factors such as the width of the allocated band, by limitations imposed by the transmission medium and considerations of noise and interference.

An example of a system, developed to exploit to the full the properties of the transmission medium, is the navigational system known as Loran-C operating at 100 kc/s. This system has been demonstrated to be capable of high precision for the distribution of time information. The pulse in this system is chosen to be sufficiently brief in duration that, at ranges exceeding 2000 km, its arrival can be detected before the arrival of the first ionospheric wave returned from the D-layer. The relative delay was found by measurement to be 25 to 30 μs. This leads to a pulse having an equivalent bandwidth of 20 kc/s.

At high frequencies, where long-distance propagation is wholly dependent upon ionospheric propagation, the precision with which time-signals can be received is limited by the characteristics of the propagation medium. The bandwidths in use have been determined largely by administrative decision rather than by the physics of the problem. The waveform at present in use for standard-frequency broadcasts is considered in Doc. VII/10 of Geneva, 1962 [1], where a Fourier analysis is performed and examined. Similar work on other waveforms seems desirable. It would also seem desirable to extend the study to include the effects of noise and propagation. Certain aspects of propagation in band 10 are considered in Report 271. Although this Report has an application limited mainly to long-distance transmission in bands 6 and 7, the analysis of waveform and of propagation effects are of considerable general interest. Here again noise is likely to be an important factor and the study merits the inclusion of considerations of non-Gaussian noise.

Doc. VII/11 of Geneva, 1962 [2], contains information about the effects of propagation upon frequency measurements over long-distances. This and similar data are useful for the building-up of information for the evaluation of propagation conditions on time-signal accuracy.

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* This Report was adopted unanimously.

It is considered important that further work should be based on Study Programme 250A(VII). Doc. VII/4 of Geneva, 1962 [3], refers briefly to proposed experiments and it is most desirable that, as soon as possible, the experimental emission of alternative forms of time-signal should be made. Administrations should be requested to cooperate in the proposed experiment which will study the characteristics of, for example, the " sine-squared pulse ", which appears to be capable of best time identification for a given bandwidth.

It is considered also that experiments of the kind referred to in Reference [3] should be supplemented by laboratory experiments employing a multipath-propagation simulator, so that systematic comparisons may be made of different signals under various conditions of propagation and noise.

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2. C.C.I.R. Doc. VII/11 (Japan) of Geneva, 1962. Studies of the variation in HF standard-frequencies as received.
3. C.C.I.R. Doc. VII/4 (U.R.S.I.) of Geneva, 1962. Frequency spectrum conservation for high-precision time-signals.

REPORT 271 *

A CAUSE OF REDUCED STABILITY AND ACCURACY IN STANDARD-FREQUENCY AND TIME-SIGNALS AS RECEIVED

(Study Programme 250B(VII))

(Geneva, 1963)

It has been shown that the stability of standard-frequency signals may be adequately described in terms of the frequency spectrum of the fluctuation $\Delta f = f_0 - f_s$ of the instantaneous observed frequency f_0 about its mean value f_s. The fluctuation Δf of the instantaneous frequency may be considered to be a random continuous function of the time and this random function will have somewhat the same appearance, when plotted on graph paper, as the envelope of a random noise voltage as received at the output of a narrow band filter. Thus, there will be present a continuous spectrum of fluctuation components having periods ranging from zero up to the period of time T over which the observations are made.

It is shown in [1], that the spectrum of the fluctuations of a standard-frequency, observed after propagation over a line-of-sight micro-wave link, may be divided into two additive components. One of these components is associated with the signal prior to its emission over the link, while the second component represents the additional fluctuations which are added to those present at the source as a result of propagation through the turbulent propagation medium. The first part of [1] deals with the component of the spectrum associated with the propagation, while the second part of the report contains a brief discussion of the fluctuation spectrum of some of the more stable oscillators presently available in the United States. One of the important conclusions is that oscillator instability is an order of magnitude larger than the propagation instability and this represents, at the present state of the art, the controlling influence on the

* This Report was adopted unanimously.

stability of signals propagated over line-of-sight microwave links. This is in marked contrast to the stability of signals propagated via the ionosphere. Thus, it is known that ionospherically propagated signals have an instability spectrum which is at least comparable to and possibly substantially larger than that of the best currently available oscillators.

The fractional standard error of the average frequency of a good oscillator varies from 8×10^{-11} to 2×10^{-12}, as the averaging time is varied from zero to 10^6 s and, for still longer averaging times, varies inversely as the square root of T. The contribution to this instability by a 50 km line-of-sight path in Florida can be represented by a fractional standard error which varies from about 3×10^{-12} to 1×10^{-14}, as the averaging time is varied from zero to 10^6 s and, for still longer averaging times, varies inversely with T.

Article [1] also discusses the inaccuracy of time intervals which are measured by counting the number of cycles of an oscillator having a known mean frequency f_s. The standard error σ_{Tes} of a time interval T measured by counting the cycles of a good oscillator with a mean frequency $f_s = 50$ Mc/s varies from about 1×10^{-8} to 2×10^{-6} s, as the time interval T is increased from zero to 10^6 s and thereafter increases as the square root of T. The contribution to this standard error by a 50 km line-of-sight path in Florida for a mean frequency $f_s = 9$ Gc/s varies from 6×10^{-11} to 1×10^{-8} s, as the time interval T varies from zero to 10^6 s and thereafter is independent of T.

Article [1] shows that the asymptotic behaviour of the standard error σ_{Tes} of a time interval T, as T is allowed to increase without limit, depends upon the behaviour of the spectum of the oscillators at very low fluctuation frequencies and, since little is actually known about this spectrum at these very low fluctuation frequencies, the results for σ_{Tes} given for large values of T are based merely on extrapolations of the measured behaviour of the spectrum at higher fluctuation frequencies.

In addition to providing the above information on the effects of the troposphere on the stability of standard-frequency signals transmitted through it, the analysis in this Report provides an interesting confirmation of the Obukhov-Kholmogorov theory relative to the frequency spectrum of atmospheric turbulence.

Bibliography

1. Norton, K.A., Barrows, E., Thompson, M.C., Jr. and Janes, H.B. Variance of radio frequency caused by atmospheric turbulence in line-of-sight transmissions. *Trans. IRE, PGI* (December 1962).

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STUDY GROUP VII

(Standard-frequencies and time-signals)

Terms of reference :

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

Chairman : Mr. B. DECAUX (France)
Vice-Chairman : Professor M. BOELLA (Italy)

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP VII

One cannot really say that any of the problems under study by Study Group VII have been " liquidated ". The field of activity of this Study Group is continually widening and from one Plenary Assembly to another, the various problems receive partial but progressively better solutions; moreover, new solutions appear, which must in their turn be studied. Report 267 gives a general impression of the work of Study Group VII.

The main problems under study are:

1. **Increase in accuracy** of measurements made on standard-frequency emissions. This appears in different guises:

1.1 Recommendation 374 has tightened the tolerances on the frequency emitted from $\pm 5\times10^{-9}$ to $\pm 5\times10^{-10}$.

1.2 The same Recommendation lays down, in accordance with an U.R.S.I. resolution, that the Bureau international de l'Heure should fix, for each year, the offset between the emitted frequency and the nominal frequency, so that time-signals, derived from the emitted frequency, should follow approximately Universal Time.

1.3 Definition and increase in stability of standard-frequency generators are the subject of Study Programme 250A(VII) and Report 271.

1.4 The use of frequencies much lower or much higher that those of the former emissions should allow interference due to propagation to be avoided (Question 249(VII) and Recommendation 375).

1.5 New methods for the emission of time-signals are likely to increase accuracy. This is so when signals of special shape are used (Question 250(VII) and Report 270), or artificial satellites (Study Programme 249A(VII).

2. **Reduction of interference,** harmful to the standard-frequency service. This interference is of two types:

2.1 Mutual interference between stations of the service operating at the same frequency. Study Programme 140A(VII) and Report 269 propose remedies, in particular by time-sharing between the transmitters. Study Programme 140B(VII) forsees the use of single-sideband emissions, with the same object in view.

2.2 Interference caused by stations outside the standard-frequency service. Recommendation 376 stresses yet again the urgency with which Administrations should free the standard-frequency bands.

3. **Tables of characteristics of emissions** are given in Reports 267 and 268. The later, specially concerned with emissions in bands 4 and 5, also gives a list of laboratories which make regular measurements of these emissions.

RESOLUTION 14

STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS

(Question 140(VII))

The C.C.I.R., (Geneva, 1963)

CONSIDERING

the provisions of Art. 44, Section IV, of the Radio Regulations, Geneva, 1959;

UNANIMOUSLY DECIDES

1. that, whenever an assignment to a station operating standard-frequency emissions is put into service, the Administration concerned shall notify this assignment to the I.F.R.B., in accordance with the provisions of Art. 9 of the Radio Regulations, Geneva, 1959; however, no notice should be submitted to the I.F.R.B. until experimental investigations and co-ordination have been completed, in accordance with Art. 44, Section IV, of the Radio Regulations;
2. that each Administration should send all pertinent information on standard-frequency stations (such as frequency offset, changes in the phase of time pulses, changes in transmission schedule, etc.), to the Chairman of Study Group VII for forwarding, via the Director, C.C.I.R. to the I.T.U. for official publication;
3. that cooperation of Study VII should continue with the I.A.U. (Committee 31), the U.R.S.I. and the B.I.H.

QUESTION 140(VII) *

STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS

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

CONSIDERING

(a) that the Administrative Radio Conference, Geneva, 1959, called for the study of the establishment and operation of a world-wide standard-frequency and time-signal service;

* This Question replaces Question 87.

(b) that a number of stations are now regularly emitting standard-frequencies and time-signals in the bands allocated by this 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 diminish the utility of the service by producing harmful interference;

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 this 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 140A(VII) *

STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS

(Geneva, 1951 – London, 1953 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that Question 140(VII) and Recommendation 374 call for information on methods for improving the usefulness of the existing standard-frequency and time-signal service;

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

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

UNANIMOUSLY DECIDES that the following studies should be carried out:

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

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

1.2 use of a modulation which gives the required information and accuracy with minimum bandwidth;

1.3 staggering the emissions in the allocated bands and using a convenient type of modulation;

1.4 a convenient coordinated time-sharing of frequencies for those areas where there is mutual interference;

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

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

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* This Study Programme replaces Study Programme 155.

STUDY PROGRAMME 140B(VII)

SINGLE-SIDEBAND OPERATION FOR THE STANDARD-FREQUENCY AND TIME-SIGNAL SERVICE

The C.C.I.R., (Geneva, 1963

CONSIDERING

(a) that No. 465 of the Radio Regulations, Geneva, 1959, urges Administrations to discontinue the use of double-sideband radiotelephone transmissions in the fixed service, in the bands below 30 Mc/s;

(b) that an I.T.U. Panel of Experts, in September, 1961, listed technical and economic advantages of single-sideband systems and urged Administrations to accelerate the conversion of their double-sideband radiotelephone systems, in the bands below 30 Mc/s, to single-sideband systems and to complete such conversions by 1967 or earlier if possible;

UNANIMOUSLY DECIDES that the following studies should be carried out:

what improvements may be obtained in the distribution and use of standard-frequency and time-signal emissions by the use of single-sideband operation, particularly in the bands at 2·5; 5; 10; 15; 20 and 25 Mc/s?

QUESTION 249(VII) *

STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS IN ADDITIONAL FREQUENCY BANDS

The C.C.I.R., (Warsaw, 1956 – Geneva, 1963)

CONSIDERING

(a) 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 service;

(b) that the bands allocated for standard-frequency and time-signal emissions are more useful for long-distance distribution than for local distribution;

(c) that a better service is needed in certain areas and this service may be given by use of frequencies in band 8 and higher;

(d) that high accuracy frequency and time comparisons between distribution centres can be made using frequencies in bands 4 and 5;

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 approximately 100 kc/s?

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* This Question replaces Question 142.

STUDY PROGRAMME 249A(VII)

STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS FROM ARTIFICIAL EARTH SATELLITES

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that continuing advances in communications, particularly in space communications and associated science and technology, have increased the requirements for accuracy and service range of standard-frequency and time-signal emissions;

(b) that the work of Study Group IV describes radiocommunication systems making use of earth satellites which can be expected to give extensive coverage and good stability of signals over the earth's surface;

UNANIMOUSLY DECIDES that the following studies should be carried out:

what are the technical factors to consider in recommending frequencies and in determining the transmitting, modulating and receiving techniques, which are important to the development of standard-frequency and time-signal emissions from artificial earth satellites?

QUESTION 250(VII) *

STABILITY OF STANDARD-FREQUENCY AND TIME-SIGNAL EMISSIONS AS RECEIVED

The C.C.I.R., (Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that the standard-frequency and time-signal emissions as received are less stable than at the source, owing to phenomena occurring in the propagation of radio waves, e. g. the Doppler effect, diurnal variation and multipath interference;

(b) that errors, which occur during propagation, depend on the geographical location of both the transmitter and receiver, as well as on the nature and condition of the medium, and are generally different in different regions of the radio spectrum;

(c) that special techniques of standard-frequency and time-signal emissions may improve the accuracy with which they can be received;

(d) that the accuracy with which standard-frequency and time-signal emissions can be received may depend upon the design of the receiving equipment;

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;

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* This Question replaces Question 186.

3. what are the most suitable techniques for transmitting and receiving standard-frequencies and time-signals to obtain the best results in the reception of:
   - standard-frequencies and time-signals as used by those requiring moderate accuracy;
   - standard-frequencies and time-signals as used by those requiring the maximum possible accuracy?

STUDY PROGRAMME 250A(VII) *

FREQUENCY SPECTRUM CONSERVATION FOR HIGH PRECISION TIME-SIGNALS

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

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

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

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. an investigation of the relationship between bandwidths required, and precisions obtainable at present for various carrier-to-noise ratios as may be encountered in practice;
2. an investigation of narrow band techniques to generate and broadcast high precision time markers;
3. an investigation of the characteristics of the radio paths involved that limit the accuracy of time-signals as received, and how these radio-path parameters affect the choice of an optimum method.

STUDY PROGRAMME 250B(VII)

INSTABILITY OF STANDARD-FREQUENCY GENERATORS

The C.C.I.R., (Geneva, 1963)

CONSIDERING

that the employment of high quality frequency standards in a wide range of applications has given rise to a need to specify, in convenient and precise terms, the various forms of frequency instability which limit performance in relation to the increasingly stringent requirements;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. how may the various forms of frequency instability, inherent in a standard-frequency generator, be qualitatively described;
2. how may the limitations of precision, imposed by various forms of frequency instability in a standard-frequency generator, be quantitatively expressed?

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* This Study Programme was previously designated Study Programme 156(VII).

QUESTION 251(VII)

STANDARDIZATION OF TIMING CODES

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that continuing advances in communications and electronic technology have shown a need for the further development of methods of emission, distribution and recording of time;

(b) that timing codes are being used by observatories, monitoring and tracking stations located in various countries all over the world;

UNANIMOUSLY DECIDES that the following questions should be studied:

1. how can coded time-signals be distributed by radio emissions from earth or from space;
2. what standard format should be used for timing codes?

LIST OF DOCUMENTS OF THE Xth PLENARY ASSEMBLY CONCERNING STUDY GROUP VII

Doc.	Origin	Title	Reference	Other Study Groups concerned
7	Chairman, Study Group VII	Report by Chairman of Study Group VII (Mr. B. Decaux)	—	—
21	I.F.R.B.	Proposed amendment to Draft Recommendation – Standard-frequency transmissions and time-signals	—	—
129	C.C.I.R. Secretariat	Bibliographic references in the volumes of the C.C.I.R.	—	I–XIV
147	Japan	Studies on a time schedule of audio modulation on standard-frequency and time-signal transmissions	S.P. 155	—
260	U.S.S.R.	Data on standard-frequency and time-signal transmissions for inclusion in the Draft Report in Annex 7/11	Rep. 166	—
263	Czechoslovak S.R.	Comments on Docs. VII/39 and VII/56	Q. 140 S.P. 155 Rep. 166	—
273	I.F.R.B.	Results of the special monitoring programme for October, 1962 in the exclusive standard-frequency service bands, and action being taken by the I.F.R.B. in attempting to clear these bands of out-of-band transmissions	IFRB Circ. No. 51	—
284	Study Group VII	Summary record of the first meeting	—	—
379	Study Group VII	Summary record of the second meeting	—	—
403	Study Group VII (Italy)	Compatibility of European standard transmissions on 5 Mc/s	—	—
404	Study Group VII	Single-sideband operation for the standard-frequency and time-signal service	Draft S.P.	—
411	Study Group VII	Standard-frequency transmissions and time signals	Draft Res.	—
465	Study Group VII	Stabilized frequency transmissions and monitoring facilities in bands 4 and 5	Draft Rep.	—
466	Study Group VII	Revised Tables I and II of Report 166	Rep. 166	—
467	Study Group VII	Reduction of mutual interference between standard-frequency and time-signal transmissions	Draft Rep.	—
474	Study Group VII	Standard frequencies and time-signals	Draft Rep.	—
556	Study Group VII	Summary record of the third and last meeting	—	—
2088	Drafting Committee	Standard-frequency and time-signal transmissions in additional frequency bands	Rec. 375	—
2089	" "	Avoidance of external interference with transmissions of the standard-frequency service in the bands allocated to that service	Rec. 376	—
2090	" "	Standard-frequency and time-signal transmissions in additional frequency bands	Q. 249	—
2091	" "	Stability of standard-frequency and time-signal transmissions as received	Q. 250	—
2092	" "	Timing code standardization	Q. 251	—

Doc.	Origin	Title	Reference	Other Study Groups concerned
2093	Drafting Committee	Standard-frequency and time-signal transmissions	S.P. 140A	—
2094	” ”	Instability of standard-frequency standards generators	S.P. 250B	—
2095	” ”	Standard-frequency and time-signal transmissions from artificial earth satellites	S.P. 249A	—
2096	” ”	Frequency spectrum conservation for high precision time-signals	Rep. 270	—
2107	” ”	A cause of reduced stability and accuracy in standard-frequency and time-signals as received	Rep. 271	—
2186	” ”	Single-sideband operation for the standard-frequency and time-signal service	S.P. 140B	—
2187	” ”	Standard-frequency and time-signal transmissions	Res. 14	—
2188	” ”	Standard-frequency and time-signal transmissions	Rec. 374	—
2262	” ”	Stabilized frequency transmissions and monitoring facilities in bands 4 and 5	Rep. 268	—
2263	” ”	Reduction of mutual interference between standard-frequency and time-signal transmissions	Rep. 269	—
2264	” ”	Standard-frequencies and time-signals	Rep. 267	—

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RECOMMENDATIONS OF SECTION J: MONITORING OF EMISSIONS

RECOMMENDATION 182

AUTOMATIC MONITORING OF OCCUPANCY OF THE RADIO-FREQUENCY SPECTRUM

(Question 255(VIII))

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 utilization 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:

– total frequency range	– minimum 2 to 30 Mc/s; desirable 10 kc/s to 30 Mc/s or more;
– swept frequency range	variable, typical range 100 to 1000 kc/s;
– number of sweeps per hour	variable, 30 to 180;
– maximum rate of sweeping	variable; dependent on the desired frequency resolution for the band being swept and the class or classes of emission being recorded;
– sensitivity	1 μV/m or better;
– resolving power	variable; approximately 100 to 1000 c/s;
– signal characteristics recorded	– carrier frequency, – bandwidth, – field-strength, – duration of occupancy;
– 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:
- name and location of monitoring station;
- date and period of recording;
- frequency band;
- signal identification, as appropriate;
- class of emission, as appropriate;
- direction of signal;
- noise level.

RECOMMENDATION 377 *

ACCURACY OF FREQUENCY MEASUREMENTS AT MONITORING STATIONS

(Question 252(VIII))

The C.C.I.R., (Stockholm, 1948 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) the requirements of the Administrations, of international organizations carrying out monitoring observations and of the I.F.R.B., in respect of the frequency measurements necessary for the efficient performance of their duties;

(b) the general availability of suitable monitoring equipments for frequency measurements;

(c) that it is desirable that the errors of frequency measurement shall not exceed one-tenth of the frequency tolerances specified in Appendix 3 to the Radio Regulations, Geneva, 1959;

UNANIMOUSLY RECOMMENDS

that monitoring equipments and procedures 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
Measurements of the frequencies of stations, except broadcasting stations, operating in the band 10 kc/s to 4000 kc/s	± 5 parts in 10^6 (or, where this would be less than ± 1 c/s, to an accuracy of ± 1 c/s)
Measurements of the frequencies of broadcasting stations, operating in the band 10 kc/s to 4000 kc/s	± 1 c/s
Measurements of the frequencies of stations, except television broadcasting stations, operating in the band 4000 kc/s to 500 Mc/s	$\pm 1{\cdot}5$ parts in 10^6
Measurements of the frequencies of stations, except television broadcasting stations, operating in the band 500 Mc/s to 10·5 Gc/s	± 1 part in 10^5
Measurements of the frequencies of television broadcasting stations, operating in the band 30 Mc/s to 1000 Mc/s	± 100 c/s
Measurements of the frequencies of stations, operating above 10·5 Gc/s	± 5 parts in 10^5

Note 1. – It is realized that, while the accuracies quoted above are sufficient for international monitoring, higher accuracies may be needed to meet national requirements.

Note 2. – For frequency measurements made solely to investigate occupancy of frequency channels, the permissible error for stations operating in the band 10 kc/s to 30 Mc/s is $\pm$ 3 parts in 10^5.

* This Recommendation replaces Recommendation 322.

RECOMMENDATION 378 *

ACCURACY OF FIELD-STRENGTH MEASUREMENTS BY MONITORING STATIONS

(Study Programme 102(VIII))

The C.C.I.R., (London, 1953 – Warsaw, 1956 – Geneva, 1963)

CONSIDERING

(a) that field-strength measurements are made by monitoring stations in the frequency range 10 kc/s to 1 Gc/s;

(b) that accurate measurements, for use in connection with the international registration and assignment of frequencies, may be desirable;

(c) that the publication of such data from monitoring stations is also desirable;

UNANIMOUSLY RECOMMENDS

1. that, to obtain the accuracy specified in § 2, the field-strength measuring equipment at monitoring stations should be installed, calibrated and operated in accordance with 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 below:

Frequency band	*Accuracy of measurement*
Below 30 Mc/s	± 2 db
30 to 1000 Mc/s	± 3 db

3. that when, because of limitations of measuring instruments, interference, signal instability or for other reasons, the accuracies shown in § 2 are not obtainable, the measurements should nevertheless receive due consideration commensurate with the accuracy indicated;

4. that studies of methods and equipment for field-strength measurements at monitoring stations should be continued.

ANNEX

1. Fixed antenna installation

1.1 *Frequencies of 30 Mc/s and below*

It is recommended that, for frequencies of 30 Mc/s and below, vertical antennae shorter than one-fourth wavelength should be used, with ground systems consisting either of buried radial conductors, at least twice the length of the antenna and spaced 30 degrees or less apart, or of an equivalent ground screen.

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 at frequencies of 30 Mc/s and below, for the following reasons:

* This Recommendation replaces Recommendation 181.

1.1.1 it is generally accepted that random variations in polarization of ionospheric waves are such, that the vertically polarized component is, in general, substantially equal to the horizontal component;

1.1.2 the response of a vertical antenna, shorter than ¼ of a wavelength, is substantially independent of frequency.

1.2 *Frequencies above 30 Mc/s*

Antennae for field-strength measurement at frequencies above 30 Mc/s are recommended to conform to the following conditions:

1.2.1 The receiving antenna must have the same polarization as the transmitting antenna. For these frequencies, short monopole antennae, half-wave dipoles and high-gain antennae are appropriate.

1.2.2 It is preferable that the antennae be located at a height of 10 m above ground.

1.2.3 Consideration should be given to environmental conditions (e. g. terrain and obstructions), to minimize factors reducing accuracy.

1.3 *Antenna factor*

The error in the determination of the antenna factor should be kept within 1 db. The antenna factor takes into account coupling or mismatch losses between the antenna and the 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. 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. The measuring equipment should be calibrated as required to maintain the accuracies given in § 2 of this Recommendation.

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1. Recommendations U.R.S.I., Commission 1 (1960).
2. SELBY, M.C. Accurate RF voltages, Communications and Electronics, *Trans. A.I.E.E.*, **6**, 158–164 (May 1953).

RECOMMENDATION 379 *

IDENTIFICATION OF RADIO STATIONS

(Question 256(VIII))

(Geneva, 1951 – London, 1953 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that the Radio Regulations, Geneva, 1959, Article 19, set forth requirements for transmissions of call signs and state that each radio station provided with a call sign from the international series must, unless otherwise provided, transmit this call sign during the course of its emission;

* This Recommendation replaces Recommendation 323.

(b) that certain types of radio stations are exempted from the necessity of having an international call sign, for example, stations which are identified by other means;

(c) that, in some cases, the requirement of transmitting the identifying signal by interrupting the traffic imposes difficulties;

(d) that methods for identifying certain complex types of emissions have been evolved;

UNANIMOUSLY RECOMMENDS

1. that for the purpose of identification, the identifying signal should be transmitted, using:

1.1 International Morse code using class A1, A2, F1 or F2 emission, and transmitted preferably at manual speed; or

1.2 Five-unit code (International Telegraph Alphabet No. 2) using class A1, A2 or F1 emission, at the standardized speed of 50 bauds; or

1.3 Speech in clear;

2. that, if the station does not desire to interrupt traffic for identification, it should superimpose the identifying signal on the traffic by using the following methods:

2.1 *Class F1 emissions* (especially for high-speed or multi-channel operation): Additional modulation (frequency of phase) of the carrier by the identifying signal in International Morse code;

2.2 *Single- or independent- sideband emissions :* Amplitude keying of the reduced carrier or some other pilot frequency;

2.2.1 keying of the reduced carrier, with a difference in level of 5 db, gives a satisfactory compromise between an acceptable degree distortion of the traffic signals and the suitability for identification purposes, especially if the identifying signal is repeated;

2.3 *Facsimile transmissions employing class A4 emissions :* Amplitude-modulation, at a frequency below the lowest used for the facsimile modulation. When single-sideband transmission is used, amplitude keying, as in § 2.2 may be used;

3. that, to avoid additional complexity in the equipment and operation of transmitting stations, every reasonable effort should be made to provide monitoring stations with equipment suitable for the reception of identifying signals of all stations;

4. that Administrations should be encouraged to cooperate 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 to facilitate cooperative observations and also to afford other Administrations the opportunity to become acquainted with such methods for the identification of radio stations.

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REPORTS OF SECTION J: MONITORING OF EMISSIONS

REPORT 272 *

FREQUENCY MEASUREMENTS AT MONITORING STATIONS

(Question 252(VIII))

(Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

Question 252(VIII) seeks information on the desirable ratio of the error of frequency measurement to the permissible tolerances of emission and the accuracy required for frequencies extending up to, in certain cases, at least 10·5 Gc/s.

Information on equipment, accuracy of measurement and methods is contained in Docs. VIII/ 1(U.S.A.), VIII/13 (Japan), VIII/18 (Japan), VIII/27 (United Kingdom) and VIII/28 (United Kingdom) of Washington, 1962. The information available at present may be summarized as follows.

1. Equipment

1.1 With regard to measurements above 50 Mc/s, the frequency measuring equipments of the individual countries differ so much that it is only possible to comment generally upon them. Administrations, in general, prefer to make measurements with nearly the same equipment as that 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 oscillator or by the use of 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.

1.2 With regard to the desirable ratio of the error of frequency measurements to the permissible tolerance and the use of statistical methods of evaluation, it may not be necessary or even desirable to define the accuracy of frequency measurements in terms of a statistical calculation for enforcement purposes or for reporting, if necessary, frequency measurements of stations to the I.F.R.B. Frequency measurements made on a statistical basis may be useful for inter-comparing frequency standards and, in such cases, they should be made to the greatest possible accuracy. It would appear that, to treat a number of measurements to a statistical evaluation, it should be presumed that the emissions did not themselves shift in frequency between measurements or that the various measurements were made simultaneously either at different monitoring stations or on different measuring equipments, but such is not usually the case.

1.3 When an individual measurement of a radio station is made, its accuracy can be estimated from a knowledge of all of the factors (except perhaps that of Doppler effect), which produced the error. The sources of error which should be known to the measurer, are: the maximum error in the frequency standard of reference; the maximum instability error of the transfer oscillator and the error of setting that oscillator to zero-beat with the signal. Inasmuch as the direction of errors, other than that of the reference standard, will not usually be known, the errors of measurement should be estimated as if they were all in the same direction after allowing for any known error of the reference standard.

* This Report, which replaces Report 169, was adopted unanimously.

1.4 It is considered, that a conservative ratio of error to tolerance as applied to the majority of frequency measurements, is to be preferred over a ratio difficult to obtain. With a conservative ratio, the measuring equipment may be operated well within its capabilities with a greater degree of assurance that all measurements meet the desired minimum accuracy.

1.5 The ratio of 1 to 10 between the error of measurement and the tolerance appears to be a reasonable general criterion to retain.

1.5.1 The absolute accuracy of the secondary standard of a mobile frequency measurement installation is determined by calibration. Although a stability of $\pm$ 1 part in 10^9 or better can be achieved with currently available standards designed especially for mobile use, the absolute accuracy may not exceed $\pm$ 1 part in 10^7 where standard-frequency transmissions must be received over a sky-wave path. This problem could be greatly alleviated by the use of VLF standard-frequency emissions in areas where the signal strength from such stations is adequate for the purpose. Another approach is the use of an atomic frequency standard. A portable atomic frequency standard is available with an absolute accuracy of $\pm$ 1 part in 10^9, weighing about 10 kg and requiring about 50 W of power for its operation. Use of such frequency standards in mobile installations would provide the desired 1 to 10 ratio of measurement error to established tolerance.

2. Accuracy of measurement

With regard to § 1 of Question 252(VIII), on the accuracy of frequency measurements which can be accomplished at monitoring stations, the following statements may be made:

2.1 Standard-frequencies are emitted with an accuracy of a few parts in 10^{10}. Secondary frequency standards, with a stability better than $\pm$ 1 part in 10^9 per day, are available for both mobile and fixed monitoring stations. However, where dependence must be placed on sky-wave HF standard-frequency emissions, variations in the length of the propagation path must be taken into account. Where the comparison period between the secondary standard and the standard-frequency emissions is short (of the order of one minute or less), the accuracy may at times be no better than $\pm$ 1 part in 10^7. However, by selecting a time of day for the comparison during which sky-wave propagation conditions are most nearly stable (usually around noon of the path mid-point), and by continuing the comparison over a period of several minutes, accuracy of a few parts in 10^8 is readily achievable. Where ground wave HF or useable VLF/LF emissions from standard-frequency stations are available, the secondary standards may be maintained to better than $\pm$ 1 part in 10^8.

2.2 Table I lists the accuracy of measurement of various classes of emissions which can be attained under optimum conditions at fixed and mobile monitoring stations; n is the integer equal to, or immediately above, one thirtieth of the measured frequency in Mc/s.

2.3 The methods of measurement usually employed result in the determination of the instantaneous frequency as received. Therefore, when measuring distant stations, due regard must be given to frequency shifts caused by varying propagation conditions (e. g. Doppler effect). Errors, due to the use of a stable transfer oscillator, can be reduced to a negligible amount by the use of an oscilloscope for zero-beat adjustment. In anticipation of the extensive use of VLF/LF standard-frequency emissions, the desirability of future reduction of the error to an appropriate smaller value should be kept in mind. This is of particular importance in connection with services in which a 1 to 10 ratio of measurement error to station tolerance cannot be achieved with a frequency standard having an accuracy of only $\pm$ 1 part in 10^7.

TABLE I

Accuracy of measurement attainable under optimum conditions at fixed and mobile monitoring stations

Class of emission	Fixed stations	Mobile stations
A0, A3, A3B	$\pm 2{\cdot}5 \times 10^{-8} \pm 0{\cdot}5\, n$ c/s	$\pm 4 \times 10^{-8} \pm 0{\cdot}5\, n$ c/s
F1, A1	$\pm 2{\cdot}5 \times 10^{-8} \pm 0{\cdot}5\, n$ c/s $\pm$ 2·5 c/s	$\pm 4 \times 10^{-8} \pm 0{\cdot}5\, n$ c/s $\pm$ 2·5 c/s
F1, MUX	$\pm 2{\cdot}5 \times 10^{-8} \pm 0{\cdot}5\, n$ c/s $\pm$ 10 c/s	$\pm 4 \times 10^{-8} \pm 0{\cdot}5\, n$ c/s $\pm$ 10 c/s
F3 using discriminating equipment	$\pm 2{\cdot}5 \times 10^{-8} \pm$ 100 c/s	$\pm 4 \times 10^{-8} \pm$ 100 c/s

2.4 For emissions with a discrete component at the assigned frequency, which can be identified, the accuracy is practically the same as for unmodulated emissions. For emissions having discrete components which can be identified at other than the assigned frequency, the accuracy is further limited by the accuracy with which the displacement is known.

2.5 Under conditions of fading, and where the measurement is made using a pattern on the screen of an oscilloscope, the measurement is performed only when there is sufficient signal strength, e.g. A1 stations are measured only during on-keyed conditions and not during a field-strength minimum period. Under these conditions the accuracies listed in Table I can be obtained.

2.6 Under conditions of interference between two amplitude-modulated stations, the frequency of the weaker station can still be measured with the accuracy indicated in Table I, if the carriers of the wanted and unwanted stations are spaced by at least 40 c/s. With a field-strength ratio between the wanted and the unwanted stations of 1 to 1, good measurements may be made with the accuracy indicated in Table I, when the carriers are only spaced by 12 c/s. For a field-strength ratio of 2 to 1, the minimum frequency spacing at which good results are obtained is 2 c/s. These high accuracies of measurement are made possible, even under conditions of interference by other stations, by visual observation of the Lissajous patterns produced on the oscilloscope screen by combining the heterodyne beat between the received signal and the comparison frequency and a fixed standard-frequency of 1000 c/s. By receiving mutually interfering stations on a direction finding equipment, their ratio of signal strengths at the receiver input can be improved, thus making possible measurements with the accuracies shown in Table I at smaller carrier spacings.

2.7 Two interfering frequency-modulated stations can be measured for unfavourable field-strength ratios when the frequency separation between their carriers is at least 2 to 3 kc/s. The measurements are taken during periods of no modulation by heterodyning the wanted carrier with the comparison frequency and observing the results on a panoramic display screen. The accuracy will then be within ± 500 c/s. Here too, by employing a direction-finding technique, the received signal strength of the unwanted station may be sufficiently attenuated to attain the accuracies indicated in Table I.

2.8 Measurements of carrier instability can be made, either as a series of measurements of instantaneous frequencies employing the oscilloscope method or, in the case of rapid variations of the carrier frequency, the centre frequency can be determined by means of a discriminator equipment, or a panoramic adaptor, resulting in an accuracy of measurement of the edge frequencies of about ± 50 c/s.

2.9 Keyed carriers can be measured by the oscilloscope method with the accuracies listed in Table I.

2.10 For suppressed carriers, individual frequencies of the types listed under §§ 2.5, 2.6, 2.7, 2.8 and 2.9, which are contained in the emission spectrum, can be measured with the accuracies listed in those paragraphs. For a carrier not completely suppressed, the measurement can be made with the accuracy indicated in § 2.6.

3. Methods

3.1 With regard to preferred equipment and methods for the measurement of frequency of frequency-modulated emissions, the carrier frequency may be measured by any of the usual methods during intervals of no modulation. With modulation, it is common practice to measure the average frequency by means of a frequency counter. In many types of programme material, the peak excursions of an FM carrier in the positive and negative directions may be considerably different while, at the same time, the average frequency will remain constant. This non-symmetrical programme material may result, for example, from certain combinations of a fundamental tone and its various harmonics. Then the average over a period of several cycles at the lowest modulating frequency will approximate the unmodulated carrier frequency. Therefore, the averaging technique is valid under all normal conditions, provided the period of the frequency count is long compared with one cycle at the lowest modulating frequency. Instabilities in the transmitter may, of course, result in a shift in the average frequency of the carrier, so that the frequency indicated by the counter would be somewhat different than the unmodulated carrier frequency.

3.2 With the availability of portable battery-operated frequency standards, stable to ± 1 part in 10^8 per day, UHF television stations operating with ± 1000 c/s tolerance may be measured to the recommended accuracy. A daily check against standard-frequency emissions at the optimum time of the day as regards propagation stability will suffice to achieve an accuracy of the standard considerably better than the ± 1 part in 10^7 that is required for these measurements. For greater accuracy, such as might be involved where precision offset techniques are used, very accurate measurements could be achieved by use of a portable atomic standard. VLF standard-frequency emissions also provide a means of improving the accuracy at mobile as well as fixed monitoring stations. Battery-operated equipment, comprising a selective VLF receiver and phase or time comparison circuitry, may be used to permit accurate calibration of the frequency standard. Such comparison equipment, in combination with a battery-operated frequency standard and a transistorized electronic counter, provides a convenient means of achieving a high degree of accuracy even under mobile conditions.

The importance and potential usefulness of statistical analyses of frequency measurement data is described in Doc. VIII/18 of Washington, 1962. This document also suggests a method of arriving at the accuracy of a measurement of an unknown frequency by obtaining the standard deviation of a number of measurements made of a known frequency.

In Doc. VIII/27 of Washington, 1962, the overall accuracy of frequency measurements, attainable in the range 1 to 10 Gc/s, was indicated using a typical spectrum analyzer with the following characteristics: varies from 8 kc/s (for a 250 kc/s sweep), to 100 kc/s (for a

70 Mc/s sweep), equivalent to ± 8 parts in 10^6 and ± 1 part in 10^4 respectively at a frequency of 1 Gc/s. Thus, an accuracy of ± 1 part in 10^5 would appear possible, in practice, for the range 1-10 Gc/s for the condition where the emission contains a known discrete component whose position relative to the unmodulated carrier frequency is accurately known. Where it is possible to obtain a beat frequency output, the accuracy of measurement may be increased to ± 1 part in 10^6 or even better.

REPORT 273 *

FIELD-STRENGTH MEASUREMENTS AT MONITORING STATIONS

(Study Programme 102(VIII))

(Los Angeles, 1959 – Geneva, 1963)

Study Programme 102(VIII) seeks information on various aspects of the measurement of field-strength at monitoring stations, including the preferred methods and equipment for making such measurements in connection with propagation studies, measurement problems peculiar to certain special types of emissions (e.g., interrupted and reduced carriers and television signals), measurements in the presence of noise and interference; together with determination of the extent to which measurements at a distance can give useful information relative to harmonic levels at the transmitter itself; and a determination of the most useful programme which can be carried out in fulfilling the needs of the I.F.R.B., other Study Groups of the C.C.I.R. and other bodies.

The contributions (Docs. VIII/6, VIII/8, VIII/16, VIII/20 and VIII/22 of Los Angeles, 1959, together with Docs. VIII/6 and VIII/25 of Washington, 1962), are summarized herein. In considering Study Programme 102(VIII), reference should also be made to Report 227 which contains useful information.

1. Preferred methods and equipment

1.1 *Methods of measurement*

A number of methods of making field-strength measurements at monitoring stations are described, including:

- continuous recording over periods of several hours;
- continual sampling at short intervals (for example, for 5 s every two minutes) (see § 1.2.6 for details);
- sampling at longer intervals (for example, for 10 min each 90 min).

In some instances, especially where a ground wave is being observed, a single short period of measurement may suffice, depending upon the purpose for which the measurement is required.

In certain cases, e.g. measurements for the purpose of HF propagation studies, one may require information concerning the overall propagation conditions over a band of frequencies. The present method of automatic monitoring of spectrum occupancy will yield only a very rough impression of the propagation conditions, since it does not discriminate between the various path directions and cannot make allowance for the difference in distances between

* This Report, which replaces Report 170, was adopted unanimously.

the transmitting stations and the location of the receiver. Therefore, it may be expedient to make short records lasting about 10 min, over the entire high-frequency band at intervals of about 90 min, of stations known to be working for 24 hours a day, so chosen that the ranges of frequencies and distances of interest are well represented.

Time constants of the detector circuit for measuring non-interrupted carrier emissions are selected according to the results desired, with values of the order of a few seconds on both the charge and discharge cycles commonly used for average values. For quasi-peak values, a short charge time constant with a much longer discharge time constant is needed.

For the measurement of the quasi-peak values of field-strength of an emission with interrupted carrier, a circuit may be employed with time-constants of 1 ms build-up time and 600 ms decay time. When this method is not suitable (e.g. keyed pulses), because of too long a build-up time, the measurement may be made by the substitution method using a cathode-ray oscilloscope.

1.2 *Measuring and recording equipment*

1.2.1 *General*

A typical field-strength recording installation consists of a suitable antenna, a sensitive receiver with a bandwidth appropriate to the emission to be recorded and including provisions for converting the received signal into a corresponding direct-current for operation of an associated recording device, and a standard signal generator for use in calibrating the receiver in terms of radio-frequency voltage input levels. To ensure minimum frequency drift, the conversion oscillators in the receivers are, wherever possible, controlled by quartz crystals. Stabilization of the alternating current line voltage is provided by primary voltage regulators. Further protection against fluctuation is obtained by stabilization of the d.c. voltages in the receiver. Minimization of changes in receiver gain is accomplished by careful design of receiver circuits, by the aforementioned voltage stabilization and by operating the equipment at an essentially constant temperature.

1.2.2 *Antennae*

For measurements in the low, medium and high frequency bands, a stub antenna with impedance matching transformers or a wideband stub antenna with constant feed impedance may be used. In some particular cases, however, a directional antenna designed for a single frequency or a narrow band of frequencies may be preferred. Field-strength measurements on VHF and UHF bands are best made by means of a wideband dipole or a special directional antenna (e.g. a dipole installed in a corner-reflector or parabolic reflector). In the upper part of the UHF band and in the SHF band successful use has been made of log-periodic antennae, either with or without parabolic reflectors, so installed that near optimum results, with low standing-wave ratios, are achieved over a frequency range of 2/1 or greater.

1.2.3 *Recorders*

Although ink-line, strip-chart recorders continue in common use, direct recording of the statistical distribution of the variations in field-strength by automatic distribution counters is also being done. Another method, reported by the Federal Republic of Germany, makes use of magnetic tape equipment. In this method, the variations of the d.c. voltage on the a.v.c. line, representative of the field-strength, are transformed to audio frequencies (50 to 300 c/s), by means of an oscillator controlled by a reactance valve and used to modulate the amplitude of a low frequency carrier (about 5 kc/s).

1.2.4 *The calibrating equipment*

The calibration process involves two phases:

- determination of the effective height of the receiving antenna, taking into account losses in the connecting transmission line;
- daily, or more frequent, receiver calibration, to eliminate possible errors due to progressive changes in sensitivity.

Doc. VIII/6 of Los Angeles, 1959, suggests that it is good practice to calibrate initially the field-strength meters, for use on frequencies below about 30 Mc/s, on a loop antenna. The loop is placed at a small defined distance from a Lecher line which is terminated with a resistance equal to its surge impedance, which can be coupled to a radio-frequency source. If the current flowing in the Lecher line is known, the field intersecting the loop can be computed.

To determine the effective height of an antenna, the input signal to the receiver is compared with the indication of a calibrated field-strength meter.

1.2.5 *Frequency ranges involved*

Although field-strength measurements have been made over almost the entire usable spectrum, most of the activity up to the present has been concentrated at frequencies below 1 Gc/s. As greater use is made of the microwave frequencies for space-to-ground transmissions, it seems likely that there will be increased activity in field-strength measurements in these higher frequency ranges. Examples of measurement programmes for field-strength which are now under way, or have been concluded in recent years, are:

- in the 540 to 1600 kc/s broadcast band, continuous recordings have been made during the past two sunspot cycles;
- VHF and UHF field-strength measurements (FM and television broadcast stations), have been in progress since 1946 at various locations over paths having lengths from 60 to 1000 km (38 to 633 miles);
- certain monitoring stations in the U.S.A. are determining the field-strength of experimental UHF television stations located in aircraft. These experiments are done in connection with extending the service area;
- a monitoring station in the United Kingdom is making regular field-strength recordings of incoming radiotelegraph signals from Accra, Bombay and Colombo, as a partial contribution to Resolution 7 (Systematic sky-wave field-strength measurements on frequencies between the approximate limits of 1·5 and 40 Mc/s);
- the station in the United Kingdom has also made long-term field-strength measurements of ten distant VHF (metric) and UHF (decimetric) transmitters and two distant ionospheric-scatter transmitters and the data obtained have been summarized and submitted to the C.C.I.R. (Doc. VIII/25 of Los Angeles, 1959).

1.2.6 *Analysis of the records*

Recordings made in the 540 to 1600 kc/s broadcast band are analyzed, to obtain hourly median values of field-strength and from these data monthly median values may be obtained. Particular attention is given to the second hour after sunset for the mid-point of the path between transmitter and receiver. Values for other hours and for levels other than the median may be obtained in a similar manner.

In the HF, VHF and UHF bands, it is often desirable to determine the upper decile (F_{10}), the median (F_{50}) and the lower decile (F_{90}) values. The median value, in db relative to 1 μV/m, is a desirable form of presentation of measurements at discrete frequencies for propagation studies.

A system of analysis, which eliminates much of the human effort, is based upon a method of recording periodic samples of signal strength, using regular equipment with simple modification rather than a continuous registration of signal levels. A time switch operated by a synchronous motor is provided in each recorder so that a contact is closed once every two minutes for a duration of about five seconds. This contact is inserted in an appropriate circuit in the receiver, where it will cause the recording instrument to respond by drawing an inked line with each operation of the switch. The recorder chart will then show a series of transverse lines. When operated at the usual speed of about 75 mm (three inches) per hour, the paper will show 10 lines per inch, each having an amplitude with a known relationship to field-strength. It has been found that 30 samples per hour will yield an accuracy adequate for most applications. After the recordings have been made, the charts are analyzed on equipment specially constructed for this purpose. This equipment may consist of a photoelectric cell arrangement for counting the hourly number of samples with amplitudes exceeding a pre-set level, while the chart paper moves through an appropriate optical system. Hourly numbers of samples at each level are counted automatically and printed by means of an electrical counter and a sequential count printer. These numbers may be directly converted to equivalent percentages of time, for all signals exceeding given levels. The data are thus available in hourly values, from which monthly and yearly distribution curves may be plotted, showing daily and seasonal variations of field-strength at any percentile levels.

2. Preferred equipment and methods of measurement in the presence of noise and interference

No particular problems are presented in measuring the field-strength of emissions with interrupted carrier and of television video signals in the presence of noise and interference, as long as the noise and interference peak levels are below the level of the wanted signal, since the quasi-peak indicating device will respond to the highest level present. However, in the case where the peaks of noise and interference are greater in intensity than the wanted emission, other techniques must be used. In some instances, reduction of the receiver bandwidth may be effective in eliminating unwanted emissions. The effect of high noise peaks of short duration can possibly be avoided, by increasing the charge time-constant of the detector sufficiently to minimize receiver response to the noise without appreciable reduction in the indicated level of the wanted signal. The efficacy of such expedients would, of course, depend on circumstances and very likely would not be valid under conditions of heavy fading. Doc. VIII/16 of Los Angeles, 1959, describes a method used in Japan, for the measurement of emissions in the presence of adjadent channel interference, using a panoramic unit attached to the equipment, so that an interfering emission may be separated from the wanted signal and the field-strength represented by the deflection of the oscilloscope trace caused by the interrupted carrier under study, may be determined by comparison with a signal from the equipment used for calibration purposes.

3. Determination, at a distance, of relative radiation levels of fundamental and harmonic frequencies of an emission

It would appear that this matter should be considered in two parts:

- conditions where both the fundamental and the harmonic emissions to be measured arrive at the measuring point over a ground-wave or line-of-sight path;
- where either the fundamental or the harmonic emission, or both, arrive at the measuring site over a sky-wave path.

The situation as regards these two modes of propagation will be considered separately.

3.1 *Measurement of radiation levels under conditions of ground-wave or line-of-sight propagation*

Study Group V, in response to a request for assistance on this matter, has referred Study Group VIII to Report 227. This Report contains detailed information on making and evaluating such measurements, taking into account instrument errors, differing attenuation rates at different frequencies and other variables.

3.2 *Measurements of radiation levels where sky-wave paths are involved*

Study Group I has considered this matter, as evidenced by Recommendation 329 and Study Programme 182 (I). Likewise, Study Group VI, in Reports 252 and 257, reviews progress which has been made in determining the best method of calculating the field-strength at a distance from the transmitter (ionospheric propagation), and describes plans for further study of this matter.

It is expected that the results of the further deliberations of Study Group I and VI will be of benefit to the international monitoring system in its efforts to minimize interference from spurious emissions. Pending the outcome of these deliberations, it would be highly desirable for stations in the international monitoring system to have certain guide-lines which might be followed in obtaining evidence of possible excessive radiation at the harmonic frequency. While such evidence would not be conclusive, it might serve as an indication that close-in measurements should be made to verify the existence of harmonics at excessive levels. Appendix 4 of the Radio Regulations, Geneva, 1959, gives power limitations on spurious emissions as measured at the antenna transmission line input. Although these emissions may readily be measured at that point, there is no simple means of converting the spurious power limitations given in Appendix 4 to equivalent field-strength at a distance. Since it is the actual radiated spurious field-strength rather than the power into the antenna which is of primary concern as an interference source, it might be well to consider establishment of a limitation on spurious emissions, in terms of the maximum unattenuated field-strength at about 1600 m (1 mile). Having once established such a limit, the maximum allowable inverse-distance field could readily be determined. Since the attenuation would actually increase more rapidly than inversely with the distance, the measured value of the spurious emission would be a conservative index of the actual radiated field, especially if the condition continues over a period of several days. This limitation would be in addition to, rather than a substitute for, the limitations on spurious power input to the antenna transmission line specified in Appendix 4. Admittedly, the results could not be compared directly with measurements made at the transmitter. However, it would appear that such standards might be of help to monitoring personnel in bringing about a reduction of interference due to harmonic radiation.

4. Additional propagation studies that are desirable

Resolution 7 points out the need for experimental data in the frequency range from 1·5 to 40 Mc/s for paths of different lengths and directions and requests that Administrations and Members of the C.C.I.R. render assistance to Study Group VI on this matter.

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REPORT 274 *

MEASUREMENT OF S-VALUES AT MONITORING STATIONS

(Question 189)

(Geneva, 1963)

Question 189 asked that the correlation between field-strength values, and the S-values of the QSA scale and the SIMPO and SIMPFEMO codes be studied. Docs. VIII/16 (Japan), VIII/17 (Japan), VIII/21 (U.S.A.), VIII/26 (United Kingdom), VIII/31 (Portugal), and VIII/35 (India) of Washington, 1962, referred to this matter.

Table I, derived from these documents, demonstrates the wide ranges of both field-strength and receiver input signal that are associated with S-values. It is evident that such measurements are influenced to a considerable extent by the equipment in use, the type of service, and reception conditions. S-meters have widely differing characteristics, and may vary in equipments of the same type. The subjective S-values of the QSA scale also differ widely with the operator's ability.

It is concluded that a method based on S-values is unlikely to meet the requirement for a rapid method of field-strength measurement with sufficient accuracy to be of use to the monitoring services. In consequence, this Report terminates the study of Question 189.

TABLE I

Correlation between QSA scale and field-strength or receiver input voltage

QSA Scale	Receiver input signal (db rel. 1 μV)				Field strength (db rel. 1 μV/m)		
	Doc. VIII/17 Fixed Services (1)	Doc. VIII/17 Routine Monitoring (1)	Doc. VIII/21 (2)	Doc. VIII/35 A3 Modulation	Doc. VIII/16 (3)	Doc. VIII/31 A1, A2 Modulation (4)	Doc. VIII/31 A3 Modulation (4)
0						<11	<15
1		(−30)–(+15)	0–18	5–16	<(−10)	11–22	15–23
2	15–38	(−24)–(+30)	18–30	12–20	(−9)–(+5)	22–31	23–41
3	20–42	6–45	30–42	18–28	6–20	31–45	41–59
4	25–46	10–55	42–54	26–37	21–35	45–56	59–77
5	30–65	10–65	>54	33–45	>36	>56	>77

(1) Based on statistically stable samples of results, and using the antenna system of Report 278.
(2) Conformity of operators standards was improved by use of special reference equipment.
(3) These values represent the best accuracy obtained using calibrated antenna, receiver and S-meter.
(4) Based on measurements in bands 5, 6, 7 and 8.

* This Report was adopted unanimously.

REPORT 275 *

BANDWIDTH MEASUREMENT BY MONITORING STATIONS

(Study Programme 207(VIII))

(London, 1953 – Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

1. General discussion of measurement techniques, considering the definition of occupied bandwidth – No. 90 of the Radio Regulations, Geneva, 1959

1.1 *Measurement of power ratios*

The present definition of occupied bandwidth suggests the principle described in Recommendation 327, § 1.2 of measuring the ratio of the total power to the parts remaining outside of the bandwidth being measured. It would be necessary to locate the upper and lower edges of the band, by totalling the power in the out-of-band components on the high side until the 0·5% value is obtained and then repeating this procedure for out-of-band components below the band, starting in each case sufficiently far from the centre frequency so that no appreciable energy is omitted from measurement.

1.2 *Limitations in the accuracy of bandwidth measurements made at a distance from the transmitter*

Although a determination of occupied bandwidth of an emission, by the method of measuring total power and out-of-band power, can be accomplished when the measurements are made near the transmitter, this method is not generally applicable to measurements at a distance from the transmitter because of the presence of interfering emissions or noise which tend to mask the out-of-band signal components of interest. This is particularly true in the crowded MF (band 6) and HF (band 7) portions of the spectrum, regions of primary interest to international monitoring stations.

In spite of the very definite limitations which observations at a distance place upon the accuracy of measurements of occupied bandwidth, approximate determinations have been found of value when monitoring the spectrum for enforcement of bandwidth limitations. However, these non-precise measurements made at a distance, which are subject to inaccuracies for the reasons previously enumerated, should be considered as advisory only. Where greater accuracy is required measurements at the transmitter may be desirable.

1.3 *Bandwidth measuring method which appears to be practicable for use at international monitoring stations*

It is the practice of some Administrations, in evaluating spectrum occupancy of an emission from a distant transmitter, to use the method described in Recommendation 327, § 1.1. In using this method, the occupied bandwidth is considered to include discrete components attenuated less than 26 db below the peak level of the emissions. This procedure admittedly will not give a precise measurement of occupied bandwidth in terms of the definition in the Radio Regulations, Geneva, 1959. For example, it is possible that a particular emission will have numerous low level components on either side of the main emission such, that their sum on each side would be equal to much more than 0·5% of the total mean power while having none of these discrete components exceed the −26 db level. In such a case, the occupied bandwidth, as determined at the transmitter by measuring power ratios, would presumably be somewhat greater than when measured at a distance by the method described

* This Report, which replaces Report 172, was adopted unanimously.

in Recommendation 327, § 1.1. The equipment described below will display the spectra, distribution of an emission in terms of significant discrete components.

2. Representative bandwidth measuring equipment

2.1 A spectrum analyzer, of the type described in Recommendation 327, § 1.1, is suitable for use at monitoring stations. With this equipment emission spectrum is analyzed 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.

For the measurement of narrow-band emissions, a spectrum analyzer having a high degree of resolution is desirable so that an accurate display of the emission spectral distribution may be obtained. A typical instrument has a maximum resolution of 10 c/s and provides a swept frequency range adjustable from 1 kc/s to 100 kc/s, together with a sweep rate adjustable from 1 to 30 sweeps per second.

For the analysis of wide-band emissions, spectrum analyzers are available which incorporate a complete receiver as well as those designed for use with general purpose receivers. A typical instrument covers a frequency range from 10 Mc/s to 44 Gc/s with a sweep width continuously variable from 200 kc/s or less to as much as 70 Mc/s (at the higher frequencies). The sweep rate is adjustable from 1 to 60 sweeps per second.

A major shortcoming of spectrum analyzers, which use a single filter to sweep the entire band under surveillance, is the incompatibility between high resolution and rapid sweep rates, especially where a band of considerable width must be studied. A fast sweep rate is necessary to obtain a representative display of transient components. However, as the sweep rate is increased, the resolution becomes poorer so that significant components of the emission will not be displayed accurately. A number of systems have been devised to minimize the sweep-rate versus resolution limitations. One method involves the division of the band to be observed into as many as eighteen sub-bands, each of which is individually swept. The eighteen outputs are then displayed one at a time on a single cathode-ray tube or simultaneously on separate tubes.

2.2 An energy spectrum recorder is described in Doc. VIII/13 of Los Angeles, 1959. This device makes a chart record of spectrum occupancy in terms of available power from a standard antenna.

2.3 A device for measuring frequency shift, especially in questions concerning the monitoring of complicated emissions and those types of emissions using a synchronous high speed multichannel system, is described in Doc. VIII/29 of Washington, 1962. This device permits simultaneous measurements of frequency shift of multiplex channels as well as a visual check on the frequency shift signals.

3. A somewhat different approach to the measurement of bandwidth is described as follows (see Doc. VIII/10 (Federal Republic of Germany) of Los Angeles, 1959):

Endeavours have been made to determine the bandwidth occupied by an emission by way of the signal shape instead of by analyzing the spectrum. Such experiments have been made for Class A1 emissions only, starting from the fact that the bandwidth occupied is a function of the shortest build-up (and decay) time of the emitted signals (see Recommendation 328, § 2.1.3).

As regards the effect of fading, a comparison between 60 single measurements of A1 emissions taken at the transmitter and in the far field (up to 425 km), resulted in a maximum deviation of 16%. The average value of the deviations amounted to 4·8%. The differences in the results of the measurements at the transmitter and those taken far away may be explained by the deformation due to the fading effects of the signals. Measurements made under extreme fading conditions will not yield satisfactory results.

The effect of interference was investigated by superimposing a received non-fading A1 signal with a simulated interference signal of variable frequency generated locally. It was found that the wanted signals could still be evaluated with a signal-to-interference ratio as low as 35 db. With signal-to-interference ratios lower than 35 db, evaluation was no longer possible, because the 10% value of the wanted signal could not then be recognized.

4. Spectrum analyzers may also be valuable in the recognition and classification of emissions, particularly complex emissions. Many types of emissions have certain peculiar combinations of characteristics which, when viewed on a spectrum analyzer by a trained observer, may provide valuable information leading to the recognition of the emission. Photographs of spectrum analyzer displays of known emissions may be kept available to the monitoring observer for reference and for comparison with questionable emissions.

Spectrum analyzers have also been used to advantage in connection with frequency measurements in the presence of interference, where matching of the frequency of the measuring equipment against the unknown frequency by aural methods is difficult. By observing the two signals on the spectrum analyzer, the frequency of the measuring equipment may be adjusted to that of the unknown carrier or to other discrete components in the signal.

5. Results that have been obtained using the method of measurement in which discrete components attenuated less than 26 db are considered to be within the band, show that satisfactory measurements of the spectra and bandwidths of emissions 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 which may cause interference.

6. Additional information concerning measurement of bandwidth may be found in Recommendation 327 (Volume I).

7. Conclusion

To explore fully the possible accuracy of observations at monitoring stations in approximating occupied bandwidth, as defined in No. 90 of the Radio Regulations, Geneva, 1959, studies will be required to compare such approximations with measurements made at the transmitter for the various types of emission and for regular traffic signals.

REPORT 276 *

MONITORING OF RADIO EMISSIONS FROM SPACECRAFT AT FIXED MONITORING STATIONS

(Question 188(VIII))

(Geneva, 1963)

Question 188(VIII) seeks information concerning methods and equipment desirable for measurement at fixed monitoring stations of emissions from spacecraft and practical means of identification by monitoring stations of emissions from specific spacecraft.

Information concerning these matters is contained in Docs. VIII/3 (U.S.A.) and VIII/15 (Japan) of Washington, 1962. The information in these documents may be summarized as follows:

1. Techniques of measurement

1.1 *General*

The main factors influencing the necessity for different techniques of monitoring observation and measurement of emissions from spacecraft as contrasted with observations and

* This Report was adopted unanimously.

measurements of emissions originating from fixed or mobile radio stations on or near the earth are, with reference to spacecraft:

- the difference between received and transmitted frequency, and the varying nature of the received frequency, caused by the Doppler effect;
- the generally weaker field-strength at the earth receiving point, due to distance and low transmitter power;
- the relatively short time that a signal from a near-earth orbiting satellite is receivable at a fixed monitoring point.

Administrations launching spacecraft will, of necessity, continue to provide for the required accurate tracking and telemetry reception to meet their special needs. However, monitoring stations responsible for the enforcement of domestic laws and regulations and engaging in international monitoring, pursuant to Art. 13 of the Radio Regulations, Geneva, 1959, will participate in space monitoring as a natural and necessary extension of their regular monitoring facilities, techniques and operations.

1.2 *Frequency measurements*

When there is a relative velocity between the spacecraft and the monitoring station, a difference of frequency proportional to the relative velocity arises between the transmitted and received signals owing to Doppler-shift effect. The apparent frequency of the transmitter in the case of an active satellite, as measured by a fixed monitoring station, is higher than the source frequency when the satellite is approaching the monitoring station and lower when it is receding. A measurement gives the source frequency only at the instant when the relative velocity between the source and the monitoring station is zero.

To determine the source frequency and the extent of Doppler shift, the basic requirement is a rapid frequency-measuring technique and a means of accurately timing each measurement. If frequency measurements are taken every few seconds and plotted against time, a curve is obtained from which the frequency at the point where the rate of change is greatest can be estimated with reasonably good accuracy, possibly to within $\pm$ 1 part in 10^6.

Doc. VIII/15 of Washington, 1962, describes a frequency measuring method which uses a discriminator, the object of which is to represent on a cathode-ray oscilloscope the waveform obtained by mixing the receiver output with a low-frequency saw-tooth wave (e.g. 25 or 50 c/s) from a separate source. The discriminator is used to determine the transmitted frequency by measuring the constantly changing frequency of the Doppler shift. When the figure remains stationary on the oscilloscope, the receiver output frequency is an exact multiple of the standard low-frequency. From the value of this exact multiple and the local oscillator frequency in the receiver, the exact frequency can be determined. By measuring the frequency each time the figure on the oscilloscope becomes stationary and plotting this against time, the curve of Doppler shift may be drawn.

1.3 *Bandwidth measurements*

The apparent bandwidth of a near-earth satellite, transmitted as measured at a fixed monitoring station, varies because of the Doppler-shift effect in the same manner as described for the carrier frequency. Althouth not of practical significance at present from an interference standpoint, it should be realized that the frequency shift is slightly greater for signal components near the upper edge of the spectrum of the emission than for those near the lower edge. This difference could amount to hundreds of cycles per second for the wide bandwidths proposed for some of the future spacecraft transmissions, on frequencies above 1000 Mc/s. This effect causes the apparent bandwidth as observed at the fixed monitoring point to vary slightly. However, it is doubtful that the currently available spectrum analyzers have sufficient resolution to detect it when the entire signal is being observed, under operating conditions of weak signal and relatively high background noise.

2. Equipment and facility requirements

2.1 *General*

In general, as in more conventional monitoring surveillance, equipment for monitoring signals from spacecraft must have adequate flexibility to cover a wide range of frequencies, in contrast to the spot frequency coverage that suffices for the needs of a research or operating space agency. The location of the monitoring station should be such that interference from man-made signals and noise is at a minimum.

Automatic sweeping of a band of frequencies, by varying the receiver tuning, and automatic recording of intercepted signals on a chart-type ink-line field-strength recorder, may assist in " acquiring " space signals and in timing their periods of reception.

An electronic counter, providing printed frequency and time records, has been found useful to meet the requirement of taking high-speed measurements to follow the Doppler shift.

For bandwidth measurements, it is desirable to employ a camera to photograph the spectrum display for later analysis. The exact time of taking the picture should be recorded on the film at the time of exposure.

Although good results have been obtained by tracking the satellite signals by manual adjustment of antenna azimuth and elevation, and by manual adjustment of the receiver tuning to follow the Doppler frequency shift, automatic tracking of both is suggested, if practicable. Further studies should be undertaken to determine practicable means to provide such tracking capabilities. Automatic antenna and receiver tracking will become of more importance for satisfactory monitoring at frequencies above 1000 Mc/s.

2.2 *Antennae*

Antennae ranging from fixed dipoles to log-periodic types capable of being rotated in azimuth and adjusted in elevation have been tested. The latter type has been employed for frequencies between 50 and 5000 Mc/s and has provided good general coverage over a 10 to 1 frequency range in a single antenna. Other antennae used successfully include a multi-bay Yagi, single and twin helical, conical helix, dipole with corner reflector, folded crossed doublets with half-wave phasing stubs between the doublets, 4-element folded dipole (in-phase array), and a series of uni-directional " V " antennae with a selective switching arrangement to change orientation. Studies are progressing for use of parabolic reflectors of up to about 8·4 m (28 ft) in diameter, for monitoring antennae to be used for frequencies in the 4000 Mc/s range and higher and using various antenna elements including a wide-band log-periodic array. Because of the quite sharp directivity of such high gain antennae, considerable care is required in acquiring and tracking the signals from the spacecraft.

2.3 *Receivers*

For economic reasons, and because a general-coverage receiver is required at monitoring stations, the extremely low noise figures possible for fixed-frequency receivers used for space research and operational purposes are not equalled by available monitoring receivers. However, the receiver should have a relatively low noise figure and be capable of receiving signals in the order of a few hundredths of a microvolt at the receiver input, and should have a wide range of adjustable bandwidth to permit reception of both wide and narrow-band transmissions from spacecraft.

2.4 *Specialized equipment*

To facilitate " acquisition " of the signal from a spacecraft, it is desirable to be able to sweep a narrow band of frequencies automatically and to record the received signals both aurally and on a field-strength recorder. A sweeping device has been developed for this purpose, using a semi-conductor diode as a voltage variable capacitor applied to the frequency-determining circuits of the receiver. In operation, the sweeping device is set to vary the receiver frequency over a band greater than the amount of predicted Doppler shift.

3. Identification of transmissions from spacecraft

Considerable thought has been given to the extent of the need by space Administrations and by monitoring stations for a call-sign or other special identifying signal to facilitate identification of emissions from spacecraft and of the effects of installation of equipment for that purpose. It has been concluded that neither need is great enough at present, nor likely to be in the near future, to warrant pressing for the use of an identifying signal.

The techniques employed for space research and operations in satellite and other spacecraft tracking, and foreseen for communications and other uses of space emissions, are such that special identifying signals are normally not essential. There normally being no requirement on the part of the tracker and user for identifying signals, to require their use to facilitate monitoring observations could impose limitations adversely affecting reliability, weight, cost and operation of the system involved.

It has been found possible to identify emissions from particular satellites from signal characteristics and ephemeris data. It would thus appear that the provisions of Article 19, No. 737 of the Radio Regulations, Geneva, 1959, relating to recognized means of identification other than call-signs, will be met if Administrations launching satellites and other space vehicles will continue to make such information currently available to monitoring services. The following information will assist in identification:

- carrier frequencies;
- orbit time;
- angle of inclination of orbit to equator;
- equator crossing time and longitude of crossing;
- perigee and apogee distances, and
- signal characteristics such as type of modulation and bandwidth for each frequency.

In addition, data on the transmitter power, antenna characteristic including antenna polarization and other related parameters will be useful in the prediction of reception.

From the ephemeris data, monitoring stations have been able to calculate when a particular satellite will be above the horizon for a particular monitoring station and the distances involved, to predict reception and assist in identification. A considerable amount of published information is available, regarding the techniques of satellite and spacecraft tracking and the problem associated therewith (see Bibliography and Recommendation 350).

3.1 *Special aids for determining satellite positions and expected reception times*

Graphical and slide rule aids have been found useful for determining reception time for spacecraft based on past reception data (see Doc. VIII/3 of Geneva, 1962).

3.2 *Direction finding as an identification aid*

To supplement determination of the exact time of closest approach of a satellite to a monitoring station, by noting the centre point of the maximum rate of Doppler shift of the carrier frequency, a curve can be plotted to show the change in direction of arrival of the signal with time, as determined by direction-finder bearings or orientation of a highly directional receiving antenna. The maximum angular rate of change will occur when the satellite is nearest to the monitoring station during a particular pass and the information obtained by this method should agree closely with the information obtained from the frequency/time curve.

3.3 *Future possibilities for monitoring procedures involving transmissions from spacecraft*

Procedures have been discussed herein for identification of transmissions from spacecraft, based on past experience of comparing the measured and observed signal characteristics with published information, and by comparing the time of closest approach to a monitoring station – as determined from the measured Doppler shift of the carrier frequency and from varying azimuth (bearing) – with ephemeris data. With the expectation of increased use of operational satellites, immediate positive identification by monitoring stations of all intercepted spacecraft emissions by these methods may become too time-consuming. Therefore, the following additional procedures may be necessary:

– a communications system involving either passive or active satellites could be identified by the identifying signal of the ground station reflected from or relayed by the satellite, even if this did not immediately identify the particular satellite of a multi-satellite system, and

– in enforcement-type monitoring of spacecraft emissions, particularly when noncompliance with radio regulations or cases of interference are observed, monitoring stations could log all possible information concerning frequency and bandwidth measurements, direction of signal arrival, type of modulation and other signal characteristics, together with accurate times of observation and measurements, and request identification, based on these data, from identification and tracking centres.

The time that the satellite is closest to the monitoring location on a given pass, as determined from Doppler-shift measurements, and the carrier frequency as measured for this time, will be of utmost importance to the space centre in effecting identification.

However, further consideration might be given to the incorporation of an appropriate identifying signal.

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REPORT 277 *

MEASUREMENTS AT MOBILE MONITORING STATIONS

(Question 144)

(Los Angeles, 1959 – Geneva, 1963)

1. Types of measurement

Subject to the limitations necessarily imposed by mobile operation, the size of suitable instruments and power consumption, it is considered to be practical to employ mobile stations to make all the measurements of emissions normally made at fixed monitoring stations.

Typical measurements and ranges are:

1.1	Frequency measurement:	10 kc/s to above 10 Gc/s
1.2	Field-strength measurement:	10 kc/s to above 10 Gc/s
1.3	Bandwidth measurement:	10 kc/s to above 10 Gc/s
1.4	Direction finding – with loops:	10 kc/s to 20 Mc/s
	– with dipole arrays:	20 Mc/s to above 1 Gc/s
	– with horns:	1 Gc/s to 10 Gc/s
1.5	Automatic monitoring of occupancy:	10 kc/s to above 300 Mc/s
1.6	Percentage modulation, FM deviation:	10 kc/s to 1 Gc/s
1.7	Video waveform measurement of television emissions:	40 Mc/s to 890 Mc/s

Mobile monitoring stations are particularly valuable for monitoring low-power stations and stations at frequencies above 30 Mc/s whose range is limited.

In addition to the use of equipment installed in a vehicle, certain measurements can also be made using portable equipment. Experience shows that separate mobile monitoring units, specifically designed for selected types of measurement, lend themselves more readily to operational use rather than a single vehicle equipped to make all classes of measurement.

2. Types of equipment

It is considered undesirable, to have to use special equipment for the mobile monitoring service and regular stock types of equipment with small dimensions, low weight and low power consumption are preferred. Since mobile equipment is subjected to vibration and shock, robust construction, together with shock-mounting of components, is important. With the exception of some portable units, the equipment is normally designed for operation at standard mains voltage and frequency.

It is preferred that instruments, such as frequency standards, which are sensitive to temperature changes, be designed to reach and maintain operating temperature in as short a time as possible, so that continuous application of power will not be necessary or so that only limited circuits will require continuous power. As an alternative, standards which are locked in synchronizm with VLF standard-frequency emissions should prove useful.

2.1 *Frequency standards and associated measuring equipment*

The frequency standard should be capable of maintaining a frequency stability of one part in 10^8 per day or better, after nominal warm-up periods and under the operating

* This Report, which replaces Report 168, was adopted unanimously.

conditions normally encountered in the mobile service. Currently available frequency standards, specifically designed for mobile use, are capable of stabilities of ± 1 part in 10^8 or better under field conditions.

2.2 *Field-strength measuring equipment*

The extent to which field-strength measuring instruments should be provided in a mobile monitoring station depends upon the purposes of the measurements. For regulation enforcement purposes, continuous coverage up to at least 1000 Mc/s is desirable. For obtaining propagation data, highly sensitive recorders operating on a fixed frequency have certain advantages, although the instruments used for enforcement measurements may also be used for this purpose with some compromise in sensitivity and frequency stability.

This discussion will deal only with tunable continuous coverage instruments.

Wherever possible, field-strength measurements should be made in an area where the signal field is relatively undisturbed by local reflections and re-radiation. Where there is strong dependence on location, measurements may be made in terms of median values, the recording being made continuously as a function of location or time.

The mobile station itself may contribute errors and the calibration includes antenna, receiver and recording equipment. It is desirable, therefore, that the equipment be portable so that measurements can be made away from the vehicle. To avoid directivity effects when measurements are made from the vehicle in motion, omnidirectional antennae are used. Since measurements of harmonic attenuation may involve comparatively weak signals, it is desirable that the field intensity meter be capable of the measurement of signal levels of the order of 1 μV/m. The instrument should likewise be immune to overloading from strong signals of 1 V/m or more. To attain satisfactory accuracies, considering that undisturbed fields are the exception at frequencies above 30 Mc/s, the errors contributed by the instrument itself should be less than ± 2 db. It is desirable that circuitry be incorporated for determination of peak and quasi-peak levels of pulsed emissions, as well as for the average field intensity of amplitude- and frequency-modulated and similar emissions.

2.3 *Bandwidth measuring equipment*

Authorized bandwidths, for stations assigned to the various VHF and UHF services, vary from less than 1 kc/s for radiotelegraph services to several Mc/s for television broadcast services. Mobile monitoring stations should, therefore, be equipped with spectrum analyzers having very flexible characteristics including a sweep width of 20 kc/s or less for narrow band emissions and with the capability of displaying at least 5 Mc/s of spectrum at a time on certain broadband emissions.

The sweep rate should be variable from about 1 to 30 sweeps per second to permit optimum utility for various types of observation. Provision should be made for either linear or logarithmic display of signal levels and calibrated scales should be provided for direct measurement of level ratios.

Mobile measurements of bandwidth may be made by a frequency occupancy recorder, for those types of modulation for which no measurement method of higher accuracy exists, or when it seems impracticable to carry out such measurements in the mobile service because of the high technical expense involved. With telegraph signals for instance, the bandwidth can be determined from the signal element with the shortest rise time (see Doc. VIII/10 of Los Angeles, 1959). In the VHF band, estimated bandwidths can also be read off the oscillograph screen of a panoramic set with a calibrated frequency scale. The measurement of bandwidth can also be made by a method of frequency analysis, using a very narrow (± 100 c/s) filter to measure the magnitude of the spectrum components passing through the filter in relation to the carrier.

2.4 *Direction-finding equipment*

It is desirable that the monitoring receivers in a mobile installation also serve as receivers for the mobile direction finder. Light weight, compactness, high sensitivity, effective shielding, stability, robust construction and low power consumption are desirable features for mobile monitoring receivers. Furthermore, receivers for mobile monitoring should provide continuous tuning coverage of as wide a frequency range as possible. Accurate calibration of the order of 1 kc/s at 30 Mc/s and below, and 10 kc/s above 30 Mc/s is highly desirable. Accuracy of frequency resetting of the order of 1 part in 10^4 or better is also desirable. Although band-switching is preferable, plug-in radio-frequency units for different bands may reduce the circuit complexity.

The loop rotater should preferably be installed in the approximate centre of the roof of the vehicle, with the loop socket extending through the roof and with the azimuth scale and rotating mechanism (usually a hand wheel) inside the vehicle at a convenient location. A number of plug-in-loops with different electrical characteristics will permit optimum results to be obtained over a wide range of frequencies.

Directional antennae are needed to extend the frequency range above the limits of loop antennae. Desirable characteristics are: high directivity, broadband frequency coverage, high gain, horizontal and vertical polarization and small size. Antennae types in use are horizontal and vertical dipoles, Yagi-beam, helical and rotatable H-type Adcock, while parabolic, horn type or corner-reflector antennae can be used above 300 Mc/s.

An antenna finding, increasing acceptance above 1 Gc/s, is a broadband horn covering approximately a 2 to 1 frequency range. For added gain and directivity, the horn may be mounted in a parabolic reflector.

2.5 *Automatic monitoring of occupancy measuring equipment*

Monitoring of spectrum occupancy, at specified locations or along specified paths, may be made in the mobile monitoring unit, by means of a frequency spectrum recorder or by means of a panoramic adaptor.

The latter permits visual observations to be made over a relatively small band of frequencies while the vehicle is in motion.

2.6 *Modulation measurement equipment*

It is desirable to provide facilities for measurement or percentage modulation of both amplitude- and frequency-modulated emissions. For the former, a cathode-ray oscilloscope with a wide band vertical amplifier usable up to 10 Mc/s or more is desirable. For measuring modulation deviation of FM emissions, an instrument capable of accurate measurement of carrier deviation, over a range from $\pm$ 5 kc/s or less to $\pm$ 100 kc/s or more, is desirable and should be capable of indicating instantaneous values. An overall accuracy of 5% or better is highly desirable. A cathode-ray oscilloscope may be used as an indicator for the carrier deviation meter to permit measurements of instantaneous peaks of deviation of FM stations.

2.7 *Television measuring equipment*

Measurements of the characteristics of the video waveform of television transmissions can be made with instruments specially designed for the purpose. Cathode-ray oscilloscope display of the various portions of the video signal is desirable so that individual picture lines or segments thereof, as well as individual synchronizing pulses, may be observed. Provision should also be made for viewing the entire picture on a screen of adequate size to permit evaluation of the picture quality.

2.8 *Power supplies*

To provide adequate power for large mobile monitoring units, a separate power unit either integral with the vehicle or mounted on a trailer may be used. An engine-alternator unit of 5 kW rating is usually adequate for this purpose. For the smaller mobile monitoring units, an alternator of about 500 watts driven by the vehicle fan belt is a useful source of power.

3. Accuracies and limitations of measurement

Most of the measurements listed in § 1 of this Report can be as readily performed with mobile as with fixed facilities, generally with little or no compromise in desirable accuracy.

3.1 *Frequency measurements*

Mobile frequency standards are available which will maintain stability better than $\pm$ 1 part in 10^8 per day under field conditions.

By means of frequency synthesizers or electronic counters, it is often possible to obtain direct measurements of the frequency of emissions without recourse to auxiliary interpolating instruments over a range of frequencies extending above 100 Mc/s. Transfer oscillator techniques may be used at much higher frequencies with interpolation between the transfer oscillator and the frequency standard being made with an electronic counter or other appropriate means. Measurement accuracies, within the desirable limit of $\pm$ 1 part in 10^7, may be accomplished under optimum conditions when the nature of the carrier is such, that a precise zero beat may be obtained or where direct counting techniques may be used.

On FM emissions, frequency averaging techniques with an electronic counter will provide an accuracy of 1 part in 10^6 or better.

3.2 *Field-strength measurements*

The accuracy of field-strength measurements above 30 Mc/s is limited, not so much by the instruments themselves, as by the local conditions which tend to distort the electromagnetic field, so that a considerable variation in field-strength over relatively short distances may be expected. This problem may be alleviated to some extent by making several measurements at each measuring location moving the antenna a few feet horizontally between measurements. Under average conditions, even when appropriate precautions are taken to ensure optimum accuracy, the accuracy cannot be depended upon to be better than $\pm$ 2 db. If large numbers of measurements are made as functions of time, location or distance, etc., the statistical evaluation will yield values of the quasi-maximum, quasi-minimum and median values with an accuracy of about $\pm$ 3 db or better, depending somewhat on the distribution of field-strengths. A major limitation of portable or mobile field-strength meters is the limited sensitivity, particularly at the higher frequencies. In the lower portion of the spectrum, up to several Mc/s, atmospheric noise is likely to be a limiting factor on the usable sensitivity, while at higher frequencies the noise introduced by the instrument itself becomes important. Under average field conditions and depending upon the frequency involved, the minimum field-strength, which may be measured with portable instruments with the accuracies mentioned above, will range from about 2 to 100 μV/m in the frequency range from 10 kc/s to 1000 Mc/s.

3.3 *Bandwidth measurements*

Generally, the same limitations apply on measurements of bandwidth by mobile installations as for measurements at fixed monitoring stations. The same measuring instruments are applicable to both types of installation. One advantage of mobile as contrasted with fixed installations is that, in the case of the former, measurements can often be made immediately adjacent to the transmitter, eliminating some of the measurement problems (such as those associated with interference and noise), which are mentioned in Report 275.

3.4 *Direction finding*

A major limitation of loop-type direction finders is their polarization error in the presence of signals with significant skywave components. A further serious limitation of a direction-finder, which depends upon the direction of arrival of the wave front, is the likelihood of local reflections or re-radiation from nearby objects such as buildings, transmission and telephone lines, etc. In an area where the wave is relatively free from distortion due to local conditions, where the path of arrival is essentially horizontal (vertically polarized wave), and taking into account possible errors introduced in orienting the direction-finder azimuth scale, accuracies of the order of $\pm 5^{o}$ with vehicle-mounted loop-type direction-finders are typical, with somewhat greater accuracy at frequencies below about 5 Mc/s. However, where the wave has been distorted by local conditions or where skywave components are present, bearing nulls are likely to be obscured or to deviate widely from the true direction of the emission source.

Where the ground wave is predominant (i.e. the ratio of ground-wave to reflected waves being at least 6 db), direction-finding loops may be used in the frequency range 10 kc/s to 30 Mc/s. The accuracy obtained depends upon the signal level and the equipment used.

Typical values for a direction-finding null 1^{o} wide are:

10 kc/s: 50 μV/m,
1000 kc/s: 15 μV/m,
20 Mc/s: 10 μV/m.

For the bearings of horizontally polarized signals (line-of-sight) at frequencies above 30 Mc/s, Yagi-beam antennae may be used in a maximum signal d/f method with an angular width of bearing indication of $\pm 15^{o}$.

For measurements made from a vehicle in motion, no proper bearing seems possible because of multiple reflections from nearby objects. However, when equipped with a visual indicator, mobile direction-finding sets will allow determination of a median value of the varying indications and hence yield an approximate direction.

3.5 *Monitoring of occupancy of the radio-frequency spectrum*

The accuracy obtainable from a frequency spectrum occupancy recorder depends upon the receiver and the overall calibration. Equipment used in the Federal Republic of Germany has the following characteristics:

- Sensitivity: better than 1 μV/m.
- Accuracy of field-strength indications: $\pm$ 3 db at angles of incidence below 60^{o}.
- Frequency stability of receiver: $\pm$ 5 parts in $10^5 \pm$ 40 c/s (where $\pm$ 40 c/s is the bandwidth of the filter).
- Accuracy of reading time markers: $\pm$ 1 min or $\pm$ 30 s.
- Adjustable maximum frequency spread on the recording strip by choice of appropriate gear reduction: 100 c/s per mm. When monitoring above 30 Mc/s by means of panoramic sets the resolving power may be about 400 c/s.

3.6 *Percentage modulation*

Cathode-ray oscilloscopes, with the desirable characteristics for measurement of percentage modulation of amplitude-modulated signals, are available. Accuracy of such measurements can usually be maintained within $\pm$ 5%. For measurement of carrier deviation, instruments are available which meet the desirable characteristics listed in § 2.6. Self-contained calibrators are provided to maintain an instrument accuracy better than 5%.

3.7 *Television measurements*

Instruments are available for performance of all desirable television measurements and observations mentioned in § 2.7. Measurement accuracy of the various instruments in most cases approaches or equals that of measurements which can be performed at a fixed location. Comparative level measurements of components of the composite video waveform, for example, can usually be made with an accuracy of 5 to 10%.

Measurements and observations, which may be performed with the equipment installed in a mobile television enforcement unit in the U.S.A., include:

- frequency measurements of television station carriers (including chrominance sub-carrier frequency of colour emissions);
- the precision frequency measuring equipment covers a frequency range of 20 to 1000 Mc/s with an accuracy under optimum conditions of 5 parts in 10^7;
- measurements of synchronizing pulse waveform and timing, video waveform and of colour video phase relationships;
- checking of video levels with respect to synchronizing pulse levels;
- measurements of bandwidth of television emissions including observations of spurious emissions at all frequencies between 54 Mc/s and 890 Mc/s;
- percentage of modulation rate of vision and sound emissions;
- measurements of distortion and noise level at audio frequencies.

REPORT 278 *

AUTOMATIC MONITORING OF OCCUPANCY OF THE RADIO-FREQUENCY SPECTRUM

(Question 255(VIII))

(Los Angeles, 1959 – Geneva, 1963)

This Report takes into consideration the documents presented up to the Xth Plenary Assembly of the C.C.I.R., Geneva, 1963.

1. Doc. VIII/2 (U.S.A.) of Washington, 1962

1.1 In considering the accuracy of automatic monitoring equipment in determining bandwidths of emissions, due consideration should be given to relating measurements of narrow-band emissions of the order of 2 kc/s or less to the characteristics of the particular instrument in use. It has been determined, for example, that in some instruments which mechanically sweep a frequency range and resolve the bandwidth presentation by selective circuits, the shape factor of the selective circuits is such as to complicate bandwidth determinations at other than accurately known comparison levels. The variation of received signal levels due to propagation conditions, together with other factors, impose restrictions on the accuracy of indicated signal bandwidth of narrow-band signals. Consideration should therefore be given to the need for an analysis of the relative distribution of the signal level and the resolving capability of the instrument at several input levels. For signals with bandwidths of several kc/s, the errors contributed by the above-mentioned equipment limitations become less important. Nevertheless, it may be desirable, in the interest of correlating data obtained with different instruments, to take into account their resolving power and the repetition rate and duration of discrete components of the observed signals.

In determining the accuracy of field-strength measurements made by automatic devices, the polarization and directivity of the antennae are important factors. In the 3 to 30 Mc/s range, where signals received over sky-wave paths contain both horizontally and vertically polarized components to a significant extent, a decision must be made as to the component to be measured. Since the vertical angle of arrival is most commonly less than 45°, less error will usually be introduced by measuring the vertically-polarized component rather than

* This Report, which replaces Report 167, was adopted unanimously.

the horizontally-polarized component. Where greater accuracy is required, an appropriate correction may be applied, based upon a computed value for the vertical angle of arrival of the wave front.

Measurement of the vertically-polarized component may readily be accomplished by using a vertical receiving antenna, the electrical length of which is appreciably less than one-quarter wave, for the frequency band under study. To reduce errors due to non-homogeneous earth in the vicinity of the antenna, a ground screen, together with radial ground wires extending out at least 30 m (100 ft.) in all directions has been found beneficial. The level of signal input to the recorder may be measured by comparison with a calibrated standard radio-frequency signal generator. The antenna effective height is determined by comparison with measurements made with an accurate field-strength meter using an antenna of like polarization.

In evaluating the field-strength data thus obtained, due allowance must be made for errors introduced by the various instruments. Allowance must also be made for fluctuations in signal-level, since, during the sweeping process, the receiver is tuned to a particular signal for only a small proportion of the time.

1.2 Measurement of signal-to-noise ratio primarily involves a comparison between signal and no-signal conditions making use of the same techniques as for field-strength measurements. In this instance too, variations in signal-level due to propagation must be taken into account. In the lower portion of the HF range, the problem is somewhat complicated, especially during the warm months of the year, by the generally high level of atmospheric noise, which is subject to wide variations in level, both instantaneous and over significant periods of time. The effect of receiver bandwidth and of the bandpass characteristics will also need to be considered, so that satisfactory correlation between measurements made with different equipment may be accomplished.

1.3 The preferred means of analyzing and evaluating automatic monitoring records depends primarily upon the information desired. In some instances, it may be desirable to obtain information concerning the direction of arrival of the various signals in the frequency band under study; this would provide data relating to the determination of channel occupancy with respect to the different azimuths of origin of the emissions. For example, a long-range direction finder may be associated with the automatic recorder in such a way that the azimuth would be advanced a small increment (such as one or two degrees) at the start of each sweep of the automatic recorder. Signal nulls and maxima could readily be determined by inspection of the chart. Additionally, data could be extracted from such recordings which would indicate occupancy in a given azimuth at regular intervals of time. In congested bands, the use of a directional antenna would also aid in reducing overlapping of signal traces.

Identification of the type of emission, by analysis of automatic recorder indications, is subject to shortcomings with narrow-bandwidth emissions, because of limitations in the resolving power of the instrument. However, those emissions occupying a significant bandwidth, such as multi-element tone printers, multiple-component multiplex, wide-shift simplex or multiplex and certain transient types of emissions, can frequently be catalogued by inspection of recorder indications, together with precise frequency increment chart calibration.

1.4 The degree to which records may be analyzed by automatic means would appear to be an economic rather than a technological matter. Because of the variety of data normally available from the automatic recorder, equipment for complete automatic analysis would necessarily be quite complicated. Such an analyzing system might employ transducers to convert chart components into digital or analogue data which could be handled by electronic data-processing equipment.

2. Doc. VIII/8 (Federal Republic of Germany) of Washington, 1962

The method of measurement described below permits the field-strength to be recorded continuously instead of in steps. From such field-strength recordings, the bandwidth and signal-to-noise ratios may be readily determined.

A potentiometer is mechanically coupled to the recording head of the occupancy recorder, supplying a d.c. voltage directly proportional to the relative position of the recording stylus on the recording sheet. After suitable amplification, this d.c. voltage is applied to the time base (x-plates) of a cathode-ray oscilloscope, thus providing a frequency scale exactly in synchronization with the sweep of the occupancy recorder.

The intermediate-frequency output of the receiver is connected to a multi-section analyzing filter (quartz crystal), the bandwidth of which is variable in steps between 30 and 100 c/s. After detection, the filtered signal is amplified in a logarithmic amplifier and fed simultaneously to the measuring (Y) plates of the oscilloscope and to the occupancy recorder. By special arrangements, the Y-axis is calibrated linearly over a range of 80 db. The oscilloscope screen, of the long-persistence type, allows direct observation during a full sweep of the occupancy-recorder. Automatic recording is effected by photographing the screen presentation of any individual sweep by means of a 35-mm camera. The shutter release may be actuated automatically, by means of a special control contact in the occupancy recorder. By means of a simple counter device, such as is used in telephone exchanges, it may easily be arranged that each single or any nth sweep is exposed on the film. Correlation between the photographed oscillograms and their corresponding sweep numbers is easily ascertained by photographing the counter, together with the spectrum pattern.

Evaluation of the oscillograms may readily be performed by projecting the developed negative on to the occupancy recording sheet, so that both frequency calibrating scales are made to coincide. The field-strength and bandwidth of a wanted emission, as well as its amplitude ratio relative to an unwanted signal, may thus be determined easily. The values taken from the photographs are, of course, instantaneous values present at a particular point of the spectrum at the moment when the filter swept through it.

The foregoing characteristics point to the limitations of the proposed method. Setting aside for the moment the influence of fading, which will be dealt with further below, the proposed method is suitable for recording continuous line spectra as well as periodically and quasi-periodically keyed emissions, i.e. practically any binary telegraph systems encountered in practice. Some difficulties arise, however, in the representation of non-periodic pulse emissions and of types of emissions with modulation envelopes which do not vary periodically; e.g. A3, A3A, A3B; in these cases, however, the amplitude of the carrier (or residual carrier) is recorded correctly.

The extent of the frequency range that can be explored is limited by the bandwidth of the analyzing filter which, to assure the desired resolution characteristic, should not be larger than 100 c/s, and by the exploration speed which should not greatly exceed 60 s per sweep. Since, for the intended purpose, the exploration rate with a filter width of 100 c/s should be 5000 c/s per second *, the maximum sweep range would be 300 kc/s wide. Recordings of signals subjected to fading can, of course, only show instantaneous values of the field-strength. The received field undergoes irregular variations between limits that can only be estimated by taking a large number of sequential photographs. Any estimate of the actual field-strength will normally be accurate within $\pm$ 4 db. The smaller the scanning range, the better the field-strength maximum will be discernible. If, in special cases, a more accurate measurement of the statistical variation of the field-strength is desired, a conventional single-frequency recording with subsequent analysis should be made.

3. Doc. VIII/12 (Japan) of Washington, 1962

3.1 The recording system is of the disruptive-discharge type, so that the records can be examined in the course of recording. Moreover, the recorded lines are very thin and the field-strength of signals can be indicated by the thickness of the lines.

* The time increment for any discreet spectrum component of the sweep signal is in this case 20 ms; the scanning speed of spectrum analyzers given in Annex I to Recommendation 327 are considerably lower, because fine analysis of the spectrum is desired. In most cases, however, the indication of field-strength, as found from the oscillograms, will be entirely adequate to give an overall picture of the conditions in the frequency range explored. This holds true similarly for the bandwidth and signal-to-noise ratios of the recorded emissions.

3.2 Since the filter in the recording unit (the rate of sweep being taken into account), has a pass-band 30 c/s wide, it resolves the frequencies very well. This enables one to identify the type of emission from the recording.

3.3 The frequency stability of the receiver unit is better than 1 part in 10^6 and the frequency scale (capable of calibration against the standard frequency), can be marked at 10 kc/s intervals. Therefore, the accuracy of reading the frequency is 300 c/s.

3.4 To determine the relative field-strength of each of the vertically recorded lines, a variable attenuator is placed at the intermediate-frequency stage in the receiver unit, and is inserted automatically step-by-step in succession at each fixed time of sweeping. Thus, the relative field-strength can be obtained from the amount of attenuation inserted.

Furthermore, to smooth the overall gain/frequency characteristics of the equipment, including the antenna system used, a vertical omnidirectional loaded antenna of wide band-width is used (the structure and electrical characteristics of which are shown in Figs. 1, 2 and 3).

3.5 *Accuracy in determining bandwidth*

This equipment is to record the relative distribution of the spectra of signals above a certain level, but it is not intended that the occupied bandwidth, as laid down in the Radio Regulations, Geneva, 1959, should be read from the recorded lines. Therefore, as the width of the spectrum of each signal at a certain level is considered as a bandwidth, studies were carried out to determine the accuracy with which the bandwidth might be estimated in this case.

This equipment, when used with a 100 kc/s swept frequency range and 60 sweeps per hour, is capable of determining the bandwidth of the spectra of various types of emissions at a given level to an accuracy of about 100 c/s.

3.6 *Accuracy in determining field-strength*

The method of measurement of field-strength by means of this equipment is the same as described in § 3.4. In this case, the larger the number of sweeps per step in the attenuator, the higher the accuracy of reading the recorded lines. Considered from the propagation characteristics, however, because of variations in field-strength, the increase in the number of sweeps and the prolongation of measurement brings a lack of reliability to the results.

On the other hand, in the field of reception at the monitoring stations in Japan, almost all radio waves, excluding those in the standard broadcasting service, are less than about 55 db (1 μV/m = 0 db). The lowest field-strength that this equipment is capable of recording is -10 db.

From various viewpoints above, it is concluded that it is best to complete one operation of measurement in a period not exceeding 20 minutes at 60 sweeps per hour, the number of sweeps per step of the attenuator being 2, and the attenuator having 10 steps of 6 db each, that is, 60 db.

Where measurements are taken with the 100 kc/s swept frequency range by the use of the equipment with the above characteristics:
- the overall gain deviation of the vertical omnidirectional loaded antenna and the receiver unit within the swept frequency range is within $\pm$ 0·8 db;
- the accuracy of reading the field-strength from the result of recording is within $\pm$ 4 db;
- the error of the attenuator at the intermediate-frequency stage is within $\pm$ 1 db.

Taken altogether, the accuracy of determination of the relative field-strength is $\pm$ 6 db. Further, if a suitable emission is selected from among those recorded and its field-strength is measured individually, the relative field-strength of each emission can then be obtained.

3.7 *Capability of automatic monitoring equipment in determining signal-to-noise ratios*

The lowest signal-to-noise ratio (for an equivalent noise bandwidth of 10 kc/s) that this equipment is capable of recording, is less than -10 db at the input terminal of the receiver, when the equipment is in the optimum condition of recording. In case of higher values than this, the signal-to-noise ratio can be determined by measurement of the intensities of signal and noise in the same way as the field intensity mentioned above.

4. Doc. VIII/11 (Japan) of Washington, 1962

4.1 *Measurement of relative field-strength*

A variable attenuator is added to the receiver unit of the equipment, the attenuation is automatically increased step-by-step in succession at each specified number of times of sweeping, and the signal output is recorded. The relative field-strength of each signal is determined by the attenuation inserted immediately before the recorded line fades out.

The absolute field-strength is obtained as follows: the absolute value of the wanted signal among those recorded is measured by means of a second field-strength meter, and, on the basis of this value, the absolute value of other signals is derived from the relative field-strength.

The total attenuation should be 60 db, to be equally divided into about ten steps. It is desirable to make the number of times of sweeping two per step in the attenuator.

The duration of each measurement should be about 20 minutes, taking account of fluctuation in field-strength due to variation in the radio propagation characteristics.

An antenna, with good frequency characteristics such as a vertical omnidirectional loaded antenna, should be used. (Such an antenna is illustrated in Fig. 1, and its characteristics are given in Figs. 2 and 3.)

5. Occupancy-vacancy recorder

Another type of equipment now in use is called an " occupancy-vacancy recorder ". This system indicates, by an inked line on a strip recorder, the presence or absence of a signal. As the instrument scans the spectrum, a continuous line is drawn on the chart to indicate the presence of signals. In the absence of a signal, the recorder and frequency scanning mechanism stop for a pre-set interval. If no signal appears during this interval, the recorder makes a dot on the chart, the system moves forward a small increment and repeats the procedure. When signals are again encountered, the device moves on steadily until the next vacant spot is found. The equipment is provided with a special circuit that automatically adjusts the sensitivity to one or two pre-set values, the sensitivity being changed alternately at the end of each scan. Each scan makes a new trace, roughly parallel to the previous one. In this manner, approximately 48 hours of data can be placed on a single strip.

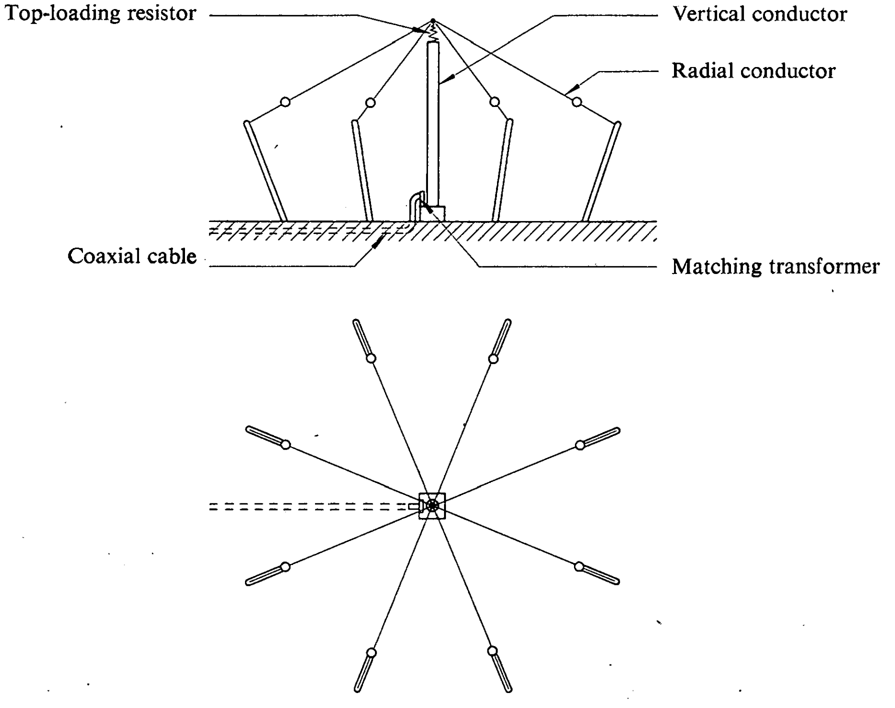

FIGURE 1

Vertical omnidirectional loaded antenna

Loading resistor: 250 ohms
Radial conductor length: 8 m
Vertical conductor length: 8 m

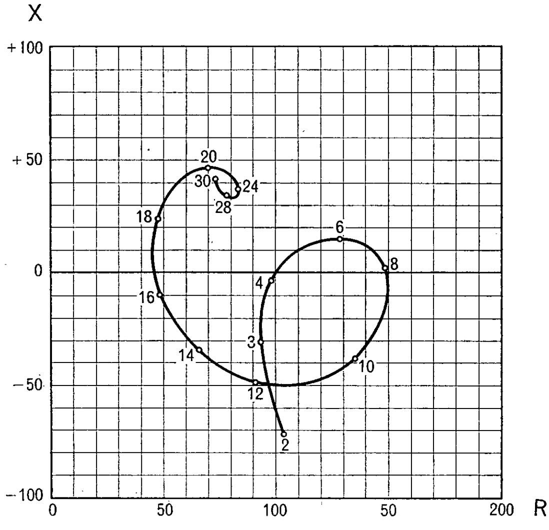

FIGURE 2

Impedance characteristics of a vertical omnidirectional loaded antenna
(see Fig. 1)

SWR: 2·0 (except at 2 Mc/s),
(The points on the curve represent the frequency in Mc/s)

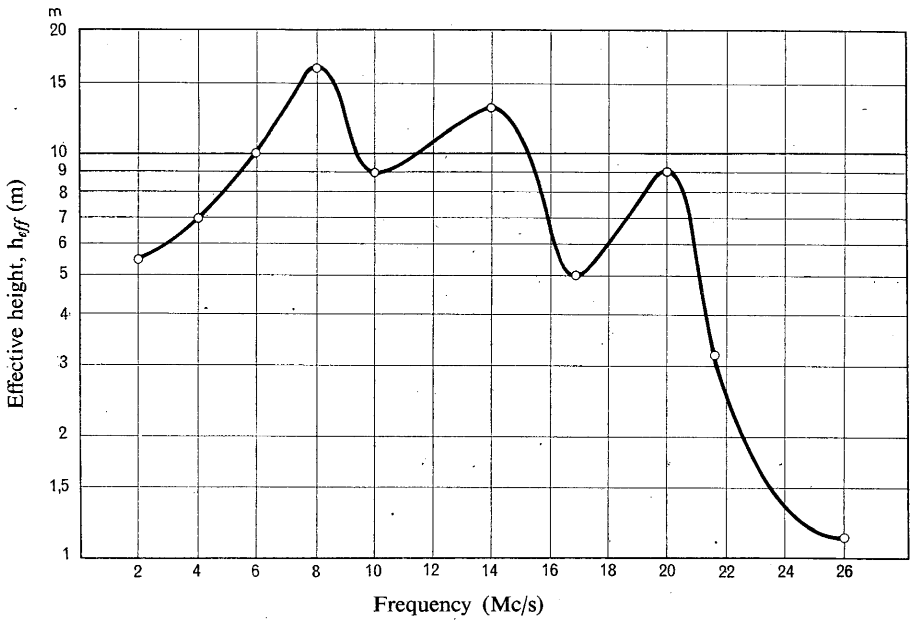

FIGURE 3

Effective height of a vertical omnidirectional loaded antenna
(see Fig. 1)

REPORT 279 *

VISUAL MONITORING OF THE RADIO-FREQUENCY SPECTRUM

(Question 191(VIII))

(Geneva, 1963)

Question 191(VIII) seeks information on preferred equipment and preferred methods for visual monitoring of broad ranges of the radio-frequency spectrum. The following is a report of progress to date, as summarized from the responses to this Question (Docs. VIII/9 (U.S.A.), VIII/19 (Belgium), and VIII/26 (United Kingdom) of Washington, 1962).

Except for the use of spectrum analyzers for signal analysis, and use of panoramic-type receivers or adapters for observation of limited widths of the radio spectrum, stations of the international monitoring system have reported little actual experience in visual monitoring operations. Further development of methods and procedures must await actual experience in the use of broadband spectroscopes at monitoring stations.

1. Spectrum analyzers are valuable in the recognition and classification of emissions especially the complex emission. The spectrum analyzer is a scanning type of instrument arranged to display, on a cathode-ray tube, the spectral contents of the frequency band under examination. Spectrum analyzers of various types are under development or in operational use.

1.1 A spectrum analyzer, described in Doc. VIII/26, can be used as a panoramic receiver covering the frequency range of 25 Mc/s to 140 Mc/s and employing a wide sweep. The width of the sweep can be varied continuously between 1% and 55% of the tuned frequency. Two output filters are incorporated, one with 7 kc/s bandwidth for sweeps up to 5 Mc/s, the other with 35 kc/s bandwidth for sweeps of over 5 Mc/s. Resolution varies from 8 kc/s for a 250 kc/s sweep to 100 kc/s for a 70 Mc/s sweep. Sensitivity varies between +48 db and +54 db relative to 1 μV across 75 ohms, for frequencies of 25 Mc/s and 40 Mc/s respectively, to give full deflection on the screen. Frequency markers at 10 Mc/s intervals and at 2 Mc/s intervals can be applied at will, appearing as a bright (or dark) spot on the trace, the 10 Mc/s markers being distinguished by double spots.

1.2 The principle on design of a spectroscope is described in Doc. VIII/9. The first of these units is expected to cover the frequency range 100 Mc/s to 1000 Mc/s. The ultimate range of the equipment is expected to be 14 kc/s to 10 Gc/s. The principle involved is that of heterodyning the incoming signals by means of a local sweeping oscillator to produce an intermediate-frequency. Increased selectivity is obtained by further conversion to a second lower intermediate-frequency. Selective filter bandwidths of 5 Mc/s, 1 Mc/s and 400 kc/s are obtained at 775 Mc/s. The first intermediate-frequency of 775 Mc/s is converted down to 30 Mc/s where, using crystal filters, bandwidths of 25 kc/s and 5 kc/s are obtainable, enabling relatively fine spectral details to be observed. This allows selection of the desired bandwidth and resolution commensurate with the sweep rate selected which should be continuously variable over a wide range. Read-out may be either linear or logarithmic. In the latter instance, a separate amplifier is provided to give a dynamic range of 140 db for display of relative signal strengths. A large cathode-ray tube (17 inch) is used for displaying the spectrum, the vertical displacement being a function of the signal strength and the horizontal

* This Report was adopted unanimously.

sweep being synchronized with the sweep of the local radio-frequency heterodyning oscillator. The average overall sensitivity of the equipment at 5 Mc/s bandwidth should be approximately −90 dbm. Tests have indicated that 100 to 1000 Mc/s wide band RF amplifiers for RF spectroscope use are capable of a 6–9 db noise figure, a gain of 25–40 db, a sensitivity of −105 dbm and an image rejection of better than 60 db.

1.3 A wide-band spectrum analyzer is available commercially which can be used by monitoring stations for visual observation of a band 70 Mc/s wide in the range 10 Mc/s to 44 Gc/s. With two dispersion ranges, 0 to 70 Mc/s and 0 to 5 Mc/s, it can be used for broadband observations of up to 70 Mc/s. The analyzer is normally equipped with a 5-inch display oscilloscope; however, a 17-inch oscilloscope is available for comprehensive frequency monitoring.

2. It has been found that a panoramic view of a broad portion of the radio-frequency spectrum can be presented on a cathode-ray tube, by the use of suitable sweep circuits in the radio receiver or in an associated panoramic adapter. Panoramic receivers or panoramic adapters are under development or in operational use.

2.1 A panoramic receiver is described in Doc. VIII/26, which consists of an HF communication receiver and a panoramic adapter in a single cabinet, to provide a visual oscilloscope display in any selected band between 1 and 30 Mc/s. Scanning is limited to a band lying between two adjacent multiples of 1 Mc/s. Sweep width can be varied continuously between 60 kc/s and 1·04 Mc/s. The frequency of the sweep can be either 1 or 10 per second. Output filters 1·2 kc/s, 3 kc/s, and 8 kc/s are provided. Either linear or logarithmic presentations are available. 100 kc/s frequency markers can be applied at will.

2.2 Panoramic equipment, designed for visual supervision of mobile services operating in the VHF bands, is described in Doc. VIII/19. A panoramic adapter used with a VHF receiver covers the bands 30 to 180 Mc/s or 85 to 300 Mc/s with an intermediate-frequency of 21·4 Mc/s. Spectrum width is 1·2 Mc/s. The selective filters consist of three fairly low frequency (2 Mc/s) amplification stages, in the form of three double-tuned transformers adjusted below the critical coupling. Visual display is made on a 5-inch oscilloscope.

2.3 A second type is not associated with an external receiver and does not include sound. The radio-frequency spectrum from 70 to 190 Mc/s is examined in small sub-bands of 10 Mc/s; harmonics from a 1 Mc/s crystal oscillator are introduced into the pre-amplifiers; reference markers at 1 Mc/s intervals are thereby obtained on the oscilloscope. Visual display is made on a 5-inch oscilloscope (Doc. VIII/19).

3. Cathode-ray tubes of various size are employed for visual observation. A 17-inch tube with a P-7 screen and amber filter is suggested on the basis of studies to date. Further development may make practical the use of larger tubes, or multiple-trace tubes, to extend the frequency axis of display (Doc. VIII/9).

4. To provide a uniform response in amplitude read out on the broadband spectroscope display, it is of course necessary to employ wideband antennae. In using the spectroscope for simultaneous observation of a large part of the spectrum, it is necessary to compromise on the selection of the antennae. The antennae giving the best results with spectroscopes are: rhombics, log-periodic types, and vertical antennae which are shorter than a quarter wavelength at the highest frequency under observation (Doc. VIII/9).

5. Recent developments in the design of broadband amplifiers, and their availability, leave few, if any difficulties regarding the broadband RF amplifier units for spectroscopes. One wideband amplifier has a frequency response flat within ± 1·5 db from 1 kc/s to 200 Mc/s. a voltage gain of 20 db, a noise figure of 9 db and a rise time of less than 0·0026 μs (Doc, VIII/9).

6. Conclusions

Within the next few years, it is expected that various types of " broadband " spectroscopes for visual monitoring will become available for use at monitoring stations. The trend in design and construction of spectrum analyzers is towards an increasing value of total scanning excursion (sweep width).

Several units will probably be required to simultaneously cover the spectrum from 10 kc/s to 1000 Mc/s; however, at the present time no need has been shown for such simultaneous coverage. Rather, a monitoring station will probably find it more convenient to observe only one broad segment of the spectrum at a time.

Actual experience is needed in developing operating methods and techniques in the use of " broadband " spectroscopes for monitoring purposes. Therefore, it is advisable that studies under Question 191(VIII) be continued.

REPORT 280 *

IDENTIFICATION OF RADIO STATIONS

(Question 256(VIII))

(Warsaw, 1956 – Los Angeles, 1959 – Geneva, 1963)

1. This Report summarizes the contributions and discussions in response to Question 256(VIII). It also retains that material from Report 280 which was considered to have an application to the adoption by Administrations and operating agencies either of the provisions of Recommendation 379 or of other methods of identification and operating procedures relating thereto, as discussed in this Report.

2. Since the IXth Plenary Assembly, some progress has been made, particularly with respect to phase-modulation of multichannel FSK systems, whereby the identifying signal can be sent simultaneously into all circuits using the same sub-carrier. This results in centralization of identifying signals (Doc. VIII/14 (Japan) of Washington, 1962).

2.1 The sub-carrier is directly phase-modulated by the modulator circuit added to the transmitting terminal equipment, and the identifying signal can be supplied simultaneously to all circuits using the same sub-carrier, by means of a distribution amplifier.

Because of the small modulation index required, a simple device consisting of a single transistor is sufficient for the purpose. The modulated signal is keyed in Morse code and its amplitude adjusted so that, whatever the class of amplification, the specified modulation index is independent of the frequency of the emission, type of emission, etc. The modulation index can be measured accurately during the operation time of the circuit regardless of traffic in progress.

The intelligibility of the identifying signal is affected by the modulation index and the modulating frequency. In F1 or F6 emission, the modulation index is suitable at 0·05 and no great difference in intelligibility occurs for modulating frequencies between 500 to 1000 c/s. In a composite circuit of F1 and F6 emissions, it is desirable to have the modulation index greater than 0·05 and the modulating frequency no less than 600 c/s.

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* This Report, which replaces Report 171, was adopted unanimously.

3. Two additional methods have been used for identifying F1 emissions simultaneously with traffic:

3.1 One method (Doc. 468, of Warsaw, 1956), is to superimpose an audio-frequency 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 additional sidebands on either side of the main carrier with a 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 identifying signal at a rate of 8 w.p.m. is used. The keying device consists of a notched " keying wheel " through which a beam of light is projected thereby operating a photo-electric cell. An ordinary communications receiver, with the beat-frequency oscillator turned off, is used for reception of the keyed identifying signal.

3.2 Another method has been developed which superimposes on the carrier an additional frequency-modulation at small index and at 400 c/s, keyed by the identifying signal. The conditions under which the method is used and the results obtained are described in Doc. 183 of Los Angeles, 1959.

4. Keyed amplitude-modulation, which is superimposed on frequency-modulation for identifying signals has, for economic reasons, not been generally applied because the method used employed high-level modulation.

A method for identifying single-sideband multi-channel systems by the insertion of a keyed audio tone on one of the channels was found to be unsatisfactory due, particularly, to the difficulties encountered by monitoring observers.

REPORT 281 *

IDENTIFICATION OF SOURCES OF INTERFERENCE TO RADIO RECEPTION

(Question 257(VIII))

(Geneva, 1963)

This Report shows progress made, methods used, and suggests future procedure, as noted in Docs. VIII/7, VIII/23 and VIII/30 of Washington, 1962.

At the date of this Report, one can only give a partial answer to Question 257(VIII). Much work has been done, but the ultimate production of a catalogue ** is complex. Uniform standards of measurement between the various countries have not yet been developed, and such standards are essential to make a catalogue of international value.

The preparation of a catalogue should proceed in the following order of importance:

- information primarily for use at monitoring stations to aid in solving cases of harmful interference at international level;
- information to aid in identifying the sources of industrial interference.

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* This Report was adopted unanimously.

** The term " catalogue ", as used in this Report, denotes an index of information such as photographs, magnetic-tape recordings, written descriptions, drawings, etc., describing the interference.

The replies to Question 257(VIII), relating to television interference have been quite adequate, although uniform standards of measurement and portrayal have not been developed.

Information on interference to television, obtained so far, has embraced interference caused by, or due to, the following:

- faulty adjustment of the television receiver,
- defects in television receivers,
- inherent design defects in the television receiver,
- ignition interference,
- communication equipment,
- domestic electrical apparatus,
- devices with " break " contacts,
- Radar,
- receiver radiation,
- high voltage power lines,
- neon signs,
- lighting equipment,
- electro-medical devices,
- calculating machines and cash registers,
- multipath reception,
- video interference from aural emissions,
- high-frequency generators for industrial use.

There are many other specific cases that may be included in some of the broad categories above.

It has been pointed out, in some of the replies to Question 257(VIII), that the degree of distortion of the television picture resulting from the interference will vary slightly with the class or characteristic of the receiver, but the main features of the distortion are maintained. From this it may be assumed that the standards for the catalogue of television interference need not be as rigid as the standards for catalogues of interference to other services such as those using the HF portion of the spectrum (3 to 30 Mc/s). This is because HF measuring equipment varies over wide limits in such characteristics as:

- bandwidth,
- selectivity characteristic,
- characteristics of oscilloscopes, spectroscopes and others.

The reply to Question 257(VIII), regarding a catalogue of interference in the HF range (3 to 30 Mc/s), that would be of use to monitoring stations, is not complete.

The procedures for preparing this catalogue involve search of the literature and publications relating to interference, principally for the purpose of determining how the characteristics are described or illustrated (see Bibliography).

Reviews have been made of listed descriptions, illustrations, magnetic-tape recordings and films used by Administrations and private industry. Information from many professional engineering groups is being used in the study.

A large part of the data developed thus far has been for the specific use of monitoring personnel and trainees.

Some of the monitoring stations have made aural tape recordings, oscilloscope photographs, and written descriptions of individual characteristics of interference.

From reports received in reply to Question 257(VIII), it is apparent that nothing has been found to date in the published work of the C.I.S.P.R. which can be directly related to this study; however, full account should be taken of future C.I.S.P.R. work.

The need for a catalogue of interference characteristics of radiations and uniform standards of measurement is urgent and is particularly desirable as aids to personnel at monitoring stations. Means must be found to publish such a catalogue.

To accelerate the assembly and publication of the available information, Resolution 16 has been adopted.

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REPORT 282 *

INTERNATIONAL MONITORING FACILITIES

Reply to Recommendation No. 5 of the Administrative Radio Conference, Geneva, 1959

(Resolution 15)

(Geneva, 1963)

With reference to Recommendation No. 5, adopted by the Administrative Radio Conference, Geneva, 1959, the I.F.R.B. has prepared a map (see Fig. 1), showing the distribution of monitoring stations throughout the world notified to the I.T.U. and participating in the international monitoring system, in the bands below 28 Mc/s.

For this purpose the world has been divided into 10 main areas, each divided into a number of sub-areas; the boundaries of the main areas are printed in heavy lines, while those of the sub-areas are shown by thinner lines, and correspond to the Geographical Zones for broadcasting given in the Annex to Appendix 1 of the Radio Regulations, Geneva, 1959. The numbers shown inside circles on the map are the code numbers assigned to the various main areas, while the code numbering for the sub-areas is that used in the said Annex to Appendix 1 to the Radio Regulations, Geneva, 1959.

The numbers appearing between brackets on the map represent the number of monitoring stations notified to the I.T.U. for the sub-areas concerned.

Considering the practicality of establishing new monitoring stations, experience has indicated that Administrations will continue to locate and operate monitoring stations primarily to serve their own domestic needs and to fulfil their obligations under Nos. 675 and 676 of the Radio Regulations, Geneva, 1959. Cooperating Administrations will use part of the time of such stations, to make monitoring observations at the request of the I.F.R.B. and to furnish data on spectrum-occupancy for use by the I.F.R.B. Thus, from a practical viewpoint, it would appear that expansion of the international monitoring system to close present gaps in the world coverage depends almost entirely upon:

- establishment of monitoring facilities by countries having none at present but having the desire and domestic need for such facilities;
- expansion of the number of stations where a country has at present a system inadequate to meet its own needs;
- expansion of monitoring positions or other facilities at existing stations, or readjustment of work effort, to provide more data for the I.F.R.B.;
- co-operation in the international monitoring effort by Administrations having monitoring stations, but not yet furnishing spectrum-occupancy or other monitoring data to satisfy the requirements of the I.F.R.B.

Accordingly, it is suggested that the best approach to obtain expansion of international monitoring facilities to secure the desired results which prompted Recommendation No. 5, is for the Union and the I.F.R.B. to follow up §§ 1 and 2 of this Recommendation relating to the required efforts of Administrations, as envisaged in Art. 13 of the Radio Regulations, Geneva, 1959.

* This Report was adopted unanimously.

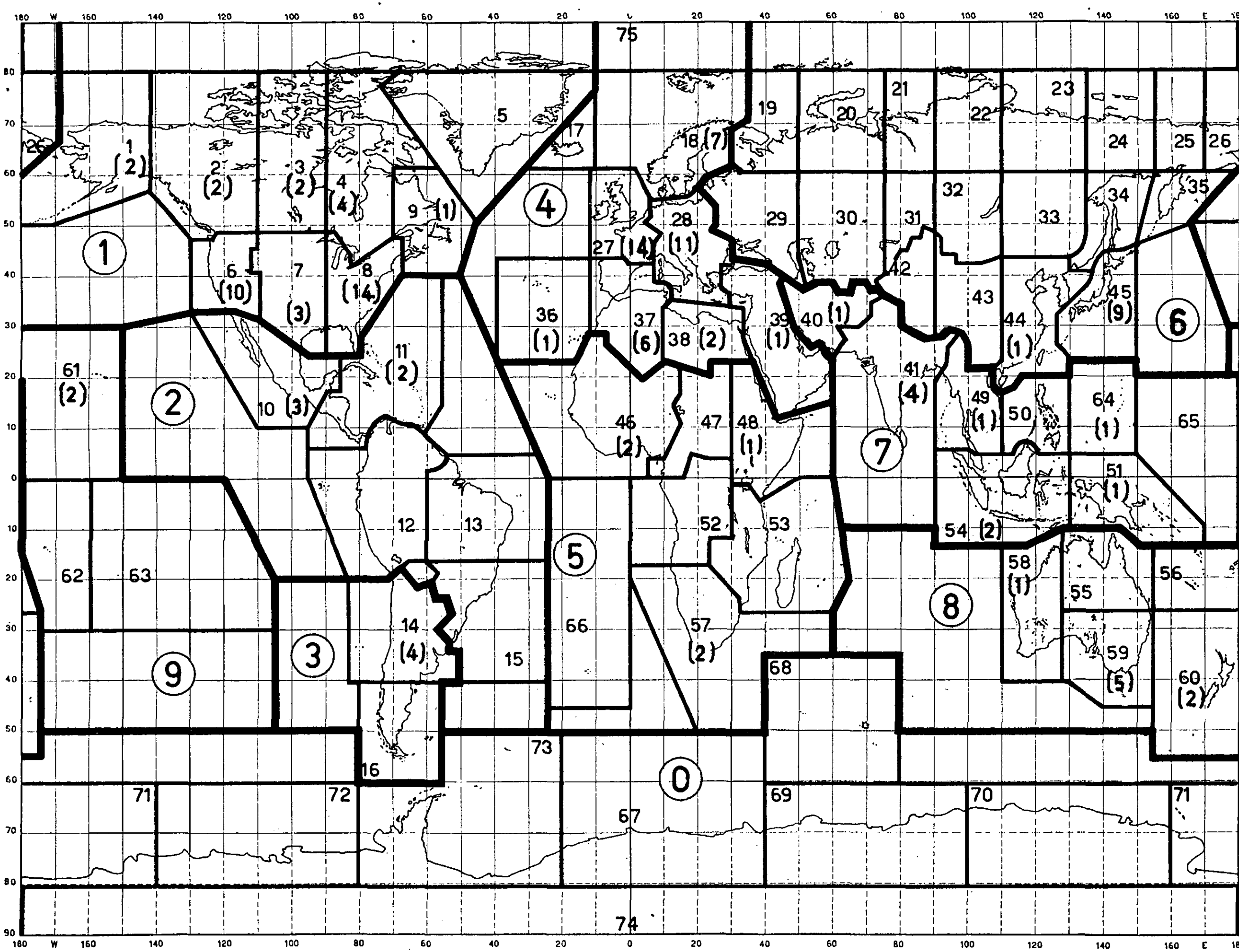

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FIGURE 1

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STUDY GROUP VIII

(International monitoring)

Terms of reference :

To study technical and operating problems, the solution of which depends principally on considerations of a technical character relating to monitoring stations participating in the international monitoring system with regard to:

1. in collaboration with the I.F.R.B., ways in which harmful interference can be verified and reported, in accordance with the International Telecommunications Convention and the Radio Regulations;

2. the development of methods and procedures to be used by monitoring stations in determining occupancy of the radio-frequency spectrum and the characteristics of emissions and in locating the source of an emission by direction-finding techniques;

3. specifications regarding the selection of sites, antennae and other equipment and instrumentation.

Chairman : Mr. G.S. Turner (U.S.A.)
Vice-Chairman : Mr. M. Amaro Vieira (Portugal)

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP VIII

1. Subjects on which action has, in principle, been concluded

1.1 *Organization of an international monitoring system*

Report 282 shows the international monitoring facilities.
Resolution 15 urges the Administrations concerned to extend the international monitoring system on a world-wide scale.

1.2 Although no Question is under study, Report 277 was brought up-to-date in Geneva concerning *measurements at mobile monitoring stations.*

1.3 The contributions to Question 189 show that *correlation between measured S-values and field-strength* was not possible to a sufficient degree of accuracy. Report 274 therefore terminates the study of this Question.

2. Subjects on which partial answers already exist but which require further study

2.1 Recommendation 377 and Report 272, dealing with *frequency measurements at monitoring stations*, are among the texts which must be revised repeatedly to take account of advances in electronic techniques.

2.2 *Field strength measurements at monitoring stations.* While Study Programme 102(VIII) has remained unchanged since Warsaw, 1956, Recommendation 378 and Report 273 were redrafted. A new Question 253(VIII) was adopted, asking for an expeditious method of determining field-strength in monitoring stations.

2.3 The information available on *bandwidth measurements* was insufficient to permit a Recommendation to be issued. Report 275 and Study Programme 207(VIII) deal with this problem.

2.4 *Identification of radio stations.* Recommendation 379, Report 280 and Question 256(VIII) represent modifications to previous texts. Opinion 11 was adopted, asking the I.F.R.B. to prepare a list of stations using special means of identification.

2.5 Recommendation 182 concerning *automatic monitoring of occupancy of the radio-frequency spectrum* remains unchanged, while Report 278 considerably modifies the preceding text, in that it includes the contents of the various contributions.

2.6 Report 281, *Identification of sources of interference to radio reception* is the first step towards the production of a " catalogue " or, in other words, an index of information such as photographs, magnetic tape recordings, written descriptions, drawings, etc. describing the interference.

In Resolution 16, Administrations are encouraged to send to the C.C.I.R. Secretariat all information to be published in such a catalogue.

2.7 In the field of *Visual monitoring of the radio frequency spectrum*, Report 279 shows the present status of this technique. It is expected that in the future various " broadband " spectroscopes will become available.

2.8 The present knowledge of *monitoring at fixed monitoring stations of radio transmissions from spacecraft* is laid down in Report 276.

3. New Questions

3.1 *Monitoring of sweeping-type pulse emissions.* Question 226(VIII) was adopted by correspondence in 1962.

The following three questions were adopted by the C.C.I.R. Xth Plenary Assembly, Geneva, 1963.

3.2 *Direction finding at monitoring stations :* Question 254(VIII).

3.3 *Types and methods of assistance by monitoring stations to the operation of various radio services :* Question 259(VIII).

3.4 *Antennae for monitoring stations :* Question 258(VIII).

3.5 During its meeting in Geneva, February 1963, the Plan Sub-Committee for Asia submitted to the C.C.I.R. Question 275(VIII): *Monitoring in new and developing countries.*

RESOLUTION 15

EXTENSION OF THE INTERNATIONAL MONITORING SYSTEM TO A WORLD-WIDE SCALE

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that Recommendation No. 5 of the Radio Regulations, Geneva, 1959, stresses the urgent need for improvement in the international monitoring system and invites Administrations to make every effort to develop monitoring facilities;

(b) that there are still wide areas of the world where the facilities available to the international monitoring system are inadequate or non-existent;

(c) that it is of utmost importance, to satisfy the needs of the I.F.R.B. laid down by the Radio Regulations, that all countries having domestic monitoring facilities make them available for international monitoring to the maximum possible extent;

(d) that it is recognized that certain stations may participate in only a limited part of the whole field of monitoring;

(e) the importance, for the safety of life at sea and in the air, of the international monitoring system in ensuring the correct use of the radio-frequency spectrum by the mobile services;

UNANIMOUSLY DECIDES

1. that all Administrations now participating in the international monitoring system should be urged to continue to do so to the maximum extent possible;

2. that Administrations who do not at present participate in the international monitoring system should be urged to make monitoring facilities available to that system, in accordance with Art. 13 of the Radio Regulations, Geneva, 1959;

3. that Administrations located in those areas of the world where monitoring facilities are inadequate (as indicated by Report 282), should be urged to promote the establishment of monitoring stations for their own use and make them available for international monitoring, in accordance with Art. 13 of the Radio Regulations, Geneva, 1959;

4. that Administrations should monitor radio stations in the mobile services systematically, in particular those stations serving maritime and aeronautical needs.

RESOLUTION 16

IDENTIFICATION OF SOURCES OF INTERFERENCE TO RADIO RECEPTION

(Question 257(VIII))

The C.C.I.R., (Geneva, 1963)

CONSIDERING

the urgent need for the collection of visual and/or aural records of the typical characteristics of various classes of interfering radiations, as an aid to personnel at stations in the international monitoring system;

UNANIMOUSLY DECIDES

1. that each Administration should be encouraged to provide the C.C.I.R. Secretariat with information on the typical characteristics of interfering radiations, such information to be published as a catalogue; *

2. that Administrations should submit information in the following order of priority;

2.1 information primarily for use at monitoring stations, which would assist in solving, at international level, cases of harmful interference;

2.2 information which would assist in identifying sources of industrial interference.

OPINION 11

LIST OF STATIONS USING SPECIAL MEANS OF IDENTIFICATION

(Question 256(VIII))

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that the Radio Regulations, Geneva, 1959, set forth requirements for transmission of identifying signals by radio stations;

(b) that certain types of radio stations are exempted from the necessity of having a call sign from the international series, for example, stations which are identified by other means;

(c) that many stations using complex or special types of emissions cannot be identified by ordinary means;

* The term " catalogue ", as used in this Resolution, denotes an index of information such as photographs, magnetic-tape recordings, word descriptions, drawings, etc., describing interference (see also Report 281).

(d) that the monitoring stations participating in the international monitoring system need to be supplied with all the available information on means of identification used by radio stations;

IS UNANIMOUSLY OF THE OPINION

1. that the I.F.R.B. should be asked to prepare, on the basis of information received from Administrations, the list of stations which use special identification means; this list to contain the identifying signal, frequency, method of identification used, time of identification, and other pertinent information;

2. that this list should be kept up-to-date by appropriate supplements.

QUESTION 188(VIII)

MONITORING AT FIXED MONITORING STATIONS OF RADIO EMISSIONS FROM SPACECRAFT

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that the rapid advances in recent years in space technology, including the successful launching of earth satellites, portend greatly expanded activity in outer space, including the likely eventual establishments of " space platforms ";

(b) that radio will play a major part in these space activities as regards communication, navigation and data collection and transmission;

(c) that " space platforms " might find a variety of uses in the telecommunication field;

(d) that the accurate measurement at a fixed monitoring station of frequency, spectrum occupancy and certain other technical characteristics of emissions from transmitters on the spacecraft and platforms, will tend to be more difficult than on fixed or relatively slow moving sources of emission on or near the earth;

UNANIMOUSLY DECIDES that the following question should be studied:

1. to what extent will the techniques of measurement, from fixed monitoring stations on the earth, of emissions from spacecraft differ from those for emissions originating from or near the earth;

2. what are the requirements for specialized equipment or associated facilities for performing frequency, spectrum occupancy, and other measurements of emissions from spacecraft;

3. what practical means can be devised for the identification, by monitoring stations, of emissions from specific spacecraft?

QUESTION 191(VIII)

VISUAL MONITORING OF THE RADIO-FREQUENCY SPECTRUM

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that every useful means of monitoring observation and measurement should be employed at monitoring stations, including visual methods employing a radio-frequency spectroscope;

(b) that a panoramic view of a portion of the radio-frequency spectrum can be presented on a cathode-ray tube by the employment of suitable sweep circuits in the radio receiver or in an associated panoramic adapter;

(c) that the simultaneous presentation of broad ranges of the spectrum on one or more cathode-ray tubes would provide for a rapid determination of spectrum occupancy, frequency, amplitude and harmonic content (if one or more octaves are presented) of individual signals, and broadband coverage characteristics of signals, including interference;

(d) that, although panoramic adapters have been employed to some extent in monitoring stations as an adjunct to aural monitoring, it appears that more information can be obtained visually by monitoring observers, particularly in broadband visual presentation of the spectrum;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the preferred equipment and the preferred methods for visual monitoring of broad ranges of the radio-frequency spectrum with regard to:

1.1 receivers and associated frequency-sweep circuits;

1.2 cathode-ray tubes (including practicable size);

1.3 antennae and associated broadband amplifiers and impedance-matching circuits;

2. what radio-frequency ranges can be presented simultaneously on one or more cathode-ray tubes of a spectroscope, taking into consideration the frequency characteristics of the antennae, amplifiers and receivers to allow relative comparisons throughout the portion of the spectrum under visual observation;

3. what adaptation of circuitry of the equipment specified in § 1 would be required for a temporary increase in the resolution of the spectroscope;

4. what are the desirable operating methods and techniques to obtain maximum benefit from visual monitoring with a radio-frequency spectroscope, either when used alone or when used as an adjunct to aural monitoring?

QUESTION 226(VIII)

MONITORING OF SWEEPING-TYPE PULSE EMISSIONS

The C.C.I.R., (1962)

CONSIDERING

(a) the increasing use being made of very short duration pulse-emissions which may be modulated in various ways and which are frequency-swept over wide ranges of the radio-frequency spectrum;

(b) that these emissions may, in some instances, be sources of interference to other transmissions, requiring identification and measurement by monitoring stations to assist in resolving such interference;

(c) that special facilities and techniques are required by monitoring stations to receive, measure and identify signals of this type;

DECIDES that the following question should be studied:

1. what is the extent of interference caused by sweeping-type pulse transmissions as they pass through, or temporarily rest on or near, the frequency of other transmissions;

2. what are the preferred facilities and techniques to permit reception and measurement by monitoring stations of these sweeping-type pulse emissions;

3. how may these sweeping-type pulse transmissions be identified as to source by monitoring stations?

QUESTION 252(VIII) *

FREQUENCY MEASUREMENTS AT MONITORING STATIONS

The C.C.I.R., (Warsaw, 1956 – Geneva, 1963)

CONSIDERING

that it is desirable to improve the accuracy, speed and convenience of frequency measurements, particularly under conditions of fading, interference, carrier instability, etc., including the case of suppressed or keyed carriers;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the accuracy and speed of frequency measurements which can be accomplished at monitoring stations, especially under the conditions set forth above;

2. what are the difficulties in meeting the required accuracy (Recommendation 377), due to limitations set by:

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* This Question replaces Question 145.

2.1 the measuring equipment;

2.2 propagation effects such as fading;

2.3 interference due to other transmissions;

2.4 the type of modulation, particularly for wideband transmissions in the frequency range 500 Mc/s to 10 Gc/s;

3. to what extent can errors be usefully reduced in practice by statistical processing of the measurement data when measurements are taken at successive times or under different conditions?

QUESTION 253(VIII)

EXPEDITIOUS METHOD OF DETERMINING FIELD-STRENGTH IN THE INTERNATIONAL MONITORING SYSTEM

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that a need exists for monitoring stations to measure field-strength, by expeditious means;

(b) that accuracies laid down in Recommendation 378 are not always necessary in monitoring observations;

(c) that, according to studies made to date (see Report 274), it is impossible to correlate field-strength values with S-values to sufficient accuracy;

UNANIMOUSLY DECIDES that the following questions should be studied:

1. what form of installation is suitable for the expeditious measurement of field-strength at monitoring stations;

2. what specification for the performance of the equipment (antenna, transmission line, receiver and calibrating source) is practicable;

3. what accuracy of measurement is desirable and practicable?

QUESTION 254(VIII)

DIRECTION-FINDING AT MONITORING STATIONS

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that direction-finding measurements in some cases have very great significance for Administrations and the I.F.R.B. in the investigation of harmful interference and in their concern with efficient use of the radio-frequency spectrum;

(b) that, while the techniques of direction-finding are well known, the methods and procedures best suited to the international monitoring system are not established;

(c) that the accuracy of bearings may be improved by certain procedures, e.g., by the statistical treatment of multiple bearings or by taking reference bearings on known stations;

UNANIMOUSLY DECIDES that the following question should be studied:

what methods of direction-finding and what procedures for improving the accuracy of bearings can be recommended for:

- fixed monitoring stations;
- mobile monitoring stations?

QUESTION 255(VIII) *

AUTOMATIC MONITORING OF OCCUPANCY OF THE RADIO-FREQUENCY SPECTRUM

The C.C.I.R., (Warsaw, 1956 – Geneva, 1963)

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 known;

(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 already recommended in Recommendation 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 frequency, bandwidth and field-strength;

2. what is the capability of automatic monitoring equipment in determining signal-to-noise ratios;

3. what are the best means of analyzing and evaluating automatic monitoring records, both singly and collectively;

4. is it possible to analyze present records by automatic means and, if not, what modifications are necessary to enable this to be done?

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* This Question replaces Question 143.

QUESTION 256(VIII) *

IDENTIFICATION OF RADIO STATIONS

The C.C.I.R., (London, 1953 – Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that Article 19, Section I of the Radio Regulations, Geneva, 1959, requires that the identifying signal be transmitted by methods which, in accordance with C.C.I.R. Recommendations, do not need special terminal equipment for reception;

(b) that special methods for identifying certain complex types of emissions have been evolved (Recommendation 379 and Report 280);

(c) that, however, there may be now, or in the future, some types of emissions to which the presently recommended methods of identification cannot be applied satisfactorily;

UNANIMOUSLY DECIDES that the following question should be studied:

1. which are the types of emissions that cannot be identified by the methods of identification recommended by the C.C.I.R. or set forth in the Radio Regulations, Geneva, 1959;

2. what satisfactory methods can be evolved for the identification of such emissions?

QUESTION 257(VIII) **

IDENTIFICATION OF SOURCES OF INTERFERENCE TO RADIO RECEPTION

The C.C.I.R., (Los Angeles, 1959 – Geneva, 1963)

CONSIDERING

(a) that interference-causing radiations have individual characteristics which, when observed aurally or visually, often enable an experienced monitoring observer to identify the type of equipment producing the radiations;

(b) that a list of all electrical and electronic equipment, which might at times cause radio interference, would include practically every device that uses electricity;

(c) that it would be helpful in solution of interference problems for both monitoring observers and radio station operators to compare interfering signals with a ready reference of all types of such signals which permit cataloguing of individual signal characteristics;

* This Question replaces Question 187.

** This Question replaces Question 190.

(d) that individual characteristics mentioned in § (c) might include, but not be limited to, frequency range, distance range, on-off cycles, times of day the source equipment is most generally used, characteristic note or tone, degree of frequency stability, usual bandwidth, type of signal as viewed on oscilloscope or panoramic presentation, type of source equipment and cause of radiations;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the preferred methods and form of listing by written description, magnetic tape recording and pictorial presentation, as appropriate, the individual characteristics of all observed types of interfering radiations;

2. what uniform standards of measurement should be adopted at monitoring stations for the collection of data to be sent to the C.C.I.R. Secretariat for implementation of the catalogue? *

QUESTION 258(VIII)

ANTENNAE FOR MONITORING STATIONS

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that the effectiveness of a monitoring station in providing adequate surveillance over the radio-frequency spectrum is determined to a major extent by the electrical characteristics of the available monitoring antennae;

(b) that substantial progress has been made in recent years in the development of broadband antennae having improved characteristics as regards frequency coverage, directivity and gain;

(c) that the anticipated future need for providing monitoring station facilities to permit observations and measurements of transmissions from spacecraft will require specialized antennae, taking into account the relatively weak signals involved and the high antenna directivity required;

UNANIMOUSLY DECIDES that the following question should be studied:

1. to what extent do currently available antennae fulfil monitoring station requirements, taking into account such aspects as: means of varying both horizontal and vertical directivity, gain, space limitations;

2. what are the desirable characteristics of antenna systems for monitoring in the various frequency bands of interest and for various propagation modes;

3. in which areas should further antenna development work be directed in an effort to improve monitoring antenna characteristics?

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* See Resolution 16 and Report 281.

QUESTION 259(VIII)

TYPES AND METHODS OF ASSISTANCE BY MONITORING STATIONS TO THE OPERATION OF VARIOUS RADIO SERVICES

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that monitoring stations in the international monitoring system exist for the purpose of increasing the effectiveness of radiocommunications throughout the various radio services;

(b) that techniques progress so rapidly, particularly in new fields such as space telecommunications, that conditions may exist whereby neither the Administration concerned nor the international monitoring system may be aware of the full potentialities of monitoring functions for rendering assistance to radio services;

(c) that the attention of all C.C.I.R. Study Groups and all Administrations should be called to available monitoring functions, for the purpose that they be alerted to keep the international monitoring system advised of types and methods of assistance that could be initiated or expanded to use the full potentialities of that system;

UNANIMOUSLY DECIDES that the following question should be studied:

what monitoring functions not now being performed, or not being rendered to full capability, could be initiated or expanded to provide improved assistance to Administrations or to the I.F.R.B.?

STUDY PROGRAMME 102(VIII) *

FIELD-STRENGTH MEASUREMENTS AT MONITORING STATIONS

The C.C.I.R., (London, 1953 – Warsaw, 1956)

CONSIDERING

(a) that Recommendation 378—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 propagations studies at monitoring stations;

* This Study Programme, which replaces Study Programme 69, does not refer to any Question under study.

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 analyzing 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.;

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

- the needs of the I.F.R.B., Study Groups of the C.C.I.R. and other bodies,
- 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

- with interrupted carrier,
- with reduced carrier,
- with other types of signals, including television signals;

4. what are the equipment and methods to be preferred for measuring the field-strength of emissions of the types given in § 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 207(VIII) *

BANDWIDTH MEASUREMENTS BY MONITORING STATIONS

The C.C.I.R., (London, 1953 – Warsaw, 1956 – Geneva, 1963)

CONSIDERING

(a) that it is desirable that monitoring stations should be able to measure the bandwidth of emissions;

(b) that the I.F.R.B. requires practical optimum standards concerning bandwidth measurements by monitoring stations;

(c) that determination of the occupied bandwdith of an emission, by the method of measuring total power and out-of-band power, in accordance with the principle suggested in the present definition of occupied bandwidth (see No. 90 of the Radio Regulations, Geneva, 1959), is not generally applicable to measurements made at a distance from the transmitter;

UNANIMOUSLY DECIDES that the following studies should be carried out:

determination of the most suitable equipment and methods for the measurement of the bandwidth of emissions by monitoring stations, taking into account;

1. the work of the C.C.I.R. concerning measurements of bandwidth made near the transmitter;

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* This Study Programme, which replaces Study Programme 103, does not refer to any Question under study.

2. the necessity for monitoring stations to examine various classes of emissions and to make measurements on a fading signal in the presence of noise and interference;
3. the current impracticability, with present equipment, of making measurements of the bandwidth at a distance from the transmitter, which would conform to the terms of the definition of occupied bandwidth in the Radio Regulations, Geneva, 1959.

QUESTION 275(VIII) *

MONITORING SERVICES IN THE NEW AND DEVELOPING COUNTRIES

(Question No. 2 of the Plan Sub-committee for Asia, Geneva, 1963)

(Geneva, 1963)

The Plan Sub-Committee for Asia,

CONSIDERING

(a) the importance of radio-frequency monitoring in the improvement of general operation of the expanding radio services;

(b) the need for establishing more radio monitoring stations in the various parts of the world, which up to now have had very little or no radio monitoring services capable of participating in the international monitoring services;

REQUESTS the C.C.I.R. to study the following question:

1. which radio monitoring services should be started by the new and developing countries in this field;
2. what guidance can be given in the establishment and organization of a radio monitoring service;
3. what facilities should the monitoring equipment provide and what are the suitable characteristics for such equipment?

Explanatory note : There is a great need for starting some radio monitoring service for conservation of spectrum space, for the avoidance of harmful interference and for finding new frequencies which the new countries need for their radio services. Guidance in these matters would be helpful.

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* This Question was adopted unanimously by the Xth Plenary Assembly of the C.C.I.R., Geneva, 1963.

LIST OF DOCUMENTS OF THE Xth PLENARY ASSEMBLY CONCERNING STUDY GROUP VIII

Doc.	Origin	Title	Reference	Other Study Groups concerned
8	Chairman, Study Group VIII	Report by Chairman of Study Group VIII (Mr. G.S. Turner)	—	—
28	United States of America	Types and methods of assistance by monitoring stations to the operation of various radio services	Draft Q.	—
104	Japan	Measurement of S-values at monitoring stations	Q. 189	—
129	C.C.I.R. Secretariat	Bibliographic references in the volumes of the C.C.I.R.	—	I–XIV
151	United States of America	Antennae for monitoring stations – Draft Question	Draft Q.	—
152	United States of America	Direction-finding at monitoring stations – Draft Question	Draft Q.	—
311	Study Group VIII	Identification of sources of interference to radio reception	Draft Q.	—
326	” ”	Summary record of the first meeting	—	—
362	” ”	Monitoring at fixed monitoring stations of radio transmissions from space vehicles	Draft Rep.	—
406	” ”	Expeditious method of determining signal-strength in the international monitoring system	Draft Q.	—
407	” ”	Direction finding at monitoring stations	Draft Q.	—
409	” ”	Measurement of S-values at monitoring stations	Draft Rep.	—
410	” ”	Bandwidth measurement by monitoring stations	Rep. S.P.	—
427	” ”	Identification of sources of interference to radio reception	Draft Rep.	—
428	” ”	Identification of sources of interference to radio reception	Draft Res.	—
429	” ”	List of stations using special identification means	Draft Res.	—
440	” ”	Extension of the international monitoring system to a world-wide scale	Draft Res.	—
441	” ”	Types and methods of assistance by monitoring stations to the operation of various radio services	Draft Q.	—
442	” ”	Antennae for monitoring stations	Draft Q.	—
443	” ”	Report of Sub-Group VIII–B to Study Group VIII	Rep.	—
499	” ”	Field-strength measurements at monitoring stations	Draft Rep.	—
534	” ”	Summary record of the second meeting	—	—
579	” ”	Summary record of the third and last meeting	—	—
2071	Drafting Committee	Accuracy of frequency measurements at monitoring stations	Rec. 377	—

Doc.	Origin	Title	Reference	Other Study Groups concerned
2072	Drafting Committee	Automatic monitoring of occupancy of the radio frequency spectrum	Q. 255	—
2073	" "	Frequency measurements at monitoring stations	Q. 252	—
2074	" "	Identification of radio stations	Q. 256	—
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