THE INTERNATIONAL TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE
(C.C.I.T.T.)

IVth PLENARY ASSEMBLY

MAR DEL PLATA, 23 SEPTEMBER - 25 OCTOBER 1968

WHITE BOOK

VOLUME IV

Maintenance

Published by
THE INTERNATIONAL TELECOMMUNICATION UNION
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APPLICABLE AFTER THE IVth PLENARY ASSEMBLY (1968)

(WHITE BOOK)

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MAINTENANCE RECOMMENDATIONS

PREFACE

In this present edition of Volume IV of the C.C.I.T.T. *White Book* use of the terms " international " and " intercontinental " for distinguishing between different maintenance methods is avoided.

The view is taken that the international telecommunications network is of world-wide extent and that most of the C.C.I.T.T. maintenance recommendations are of general application to it. However, in some cases two maintenance methods have been established and the one to be applied will depend on the length and complexity of the particular relation concerned. To distinguish the methods applicable to particular cases the recommendations refer to " Category A " in the case of the shorter or less complex relations and to " Category B " in the case of longer or more complex relations. Where no special indication is given, recommendations are applicable to both categories.

Generally, the particular category that applies will be self-evident from the individual relation under consideration, but in cases of doubt the choice of maintenance category should be a matter for agreement between the administrations concerned.

PART I

SERIES M RECOMMENDATIONS

Maintenance for telephony, telegraphy and data transmission

INTRODUCTION

RECOMMENDATION M.1

GENERAL RECOMMENDATION CONCERNING MAINTENANCE

To enable administrations and recognized private operating agencies to co-operate effectively in maintaining the characteristics required for the international telecommunications service, the relevant C.C.I.T.T. Recommendations, which are based on long experience, should be applied.

RECOMMENDATION M.2

VOCABULARY

For their dealings with their colleagues in other countries, I.T.M.C.[1] and repeater station personnel will find it helpful to refer to the *Vocabulary of basic terms used in line transmission* published by the C.C.I.T.T. for their benefit.

This " Vocabulary " gives transmission terms in the following languages: English, French, Spanish, Russian, German, Italian, Polish, Dutch, Portuguese and Swedish.

[1] International transmission maintenance centre (see Recommendation M.7).

SECTION 1

GENERAL

1.1 — Maintenance organization

RECOMMENDATION M.7

GUIDING PRINCIPLES ON THE GENERAL MAINTENANCE ORGANIZATION

1. *General*

In order to furnish guiding principles to administrations and recognized private operating agencies, the C.C.I.T.T. recommends the following principles for the general maintenance organization.

1.1 Definitions relating to the various maintenance functions are given in Recommendation M.70.

1.2 The size and complexity of the maintenance organization will depend on the particular case and the particular country concerned. In some instances it may be possible to carry out all the functions from a single centre; in others each function may be carried out from separate locations or alternatively only some of the functions might be combined and carried out from one location. The precise arrangement will depend on the administration concerned, and the C.C.I.T.T. limits itself to defining the functions of the separate elements, leaving the manner in which they are grouped to be determined by the administration concerned.

1.3 If a country so desires and/or if it judges that the complexity of its international telecommunications so requires, the international maintenance organization can be responsible for all the types of circuit for which Study Group IV makes recommendations.

2. *Types of circuits to be catered for*

The types of circuits to be catered for are as follows:

Public circuits:

— telephone circuits;
— voice-frequency telegraph links;
— phototelegraph circuits;
— sound-programme circuits;
— etc.

Private (rented) circuits:

— telephone circuits; point-to-point and multipoint;

— voice-frequency telegraph link;

— data circuits; point-to-point and multipoint;

— multi-facility circuits; that is, phototelegraph plus voice-frequency telegraph: speech plus voice-frequency telegraph: simultaneous or alternative transmission;

— phototelegraph circuits;

— sound-programme circuits;

— etc.

3. *Maintenance organization*

3.1 An essential feature of the maintenance organization for international circuits is the international transmission maintenance centre (I.T.M.C.) as referred to in Recommendation M.71 (see Figure 1/M.71).

In order to co-ordinate and ensure effective maintenance and fault reporting on international telephone circuits of all types it is desirable to set up an international transmission maintenance centre (I.T.M.C.) at an appropriate point in the international centres of the international network.

The two basic elements provided by the I.T.M.C. are given in i) and ii) below and their respective functions are described in Recommendations M.11 and M.12.

i) A " circuit testing centre " responsible for the setting-up, lining-up and subsequent maintenance of the circuits.

ii) A " fault report point " provided with all the necessary facilities and arranged in such a way that it may receive fault reports from and make fault reports to:

— similar fault-report points of other administrations and recognized private operating agencies;

— its own switching and other services;

— renters of private circuits as determined by the administration or recognized private operating agencies;

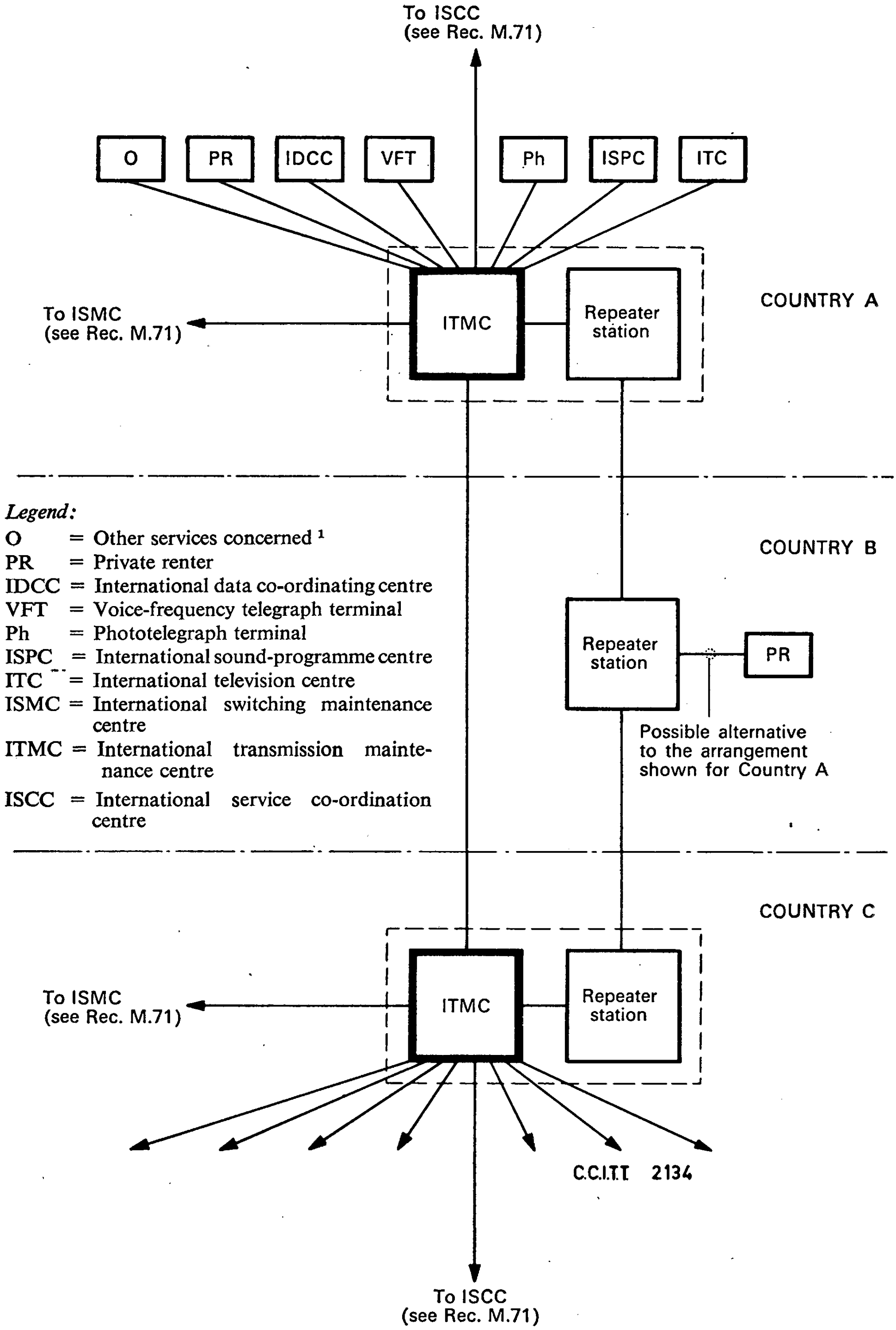
— the international service co-ordination centre (I.S.C.C.).

This fault report point will also initiate the fault location and clearing operations.

3.2 In the absence of a separate I.T.M.C. a terminal repeater station in the international service may perform the functions of the I.T.M.C. because such stations can include the elements having the responsibilities mentioned in paragraph 3.1.

Small repeater stations may also have these elements.

3.3 In general, international transmission maintenance centres are responsible for circuits, and as indicated above in paragraph 3.2, in some cases a repeater station may perform the functions of an I.T.M.C. For operations at other levels (group, supergroup, etc.) specific responsibilities are allotted to particular repeater stations. At each level, the



Legend:

O = Other services concerned [1]
PR = Private renter
IDCC = International data co-ordinating centre
VFT = Voice-frequency telegraph terminal
Ph = Phototelegraph terminal
ISPC = International sound-programme centre
ITC = International television centre
ISMC = International switching maintenance centre
ITMC = International transmission maintenance centre
ISCC = International service co-ordination centre

[1] Operations supervisors (semi-automatic and manual), the other ITMCs of the country, etc.

FIGURE 1/M.7. — **Interrelation of ITMCs and associated services** maintenance organization is based on the appointment of a control station and one or more sub-control stations. Recommendation M.8 deals with the appointment of control stations and Recommendation M.9 deals with the appointment of sub-control stations. These terms " control station " and " sub-control station " are often used with a general sense, including " circuit control ", but it is understood that " circuit control " is a function of international transmission maintenance centres.

4. *Organization diagram*

Figure 1/M.7 shows the interrelation between the I.T.M.C. and other services and also its relations with other countries.

RECOMMENDATION M.8

CONTROL I.T.M.C.s AND CONTROL STATIONS

1. The following principles for appointing control I.T.M.C.s and control stations apply to:

— every international circuit *(circuit control I.T.M.C.)*;

— every international group, supergroup, etc. *(group control station, supergroup control station, etc.)*;

— every regulated line section *(regulated line section control station)*, particularly on carrier transmission systems using a symmetric pair line, a coaxial line or a radio-relay link.

1.1 *Control I.T.M.C. for circuits*

One control I.T.M.C. is nominated for each circuit.

a) For each circuit used for public telephony and operated unidirectionally, the control I.T.M.C. is generally the one at the outgoing end.

b) For each circuit used for public telephony and operated both-way, the control I.T.M.C. can be either of the terminal I.T.M.C.s. The choice is made by common agreement between the technical services of the administrations or private operating agencies concerned. In making the choice, special consideration will be given to:

— whether the I.T.M.C. is permanently attended,

— the amount of work at each terminal I.T.M.C.,

— the length of the circuit within the territory of each terminal country.

c) For privately rented circuits the same procedure applies as in b) above. For these circuits, however, and, exceptionally, public telephone circuits, it may happen that neither of the terminal points is suitable for designation as a control I.T.M.C. (lack of qualified personnel, equipment, etc.). Another point near to the end of the circuit should be designated as the control I.T.M.C. in such cases.

d) For unidirectional circuits the terminal station at the receiving end should be the control I.T.M.C. In particular, in the case of sound programme or television circuits, the terminal I.S.P.C. or I.T.C. at the receiving end should be the control I.S.P.C. or I.T.C. (See Recommendations N.5 and N.55.)

1.2 *Group, supergroup, etc. control station*

For each international group, supergroup, etc., each terminal repeater station is a control station for the direction of transmission incoming to it. There are thus two control repeater stations, one for each direction of transmission.

1.3 *Regulated line section control station*

The procedure is the same as for groups, supergroups, etc.—that is to say, each of the terminal repeater stations is a control station for the incoming direction of transmission.

2. *Responsibilities of control I.T.M.C.s*

2.1 A circuit control I.T.M.C. is responsible for both directions of transmission.

2.2 Each control I.T.M.C. is responsible for ensuring that the circuit with which it is concerned is set up and maintained to the required standards. In particular it is responsible for:

a) controlling lining-up measurements to within the recommended limits and keeping records of reference measurements (initial measurements);

b) ensuring that routine maintenance measurements are carried out on the due dates, using the specified methods and in such a way that interruptions to service are limited to the shortest possible duration;

c) ensuring that the other I.T.M.C.s concerned take action when a fault occurs, and controlling the various tests or investigations necessary in clearing the fault. It must be possible to report observed faults at any time of day or night;

d) advising and informing the various centres, renters and other services given in Figure 1 of Recommendation M.7, of any condition which might affect the operation of the circuits for which it is the I.T.M.C.;

e) seeking the authority of the various centres, renters and other users given in Figure 1 of Recommendation M.7 for the withdrawal of circuits from service, and to arrange for the blocking in the case of automatic circuits, and to ascertain that thecircuits are functioning correctly after the clearance of the fault and to return them to the various users;

f) knowing what are the possibilities of re-routing any faulty circuits.

g) recording, on forms provided for the purpose, all incidents which arise, giving the time of occurrence of the incident, the exact location, if known, the action taken, if any, and the time of restoration to service.

3. *Responsibilities of control stations*

3.1 Group, supergroup, etc., or regulated line section control stations are responsible for the incoming direction of transmission only.

3.2 Each control station is responsible for ensuring that the group, supergroup, etc., link, or line with which it is concerned is set up and maintained to the required standards. In particular, it is responsible for:

a) controlling lining-up measurements to within the recommended limits and keeping records of reference measurements (initial measurements);

b) ensuring that routine maintenance measurements are carried out on the due dates, using the specified methods and in such a way that interruptions to service are limited to the shortest possible duration;

c) ensuring that the stations concerned take action when a fault occurs, and controlling the various tests or investigations necessary in clearing the fault. It must be possible to report faults discovered at any time of day or night;

d) informing the I.T.M.C. of any condition which might affect the operation of the circuits under its control;

e) seeking the authority of the control I.T.M.C. for any action which will take a circuit, or circuits, out of service;

f) knowing what are the possibilities of re-routing any faulty groups, supergroups, etc.

g) recording, on forms provided for the purpose, all incidents which arise, giving the time of occurrence of the incident, the exact location, if known, the action taken, if any, and the time of restoration to service.

3.3 Thus, for technical purposes (maintenance, lining-up) the control function for groups, supergroups, mastergroups, supermastergroups and regulated line sections are divided between the two directions of transmission, the station at the incoming end being the control station in each case. However, it is considered desirable to have a single routing form for each, giving information about both directions of transmission, and in order that this and similar documentation may be prepared and distributed on a methodical basis, these documentary functions shall be added to the responsibilities of one of the control stations, this " control station for documentary purposes " being chosen by agreement between the administrations concerned.

RECOMMENDATION M.9

SUB-CONTROL STATIONS (AND SUB-CONTROL I.T.M.C.s)

1. *Appointment of sub-control stations* (and sub-control I.T.M.C.s)

The following principles for appointing sub-control stations apply to:

— every international circuit (circuit sub-control I.T.M.C.), for whatever purpose (telephony, telegraphy, sound programmes, data transmission, etc.). (See in particular Recommendations N.5 in connection with sound-programme circuits and N.55 in connection with television circuits);

— every international group, supergroup, mastergroup or supermaster-group (group sub-control station, supergroup sub-control station, etc.);

— every line link and regulated line section (line link sub-control station, regulated line section sub-control station), particularly on carrier transmission systems using a symmetric pair line, a coaxial line or a radio-relay link.

The choice of the station that is to act as a sub-control station is made in its country by the technical service of the administration or private operating agency concerned, which advises the technical service of the country responsible for the control station, of its choice.

2. *Principles*

2.1 *Terminal sub-control*

2.1.1 *Terminal sub-control for circuits*

For each circuit a terminal sub-control I.T.M.C. is appointed. This is in general the I.T.M.C. at the end of the circuit remote from the control I.T.M.C. (Note that in the case of circuits the control I.T.M.C. controls both directions of transmission.) In the case of private (rented) circuits, and exceptionally in the case of public telephone circuits, it may happen that the terminal point is not suitable for designation as a sub-control I.T.M.C. (lack of qualified personnel, equipment, etc.). A repeater station near to the end of the circuit should be designated as the terminal sub-control I.T.M.C. in such cases.

For unidirectional circuits the terminal station at the sending end should be the terminal sub-control I.T.M.C. In particular, in the case of sound programme or television circuits, the terminal I.S.P.C. or I.T.C. at the sending end should be the terminal sub-control I.S.P.C. or I.T.C. (See Recommendations N.5 and N.55.)

2.1.2 *Terminal sub-control for groups, supergroups, etc.*

At the two ends of a group link, supergroup link, etc., the terminal stations are designated as terminal group link, supergroup link, etc. sub-control stations for the direction of transmission for which they are not the group link, supergroup link, etc. control station.

2.1.3 *Terminal sub-control for a line link or a regulated line section*

At the two ends of a line link or a regulated line section, the terminal stations are designated as terminal line link or regulated line section sub-control station for the direction of transmission for which they are not the line link or regulated line section control station.

2.2 *Intermediate sub-control*

2.2.1 *Intermediate sub-control for circuits*

In transit countries in which a circuit is brought to audio frequencies, an intermediate sub-control I.T.M.C. is appointed at a suitable point for each direction of transmission. It is left to the country concerned to choose:

— where this point shall be;

— whether the sub-control functions for the two directions of transmission are vested in one station or two stations (see Figure 1/M.9);

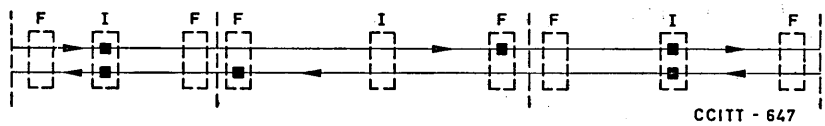
— whether, as may be desirable in the case of a large country, each direction of transmission has more than one I.T.M.C. per transit country.

2.2.2 *Intermediate sub-control for links*

In general, for links (group, supergroup, etc. line), in transit countries in which the link concerned appears in its basic frequency range, an intermediate sub-control station is appointed for each direction of transmission, the same discretion as for circuits being given to the country concerned (see 2.2.1 above and Figure 1/M.9).

2.2.3 *Intermediate sub-control for regulated line sections*

In transit countries, a regulated line section intermediate sub-control station is appointed for each direction of transmission, the same discretion as for circuits being given to the country concerned (see 2.2.1 above and Figure 1/M.9).



F = frontier station I = intermediate station —■— sub-control station

FIGURE 1/M.9. — **Possible choice for sub-control stations in a transit country**

2.3 *Combination of functions*

Any or all of the above functions may, depending on the arrangements in the country concerned, be vested in one station.

3. *Functions of sub-control I.T.M.C.s and stations*

The functions of sub-control I.T.M.C.s and stations are, for the sections which they control, similar to those given in Recommendation M.8 for control stations, but in addition they include:

— co-operating with the control stations and other sub-control stations at all levels in locating and clearing faults;

— setting up and maintaining that part of the group link, supergroup link, mastergroup link, or regulated line section link between the through-connection stations nearest to the two frontiers;

— in the case of circuit sub-control I.T.M.C.s, performing analogous functions with respect to the circuit. However, although, in the case of circuits, the principle of single-end control is retained, in the spirit of receiving end control as applied to links, the circuit control I.T.M.C. should, when appropriate, delegate its functions to the sub-control I.T.M.C.;

— functioning as a control station for the *national* section for which they are responsible. Whenever action is required in one of the sub-control station countries, in order to clear a fault, for example, the control station devolves upon the sub-control station of the country concerned the responsibility for controlling the location and clearance of the fault, and advising the control station of the appropriate details;

— seeing that the transmission on the national section with which it is concerned is within the prescribed limits;

— reporting to the control I.T.M.C. or control station all relevant details concerning the location and subsequent clearance of faults;

— keeping the necessary records on lining-up, fault location and fault clearing for the section for which they are responsible.

RECOMMENDATION M.10

SERVICE CIRCUITS

To facilitate the general maintenance of the international telephone network, " service circuits " should be set up as may be necessary between repeater stations taking part in the international service.

For the purposes of this recommendation, a distinction is made between the following types of service circuit:

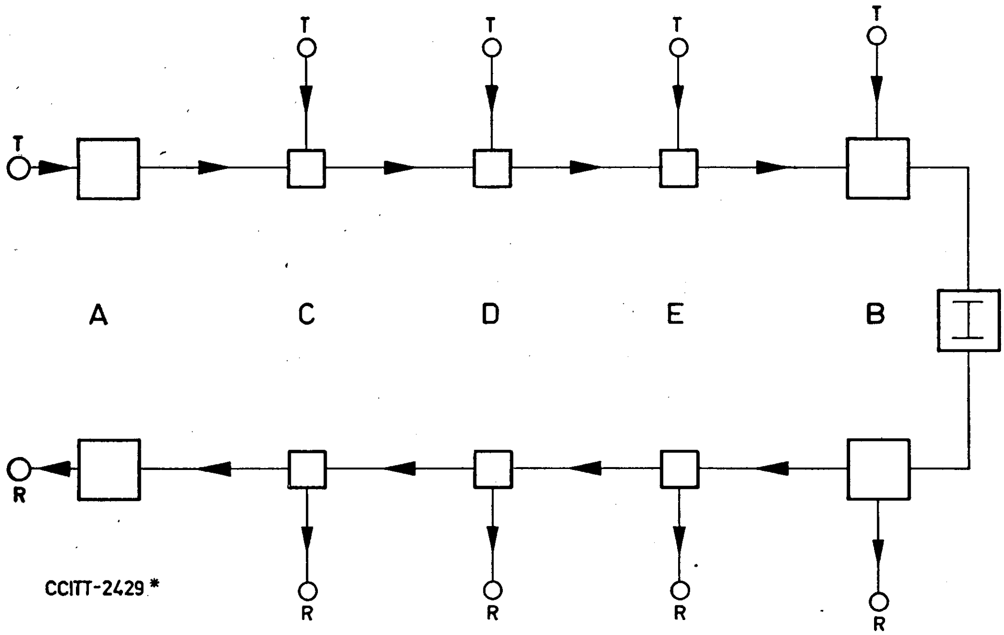
— *Direct service circuit:* a telephone or teleprinter (teletypewriter) service circuit serving only two stations and linking them directly. This can include a service circuit provided as a part of a long international system.

Note. — It will also be necessary to consider the communications required by technical staff for setting up and maintaining very long circuits routed over a number of major systems in tandem, e.g. London-Singapore circuits. These may require service circuits to be interconnected.

— *Omnibus service circuit* (see Figure 1/M.10 below): a telephone or teleprinter (teletypewriter) service circuit serving more than two stations connected in series, any or all of which may make connection to the service circuit simultaneously.

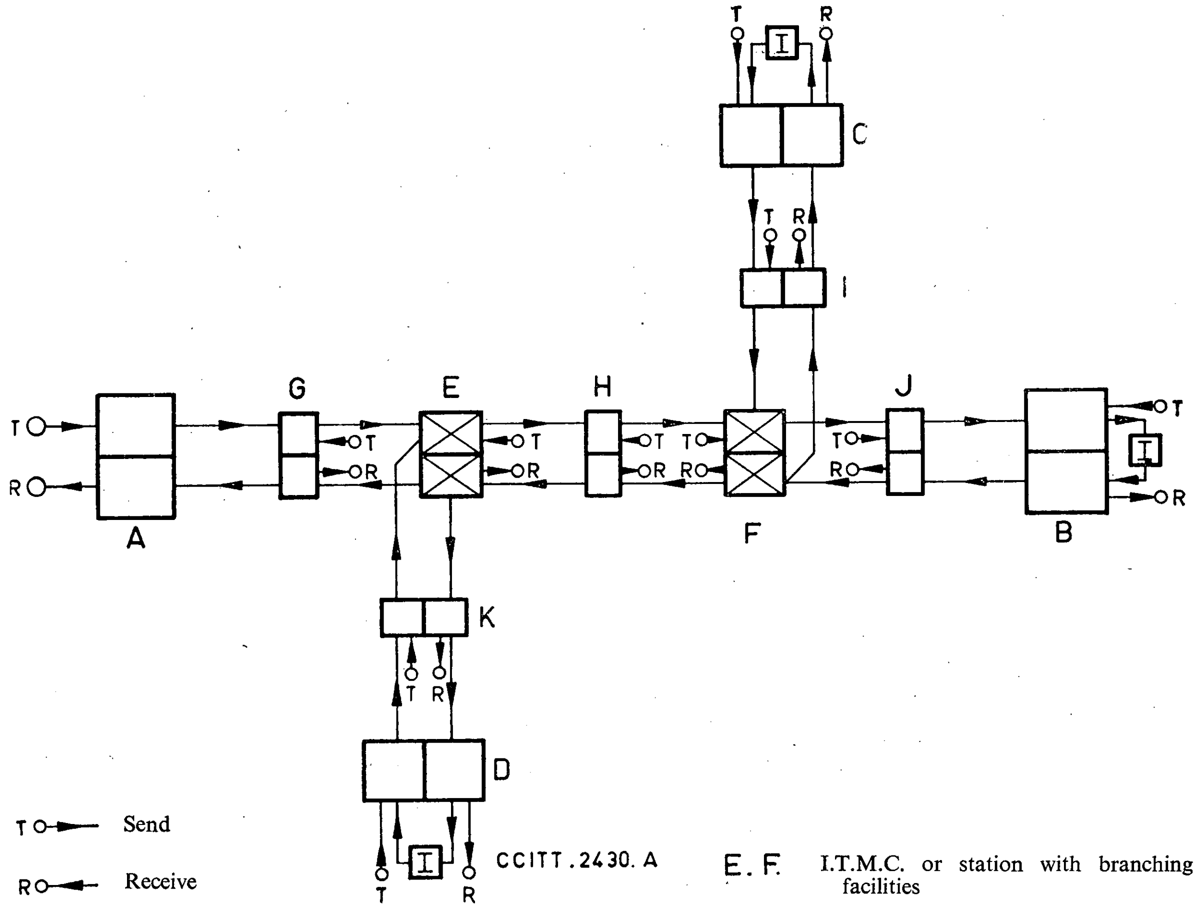
— *Multi-terminal service circuit* (see Figure 2/M.10 below): a telephone or teleprinter (teletypewriter) service circuit serving more than two stations and having at least one branching point. On each " branch " of this circuit a certain number of stations can be connected in series. Every station served can enter the circuit individually.

Note. — Attention is drawn to the possible use of selective signalling on omnibus and multi-terminal service circuits and to the problems that may arise in achieving the necessary stability on such circuits.



T	Send
R	Receive
A	Control I.T.M.C. or control station
B	Terminal I.T.M.C. or terminal station
C D E	Intermediate I.T.M.C. or intermediate station
	Artificial line looping the two directions of transmission

FIGURE 1/M.10. — **Example of an omnibus service circuit**



T o→ Send

R o← Receive

A Control I.T.M.C. or control station

B. C. D Terminal I.T.M.C. or terminal station

E. F I.T.M.C. or station with branching facilities

G to K Intermediate I.T.M.C.s or intermediate stations

I Artificial line looping the two directions of transmission

FIGURE 2/M.10. — **Multi-terminal service circuit**

It is recommended that for the maintenance of international circuits:

1. all attended stations should be connected direct to the public telephone network;

2. the terminal stations of an international system should be provided with a direct telephone service circuit;

3. terminal and intermediate stations on an international system should be provided with an omnibus telephone service circuit;

4. where the provision of direct teleprinter (teletypewriter) service circuits is impracticable or uneconomical, important repeater stations on international routes shall be provided with international telex facilities;

The equipment of the telegraph local end used on service telegraph circuits must be capable of transmitting and receiving signals conforming to International Telegraph Alphabet No. 2 and must be in accordance with the provisions of C.C.I.T.T. Recommendations;

5. repeater station staff responsible for international circuits shall have authority to make priority calls in the international service [1];

6. all service circuits shall in general conform to the Recommendations of the C.C.I.T.T. in respect of their quality and maintenance. However, service circuits may have a restricted quality which must nevertheless be such as to provide efficient communication when maintenance personnel have to use languages other than their mother-tongue;

7. in the event of a major interruption involving service circuits, these shall be accorded priority in restoration;

8. the terminal stations of a long " intercontinental " submarine cable system should be provided with a direct teleprinter (teletypewriter) service circuit;

9. terminal and intermediate stations on a long " intercontinental " submarine cable system should be provided with an omnibus teleprinter (teletypewriter) service circuit.

The C.C.I.R. has issued the following recommendation concerning service circuits for radio-relay links.

(For the convenience of users of Volume IV of the C.C.I.T.T. *White Book* this supplement is reproduced from C.C.I.R. Recommendation 400-1, Oslo, 1966. See subsequent publications of the C.C.I.R. for the latest version of the Recommendation.)

[1] The order of priority of such calls is given in the *Telephone Regulations* (Geneva, 1958), page 13, Article 20, Nos. 81 to 102.

C.C.I.R. RECOMMENDATION 400-1 [1]

SERVICE CHANNELS FOR RADIO-RELAY SYSTEMS TYPES OF SERVICE CHANNEL TO BE PROVIDED

(Question 4/IX)

The C.C.I.R., (1956-1959-1963-1966)

considering

a) that service channels are required for the maintenance, supervision and control of radio-relay links providing a number of radio-frequency channels for each direction of transmission;

b) that, if for any reason the radio-relay system itself fails to function, communication between various stations along the route, and from those stations to other points is likely to assume special importance;

c) that agreement is desirable on the number and function of the service channels to facilitate the planning of radio-relay systems;

d) that service channels will be used to provide:
- express speaker circuits;
- omnibus speaker circuits;
- supervisory and control circuits;

e) that service channels will not be connected to the public telephone network;

unanimously recommends

that, on international radio-relay systems:

1. all staffed stations should be connected directly to the public telephone network;
2. when a radio-relay link is extended by means of short cable sections, and these cable sections and the radio-relay link taken together constitute a regulated line section, the terminal stations of the radio-relay link itself should have speaker circuits to the stations at the ends of the regulated line section;
3. a telephone service channel (an omnibus speaker circuit) should be set up to connect together all the stations on the system, whether staffed or not;
4. that a second telephone service channel (a main or express speaker circuit) should be provided for direct telephonic communication between the staffed stations receiving supervisory signals;
5. wherever possible, and after agreement between the administrations concerned, one or two service channels should be provided in each direction for the transmission of supervisory and control signals between the stations of the system;

   Note. — These signals may also be transmitted directly over the main radio-relay system, if it is established for telephony.

[1] This Recommendation applies to radio-relay systems which will transmit at least 60 telephone channels or a television signal and comprise two staffed terminal stations, in which the signals are demodulated to baseband, and any number of unstaffed intermediate stations. This Recommendation applies, where appropriate, to trans-horizon radio-relay systems.

6. one of the channels mentioned in § 5 might be used for the transmission of high-speed signals associated with the switching of broadband radio channels, the other could be used for the transmission of a number of relatively low speed supervisory signals;

   Note. — It is also possible, by agreement between the administrations concerned, to transmit the relatively slow signals in the upper part of the omnibus service channel mentioned in § 3.

7. the telephone service channels should possess, whenever possible, the characteristics (excluding noise power) recommended by the C.C.I.T.T. for international telephone circuits and, in particular, should be able to transmit the frequency band 300 to 3400 Hz;

8. all telephone service channels (including those used for supervisory and control circuits) up to a length of 280 km should, whenever possible, not exceed a mean noise power in any hour of 20 000 pW psophometrically weighted, at a point of zero relative level;

9. the service channels should preferably be provided either over metallic circuits or over an auxiliary radio-relay system, in the same band as the main system, or in a different band following the same route as the main system; in special circumstances, service channels may be carried in the base-band of the main radio-relay system;

10. the characteristics of the supervisory signals and the control signals to be transmitted between the stations of the system should be the subject of agreement between the administrations concerned.

Note. — Certain administrations use the following arrangement of the base-band for auxiliary radio-relay systems, operating in a different frequency band from the main system:

— a telephone service channel (an omnibus speaker circuit), transmitted in the voice-frequency band;

— a second telephone service channel (a main or express speaker-circuit), transmitted between 12 and 16 kHz, the sense of modulation being erect;

— a band of frequencies situated between the two telephone service channels, used for the transmission of relatively slow supervisory signals and control signals, and, perhaps, also a pilot;

— a band of frequencies situated above the main telephone service channel, used for the transmission of telemetry signals and possible rapid control signals, the occupied band being as wide as necessary.

Other arrangements of the base-band are also used.

ANNEX

(to Recommendation M.10)

Service circuits needed for the general maintenance of that part of the international telephone network routed over communication-satellite systems

(Arrangements which have been adopted for the INTELSAT satellite system.)

The general principles to be applied in setting up service circuits are covered by Recommendation M.10.

This annex describes the basic arrangements for the provision of service circuits for the maintenance of international circuits routed over a communication-satellite system. Details of the arrangements can be laid down only for each individual case after all the features of the system (number of stations, locations, etc.) are known.

Various locations may require the use of service circuits such as earth stations, interface points and international transmission maintenance centres (I.T.M.C.s).

The earth stations and associated interface points where the base-band frequency spectrums are first formed may be interconnected by service circuits provided over the satellite system. These service circuits are used for management and maintenance of the satellite radio link and maybe for the line-up and maintenance of the highest order multiple-destination unidirectional (MU) main sections which embrace the satellite radio link.

Each earth station must be in touch, over a service circuit, with its international transmission maintenance centre (I.T.M.C.). In addition it must be possible for each I.T.M.C. to be connected either by direct or switched service circuits with the I.T.M.C. with which it co-operates in maintaining circuits.

The requirements for service circuits would depend on whether the route is assigned to a single destination or multi-destination satellite radio link.

For single-destination routes, the general requirements for service circuits between I.T.M.C.s and other centres (repeater stations) are given in Recommendation M.10. The telephone service circuits derived between earth stations are shared for the management of the satellite and the maintenance of circuits, groups, supergroups, etc., routed over the satellite link.

The telegraph service circuits provided are not shared because of the availability of sufficient derived telegraph service channels.

Although Recommendation M.10 does not specifically apply to multi-destination routes, it is recognized that a service circuit network will be required for such routes. For these multi-destination routes the service circuits should also be available throughout the day and night to all users of the satellite system, i.e., interface points and I.T.M.C.s, but owing to limited circuit availability it is proposed that service circuits be used on a shared basis where necessary.

The telegraph service circuits are not shared if there is a sufficient number of circuits to meet the requirements; if not, they are shared as arranged between administrations.

Interim arrangements have been provided to meet the requirements outlined above. At a later stage a centralized switching arrangement is contemplated.

The details of the proposed service circuit network are as follows:

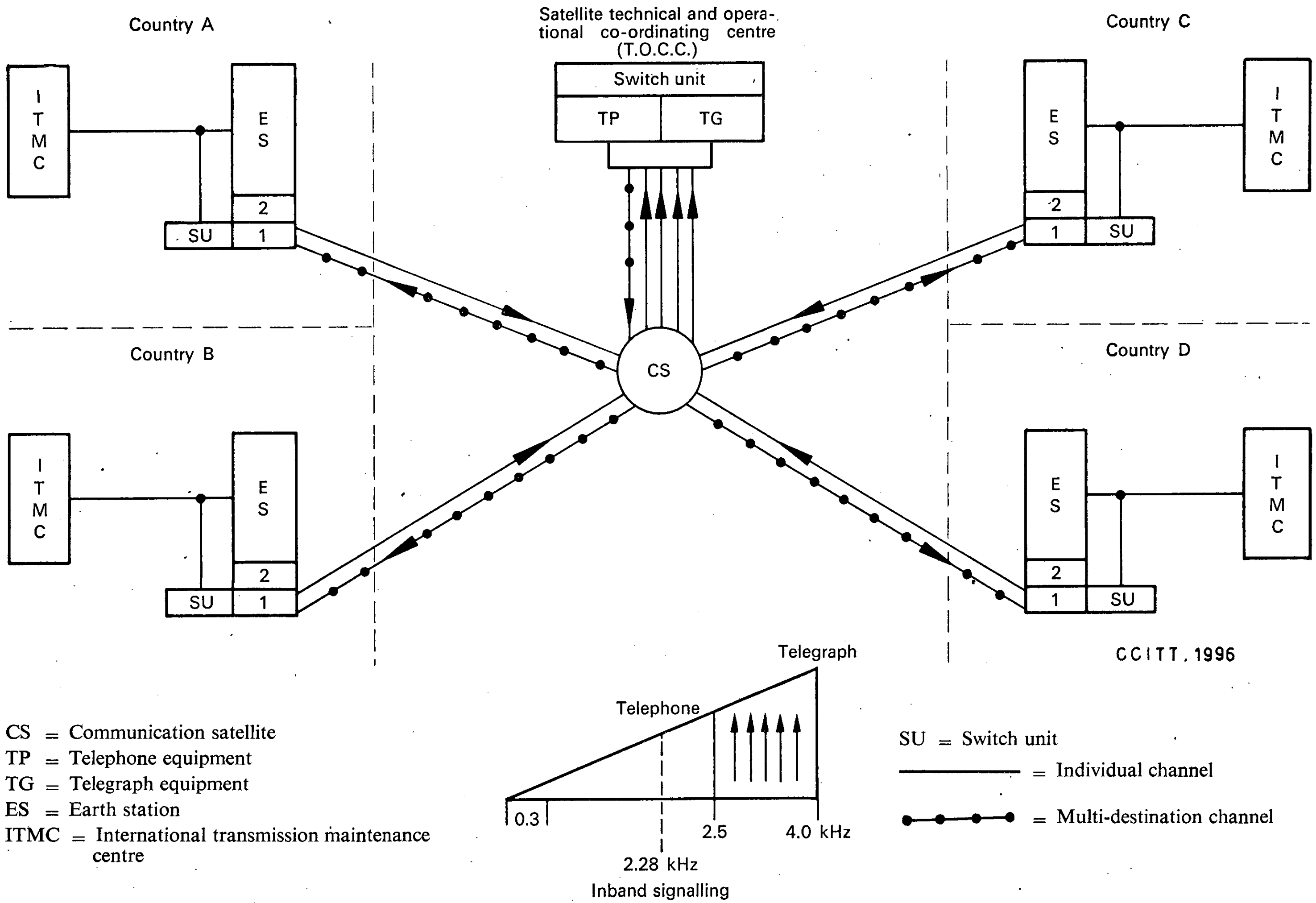


FIGURE 3/M.10. — **Multiple-destination route service-circuit network**

The telephone and telegraph service circuit assemblies shown in Figure 3/M.10 will be provided in the bands of 4 to 8 and 8 to 12 kHz. The telephone service circuit will be provided with in-band signalling and up to five telegraph channels will be available within this band.

a) *Telephone*

1. The basis of this scheme is the provision of a small automatic four-wire switching unit. The switching unit would be located at the Satellite Technical and Operational Co-ordinating Centre (T.O.C.C.) and to it would be connected service circuits from the stations in the zone [1] requiring to be interconnected.

2. The service circuit requirements for a satellite zone would probably be adequately provided by a small capacity (of about 50 circuits) four-wire switching unit employing a pulsed single-frequency signalling system, using a 2280-Hz signalling frequency.

3. The terminal arrangement would be dependent upon the degree of complication of the service circuit network. In a simple network connecting, for example, only earth stations, the equipment required at the terminal would consist of a four-wire telephone unit, signalling unit, and the equipment required to translate the 0 to 4 kHz service-circuit bandwidth into the range 4 to 8 kHz (or 8 to 12 kHz).

A more complex service circuit network, i.e. one serving the I.T.M.C.s and interface points [2] as well as the earth stations, requires a branching unit and a selective calling unit at the earth station and interface points in addition to the basic four-wire telephone unit.

b) *Telegraph*

1. The concept of a central switching unit can also be applied to a telegraph service circuit network. With this arrangement a small, automatic, telex-type, switching unit would be located at the T.O.C.C. Any station in the satellite zone requiring the use of the telegraph service-circuit network would be connected to the switching unit by one or more telegraph channels.

2. The switching unit could be a standard-type automatic-switching exchange with dial or keyboard calling as used on a telex network. International Alphabet No. 2 would be used and the speed of transmission would be 50 bauds.

3. Voice and telegraph combining equipment will be provided at each terminal to derive the telephone channel and up to five telegraph channels for each of the two service circuit assemblies.

In addition, it will be necessary to provide a teleprinter and associated signalling together with a dial unit.

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[1] *Note.* — In each of the satellite zones (for example, North Atlantic, Indian Ocean and Pacific) one earth station will be chosen as a Satellite Technical and Operational Co-ordinating Centre (T.O.C.C.). The main function of this station will be to co-ordinate operation and maintenance activities on the communication satellite system.

[2] *Note.* — The interface points referred to may be points in a station where the base-band and the multiplex equipment are interconnected, or points where the base-band is transferred from one transmission system to another.

RECOMMENDATION M.11

CIRCUIT-TESTING CENTRE

1. *Test access points*

i) Recommendation M.70 gives the definition of an international automatic circuit used for public telephony. " Access points " are required to enable lining-up and subsequent maintenance operations to be performed on such a circuit.

On a private circuit, the " circuit access points " are regarded as being located in the renter's premises.

ii) Recommendation M.64, Part B, paragraphs 1 a, 1 b and 1 c, describes the access points needed on public telephony circuits, these points being referred to as " line access points " and " circuit access points ", and recommends that these access points should be provided and used in measurements made by the repeater station staff.

iii) The circuit-testing centre should have " line access points " and " circuit access points " (or appropriate means for reaching the " circuit access points ") for all circuits in the public service other than automatic circuits.

In the particular case of automatic circuits, it should have " line access points " and appropriate means for reaching the " circuit access points ".

The circuit-testing centre should also have " line access points " for:

— circuits passing through the centre in transit from one country to another;

— circuits terminating within the country at a place remote from the international centre, for example in the premises of the users of leased circuits, in a voice-frequency telegraph terminal station, etc.

2. *Measuring and testing equipment*

i) The basic types of measuring equipment needed in the testing centre will comprise:

— signal generators (fixed and variable frequency oscillators and calibrated sending units);

— level-measuring sets;

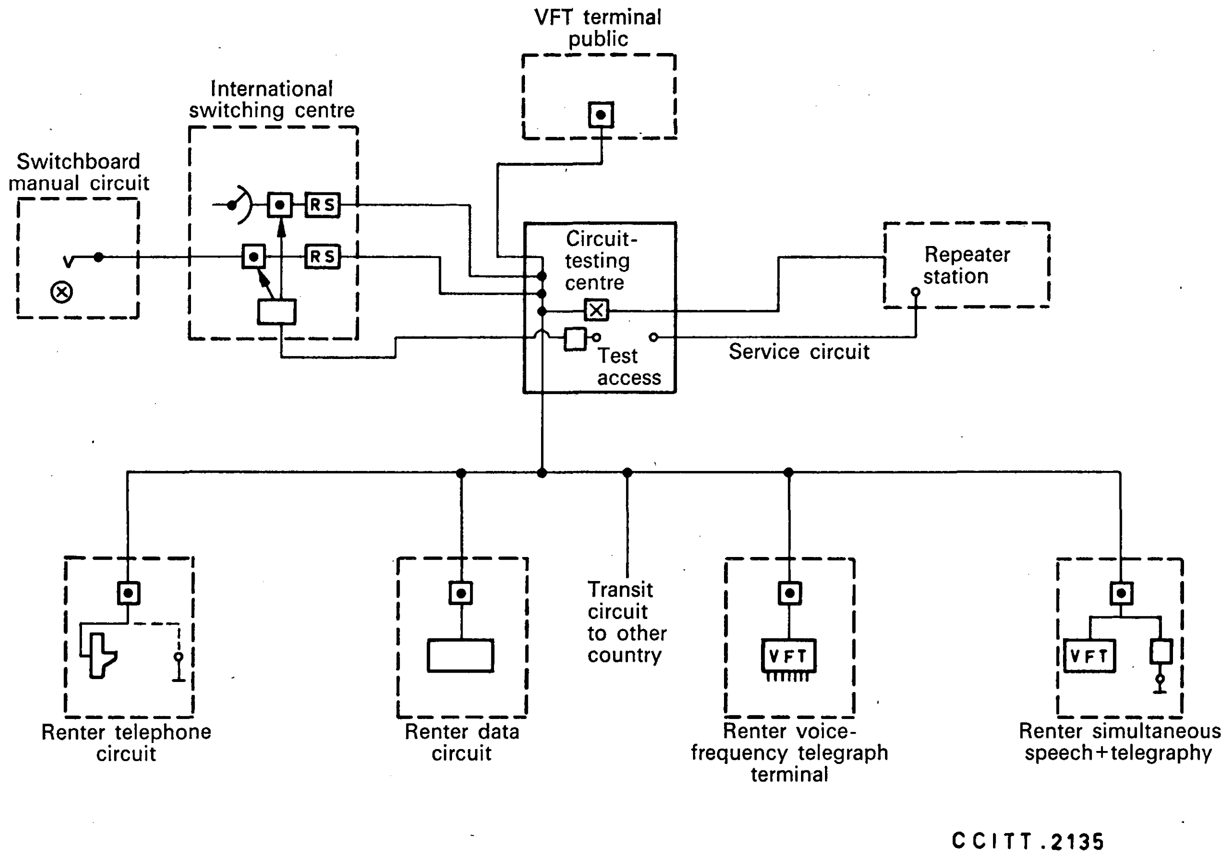
— calibration units;

— psophometers;

— standard frequency source (or access to such a source);

— programme meters;

— equipment for signalling tests.



⊡	circuit test access	RS	relay set
⊠	international line access	VFT	voice-frequency telegraph terminal equipment

FIGURE 1/M.11. — **International circuit-testing centre**

In addition, delay distortion-measuring equipment, frequency counters, interruption recorders, automatic transmission-measuring equipment, equipment for non-linear distortion measurement, etc., will be required, depending upon the types of circuit existing at the centre.

ii) The implementation of the world-wide transmission and switching plans make it necessary for international circuits to be lined up and maintained to a very high degree of accuracy.

It is essential, therefore, to use measuring equipment of high accuracy and stability in order that the maintenance requirements given in the relevant M Recommendations for circuits are met, and to ensure uniformity of measurement results.

iii) To this end it is desirable that measuring equipment provided for lining-up and maintenance of all classes of circuits should wherever possible conform to the specifications of the C.C.I.T.T. Where no C.C.I.T.T. specification is available, the best order of accuracy and stability should be provided, consistent with cost and type of measurement to be made.

3. *Responsibilities*

The responsibilities of a circuit-testing centre should be those given in Recommendations M.8 and M.9 for circuits. A circuit-testing centre should be able to function as a control or sub-control station, when so nominated in accordance with these recommendations.

4. *Organization diagram*

Figure 1/M.11 shows an example of the basic routing and testing access on all classes of circuits routed through the " circuit-testing centre ".

RECOMMENDATION M.12

FAULT REPORT POINT

1. *Fault reporting*

a) *General*

For the maintenance of international circuits it is necessary to have a recognized point to which faults on the circuits shall be reported. In the particular case of automatic circuits the principles given in Recommendation M.74 are also applicable.

b) *Private circuits*

The principles given in this Recommendation apply in general to all types of circuit, both public and private. For private circuits, however, the following special considerations apply:

i) A private circuit consists essentially of an international line between two terminal international centres, extended by national sections at each end from the international centre to the renter's premises (for a typical arrangement see Recommendation M.101, Figure 2).

The renter's premises are usually remote from the international centre, which will be in the office of the administration or recognized private operating agency that provides the circuit for the renter.

ii) The arrangements for the reporting of faults by renters should follow the practice normally applied in the countries concerned. Administrations and private operating agencies should inform the renter what procedure should be followed and to which centre faults should be reported.

iii) In a terminal country where several recognized private operating agencies are concerned or where a recognized private operating agency and an administration are concerned together in the terminal country, these organizations should agree on the procedure for reporting the fault to the fault report point in their country.

c) *Control of fault-clearance on circuits*

For practical reasons, greater technical responsibility needs to be given to the circuit fault clearance organization at one end of a circuit than to that at the other end. As mentioned in paragraph 1 above, fault clearance operations are directed from the terminal or I.T.M.C. which contains the fault-report point. At the end having the greater responsibility, this terminal I.T.M.C. exercises the functions of a control station (see Recommendation M.8).

Initial circuit fault reports may arrive at the fault report point at either end of the circuit, but it is always the responsibility of the non-controlling end to ensure that the fault reports it receives are passed to the controlling end.

In the case of public or private circuits, the terminal I.T.M.C., whether belonging to an administration or to a recognized private operating agency, should assume control responsibilities according to Recommendations M.8 and M.9.

2. *Sources of fault reports*

In general, fault reports will be received from the following sources:

i) Staff at the terminal repeater station for faults arising from:

— group pilot or line pilot alarms at repeater stations;

— local alarms at repeater stations;

— routine maintenance measurements and functional tests.

ii) maintenance staff at the international switching maintenance centre (I.S.M.C.);

iii) traffic staff at the international terminal centre. Reports from this source will concern public telephone circuits;

iv) staff of the international service co-ordination centre (I.S.C.C.) responsible for the analysis of service quality;

v) staff at voice-frequency telegraph terminal stations, concerning voice-frequency telegraph links;

vi) staff at international sound-programme centres (I.S.P.C.s) concerning sound-programme circuits;

vii) renters of private circuits;

viii) the I.T.M.C. or terminal repeater station of another country.

3. *Responsibilities of a fault report point*

The general responsibilities of a fault report point are:

i) receiving and recording fault reports from the sources given in paragraph 2;

ii) withdrawing faulty circuits from service;

iii) sending fault reports to the appropriate testing staff in its own country, or, in the case of the non-controlling end, to the controlling-end fault report point responsible for the location and clearance of the fault;

iv) in its own country, providing the information and co-operation needed to deal with enquiries by traffic and maintenance staff and by renters, or by the fault report point at the distant end;

v) notifying the point of origin of a fault report when the fault has been cleared and arranging for the return of the circuit to service;

vi) ensuring that faults are cleared as soon as possible;

vii) keeping fault and circuit records up to date;

viii) making an analysis of faults as may be necessary;

ix) investigating repeated faults;

x) to advise the International Service Co-ordination Centre (I.S.C.C.) of details of faults concerning automatic circuits.

4. *Service circuits*

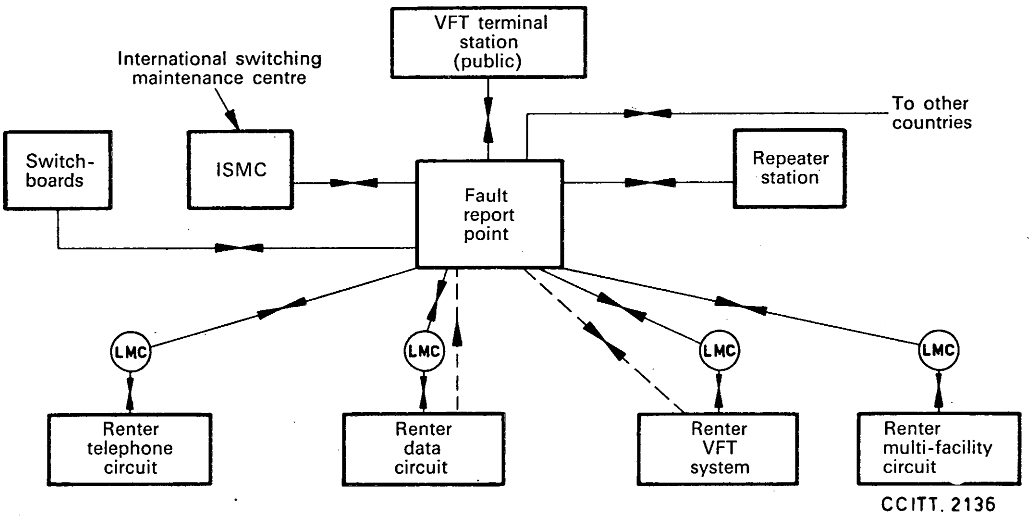
Service circuits are set up between the repeater stations at international centres as may be necessary, in accordance with Recommendation M.10.

The arrangements for terminating service circuits at any given repeater station are determined by the technical services of the administration or recognized private operating agency according to their requirements.

A fault report point should also be given access to the service circuits available. In addition, service circuits should be provided as required between the fault report point and centres such as the international switching maintenance centre, voice-frequency telegraph terminal stations etc.

5. *Organization diagrams*

Figure 1/M.12 shows an example of the possible flow of fault reports to and from the fault report point.



(LMC) local maintenance centre

—▶◀— flow of fault reports

◀– fault flow by special arrangement

FIGURE 1/M.12. — **Fault report flow**

RECOMMENDATION M.13

RESPONSIBILITIES OF CONTROL AND SUB-CONTROL I.T.M.C.s IN LOCATING AND CLEARING FAULTS

1. Faults on international circuits will be reported to a " fault report point " established in an " international transmission maintenance centre " (I.T.M.C.) and in accordance with Recommendations M.8 and M.9.

2. The arrangements for the reporting of faults on circuits is given in Recommendation M.12 and these principles should likewise be applied to the reporting of faults on groups, supergroups, etc., to the " fault report point " in a repeater station.

3. *Basic principles for locating a fault on a circuit by an I.T.M.C. circuit-control station.*

3.1 The following principles apply to all types of circuit, however constituted:

i) The fault is reported to the control and terminal sub-control I.T.M.C.s.

Note. — On circuits where " blocking " [1] possibilities exist, the circuit control I.T.M.C. and the terminal sub-control I.T.M.C. should, if the circuit has not already been " blocked ", arrange to do this immediately a fault has been notified to them. Where " blocking " possibilities do not exist, the operating staff or the renter, in the case of private circuits, should be advised immediately.

ii) Appropriate overall measurements and tests should be made to confirm the existence of the fault.

iii) Measurements should be made on the sections of the circuit between the " end " of the circuit (circuit access point, voice-frequency telegraph terminal or renter's termination, etc.) and the international line access point at the international terminal centre to find whether the fault is on these sections in either of the terminal countries concerned.

iv) If the fault is proved into these sections, national practices should be applied to locate and clear the fault.

v) If the fault is proved to be in the international line, the circuit control I.T.M.C. and the terminal sub-control I.T.M.C. should make tests and measurements appropriate to the type of fault in co-operation with any intermediate sub-control I.T.M.C. until the fault has been located between two adjacent sub-control I.T.M.C.s, that is, to a circuit section. These two I.T.M.C.s should then control the detailed location of the fault and its subsequent clearance within their section.

vi) I.T.M.C.s should, as soon as possible, make prompt use of any permitted re-routing possibilities that there may be for the line or sections under their control, in order to restore service on the circuit.

vii) If the circuit section is routed on a channel of a group, the two sub-control I.T.M.C.s should inform the group control stations of the fault.

viii) When the fault has been cleared the sub-control I.T.M.C. in whose country the fault was located should immediately notify the control I.T.M.C. of the nature of the fault and the time and details of its clearance.

ix) The control I.T.M.C.s co-operate with the terminal sub-control I.T.M.C. and makes overall measurements, requesting further adjustments if necessary.

x) When these two I.T.M.C.s are satisfied that the circuit meets the specified requirements, the control I.T.M.C. arranges to restore the circuit to service.

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[1] *Blocking.* — The act of engaging a circuit so that no automatic or manual device can have access to that circuit.

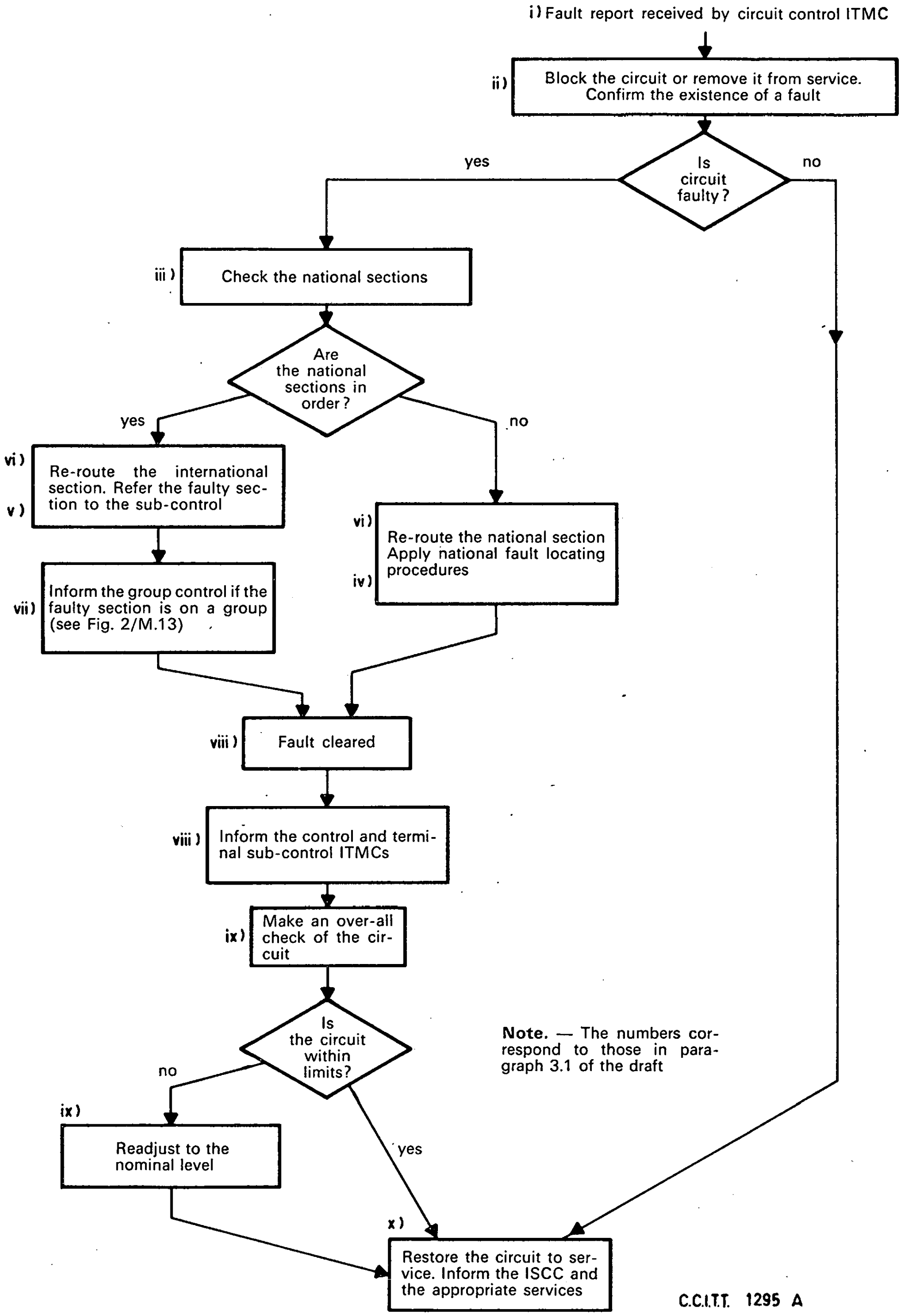


FIGURE 1/M.13. — **Possible action by a control I.T.M.C. following a fault report**

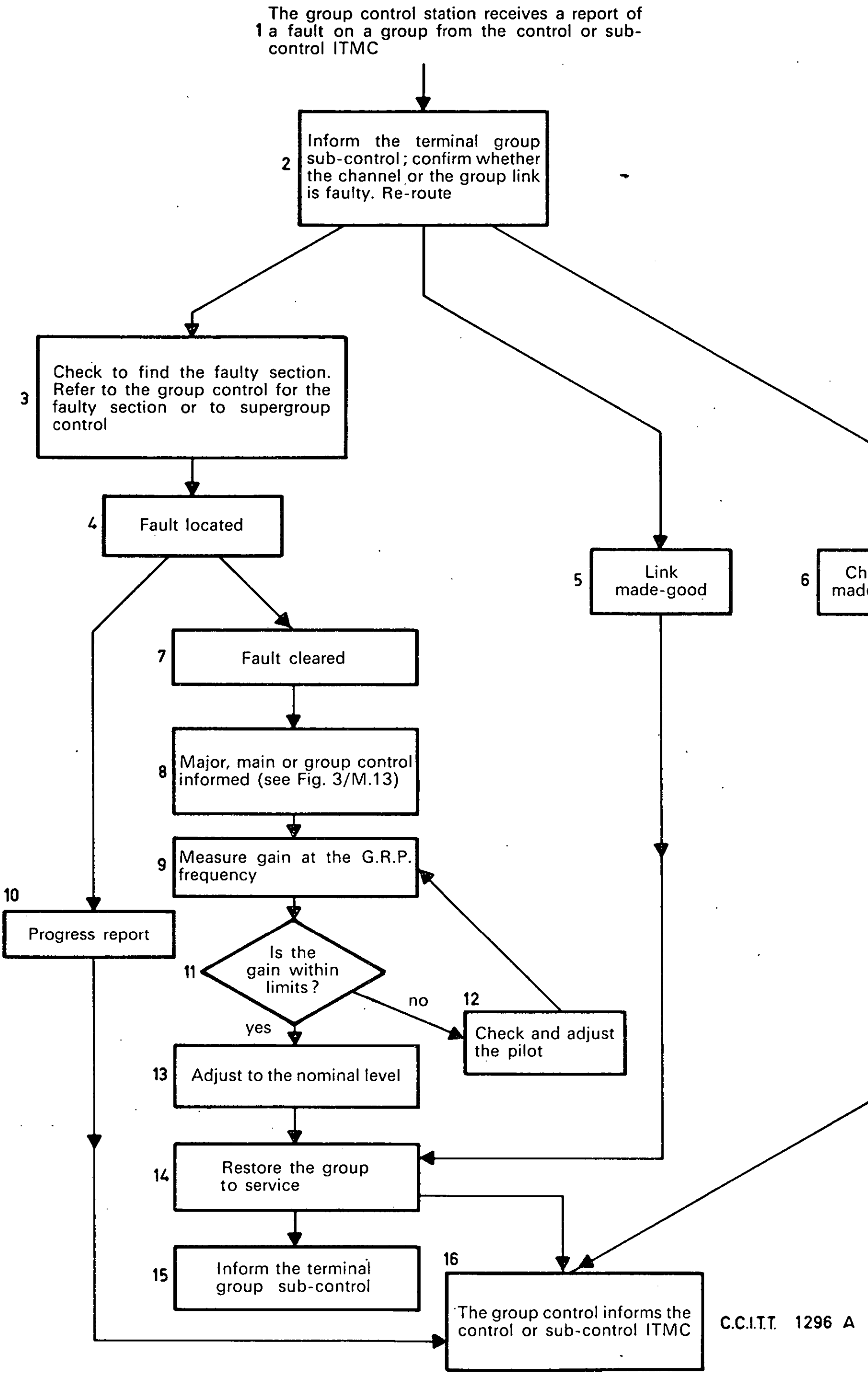


FIGURE 2/M.13. — **Possible action by a group control station following a fault report**

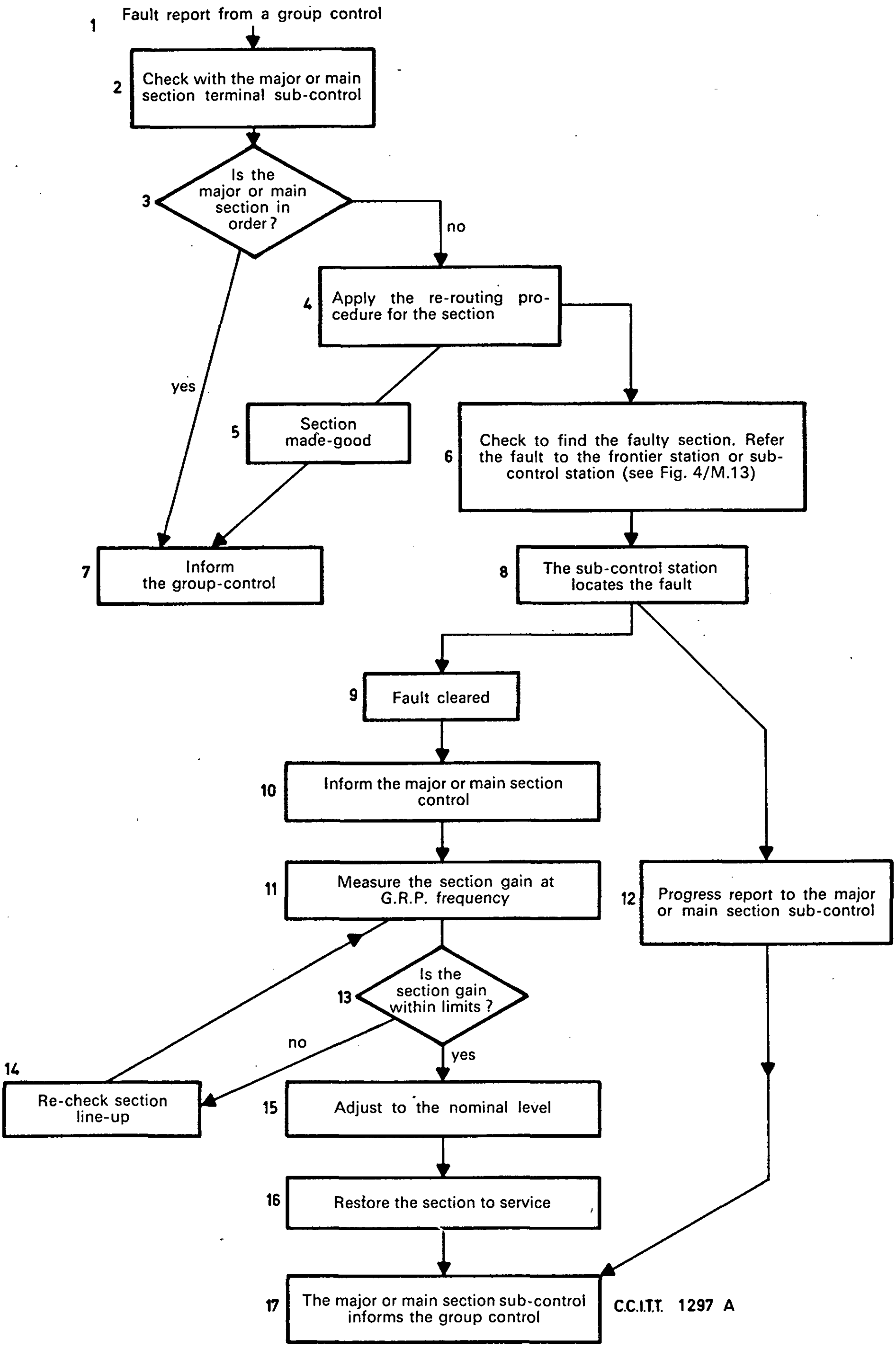


FIGURE 3/M.13. — **Possible action by a major or main section control station following a fault report**

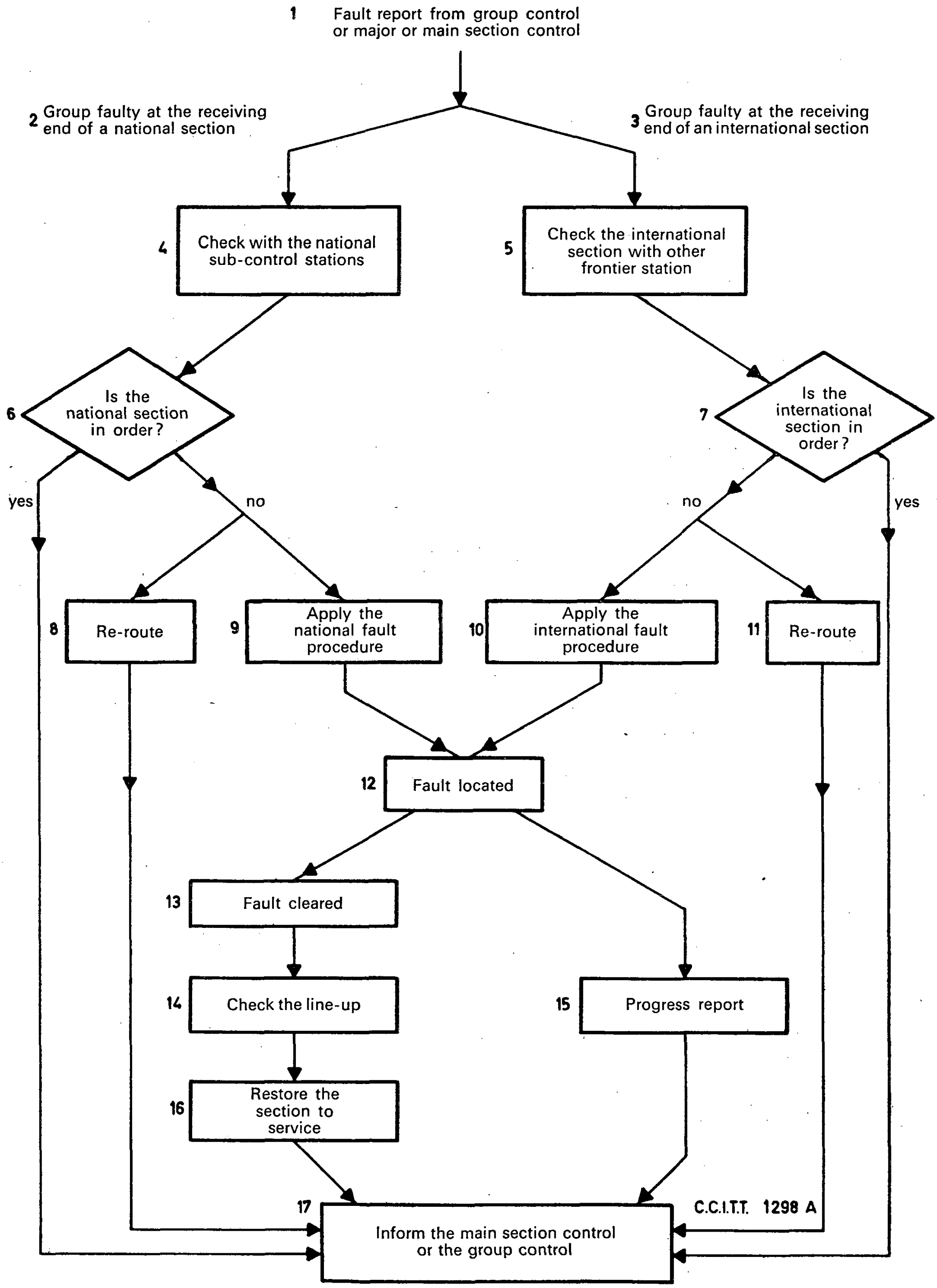


FIGURE 4/M.13. — **Possible action by a frontier station following a fault report**

3.2 Figure 1/M.13 shows a sequence of operations that may be followed by the control and sub-control I.T.M.C.s applying the principles given in paragraph 3.1.

3.3 When a fault in a circuit section is proved to be due to a group or a supergroup fault the basic fault-procedures for the group and supergroup are the same as those given for faults on an international line (see paragraph 3.1 above, points vi) and vii)).

The sequence of operations followed by the group control station and the group sub-control station in locating faults on a group is shown in Figure 2/M.13. Associated operations by other control and sub-control stations are shown in Figures 3 and 4/M.13.

3.4 The operations mentioned above can sometimes be modified according to the circumstances at the time of the fault report because of local knowledge in the control and terminal sub-control I.T.M.C.s or international switching and transmission maintenance centres of the state of the route followed by the circuit, local difficulties in international exchanges or repeater stations or in the national network.

For example, if there is a cable fault in a terminal country and if this fault affects a large number of circuits, it will not generally be necessary to carry out all the operations given in paragraph 3.1 and Figure 1/M.13 in the order shown.

4. *Faults observed at repeater stations as a result of local or extended alarms*

All fault conditions affecting transmission that are observed at repeater stations as a result of local or extended alarms should be reported to the control or sub-control I.T.M.C. of the country concerned, so that arrangements can be made to apply the fault clearing procedure. (If the fault cannot be cleared immediately the control I.T.M.C. should arrange to block the circuit or ask the international switching maintenance centre to remove the circuits from service and notify the traffic staff.) These maintenance centres should be notified of the trouble experienced, the action taken and should be kept informed of the condition of the circuit at all times.

5. *Special faults*

In the case of unusual faults, or faults which are difficult to locate with the testing equipment that is available, or faults of a similar kind occurring very frequently on a particular section, the I.T.M.C.s or control stations concerned should inform their technical service without delay. This service, in co-operation with other technical services involved, will take the necessary action to locate such faults or to prevent such faults in the future and, where appropriate, by rearrangement of the circuit layout or equipment involved. The control I.T.M.C. should be kept informed of the progress of the action taken or proposed prospect of clearance and other pertinent details.

ANNEX

(to Recommendation M.13)

Method proposed by A. T. & T. Co. for locating faults on circuits routed via a TASI system

1. *Circuits assigned to a TASI system*

The testing of circuits assigned to a TASI system follows a technique that is different from that for " non-TASI " circuits.

Basically, the equipment used for the TASI system consists of a transmitter and a receiver for each direction of transmission joined by a number of connection-channels, which is less than the total number of circuits. The transmitter is a universal access-switch which permits any combination of connections between any of the circuits and the connection-channels. The receiver is also a switch under the control of the transmitter. It establishes the required connections between the channels and the circuits at the far end in accordance with the signals received from the transmitter.

a) The programme of connection is controlled by:

1) logic-circuits which ascertain the need for a channel-connection;

2) memory-circuits which store the circuit and the channel identity and status information;

3) a signalling system that advises the receiving terminal of the required connection;

4) a switch that makes the connection of the circuit and the terminal to the channel selected.

When TASI equipment is switched out of service the basic traffic circuits are switched through to the channel facilities on a predetermined basis, one circuit per channel. These basic circuits are called " TASI and through " circuits. The additional circuits derived by TASI are called " TASI only " circuits.

When TASI is switched out of service, due to major troubles occurring in the TASI equipment, or during equipment routine test periods, the basic " TASI and through " circuits are switched through to the channels to maintain service continuity. The " TASI only " circuits are taken out of service until the TASI equipment is restored.

The I.T.M.C.s of circuits assigned to TASI equipment are kept informed of the routine test periods of the TASI equipment. In addition, the I.T.M.C.s of " TASI only " circuits are informed when the circuits are out of service due to TASI being inoperative.

The testing of TASI circuits should follow the principles outlined in the following paragraphs in order to obtain the correct interpretation of the test results. The test procedures differ slightly depending on whether the circuit under test is a basic " TASI and through " circuit or a " TASI only " circuit. The procedure is outlined separately for each type.

b) " *TASI and through* " *circuits*

The tests are made without regard to the identity of the connection channel (unless the tests are made during a period when TASI is known to be inoperative, in which case see below). The existence of a fault is first confirmed by an initial test. If no fault is detected on the initial test made or if the fault has disappeared by the time of a repeat test, it is safe to assume that the fault may have been due to the connection-channel being used at the time the fault was reported or when the initial test was made.

The probability of the same connection-channel being associated with the circuit for a repeat test is remote, unless the repeat test is made immediately following the receipt of the fault report and, in addition, the test is made during extremely light traffic periods, when the demand for connection-channels is very small.

The circuit on which test results of the above nature were obtained would be returned to service. A record of the fault reported would be given to the TASI system maintenance station for their information and use when connection-channel tests were made.

If the fault is confirmed by the initial and repeat tests, it can be assumed to be located externally to the connection-channel and further sectionalization tests would be made. However, if the tests were made during extremely light traffic periods, and identical faults were detected on each test, there might be a chance that the connection-channel was at fault, as the TASI system might not have switched the channel. Additional repeat tests would be made in an attempt to eliminate the effect of the connection-channel. In any event the sectionalization tests made would include those made at the TASI channel terminals to confirm the existence of connection-channel trouble.

If the fault reported was being investigated during a period when TASI was known to be inoperative, the fault-location procedures would be similar to those specified for a " non-TASI " circuit.

c) *" TASI only " circuits*

Tests on the circuit when a fault was reported would be made without regard to the identity of the connection-channel in use during the test period. Repeat tests would be made in a similar way to the tests for " TASI and through " circuits, in an attempt to confirm that the fault existed, and if it did, to prove it to be external to the connection-channel. If no fault were detected on the initial or repeat tests, the circuit would be returned to service. A record of the fault reported would be given to the TASI system maintenance station for their information and use when the connection-channel tests were made.

If the fault existed on the initial and repeat tests, sectionalization tests would be made to locate it externally to the connection-channels. If the testing were done during extremely light traffic periods, the same precaution would apply as given for " TASI and through " circuits.

During TASI switchout periods, this type of circuit would have been removed from service.

d) *Application*

During light traffic periods with TASI in service, there is a reduced demand for connection-channel over the TASI system. The possibility exists, therefore, that repeat tests made on the circuit in an attempt to confirm the existence of a fault and, in addition, to determine if the fault is external to the connection-channel, would not produce the desired results if the connection-channel did not switch.

It would be necessary to make sectionalization tests at the TASI channel terminal itself to determine the condition of the connection-channel when repeat test results indicated no change whatsoever and when the connection-channel was suspected. These repeat tests would be made as part of the initial test attempt or as the fault sectionalization test effort progressed. Experience with testing procedures on circuits routed over TASI systems should produce dependable indications of whether the fault is external to the connection channel.

RECOMMENDATION M.14

DESIGNATION OF INTERNATIONAL CIRCUITS, GROUPS, ETC.

The following rules should be applied for the designation of international circuits or groups of international circuits. The place names should always be written in roman characters taking the official name of a town as used in the country to which it belongs. If identical place names occur in different countries, and if confusion is likely to arise, the administrations concerned should agree to identify the country in the circuit designation by adding after the place name the code as given in the " Maintenance Programme ". If it is of interest to distinguish the private operating agency concerned, this may be done by inserting after the place name a suitable code identifying the agency.

The code for the country should be placed between fraction bars (division signs) /...../.

This is necessary to avoid any confusion either with the designatory letters assigned to the various types of circuit, or with the abbreviations used to designate private operating agencies or other recognized authorities.

1. Circuits in public service

1.1 *Telephone circuits*

1.1.1 *Telephone circuits used in manual operation*

The circuit number preceded by the prefix M follows immediately after the names of the two terminal exchanges arranged in alphabetical order:

Examples : London–Paris M1
Auckland–London M1

1.1.2 *One-way circuits used for semi-automatic or automatic operation*

These circuits are designated by the names of the two international terminal exchanges arranged in the order corresponding to the direction in which the circuit is operated and the number of the circuit is preceded by the letter Z.

The numbers of the two directions of operation of semi-automatic or automatic circuits must therefore be distinct. Circuits operated in the direction corresponding to the alphabetical order of the international terminal exchanges should have odd numbers. Circuits operated in the direction corresponding to an inverse alphabetical order of the international terminal exchanges should have even numbers. For example:

For a circuit operated in the London–Montreal direction (alphabetical order): London–Montreal Z21.

For a circuit operated in the Montreal–London direction (inverse alphabetical order): Montreal–London Z18.

1.1.3 *Both-way circuits used for semi-automatic or automatic operation*

The circuit number follows immediately and without a letter prefix after the names of the two terminal exchanges arranged in alphabetical order.

Example : London–New York 1

1.2 *Circuits used for voice-frequency telegraph links*

For the public service, these are distinguished by the letter T.

Example : Montreal–Zürich Tl

In some cases the telegraph link terminates at one or both ends in the premises of a private operating agency. If it is of interest and useful to distinguish the private operating agency concerned, this may be done by inserting, after the place name, a suitable abbreviation in brackets (. . . . .) to identify the agency.

Example : Bruxelles–New York (RCA) T1

In the case of telephone circuits used as *reserve circuits* for voice-frequency telegraph links, the telephone circuit designation for such a circuit (in accordance with the above) is followed by a supplementary indication, in brackets, comprising the letters ST followed by the number of the voice-frequency telegraph circuit for which the circuit under consideration is normally used as a reserve.

Example : London–Montreal M10 (ST1)

describes the circuit designated as a reserve for the London–Montreal T1 voice-frequency telegraph link [1].

1.3 *Data transmission circuits*

For data-transmission circuits, the letter D and a special number system are used.

Example : London–Paris D1

1.4 *Circuits specially designated for phototelegraphy or facsimile*

In the case of a circuit specially designated for phototelegraphy or facsimile, the designation of the circuit as a telephone circuit (in accordance with the above) is followed by a supplementary indication, in brackets, comprising the letter F followed by the number of the circuit when it is used for phototelegraph transmissions.

Examples : London–Paris Z23 (F1)
London–Montreal M3 (F1)

1.5 *Circuits for occasional sound-programme or television transmission*

The letter R is used in the case of a unidirectional sound-programme circuit and the letters RR in the case of a reversible sound-programme circuit. In the same way the letters V or VV are used for television circuits. The names of the terminals in the designation for a unidirectional circuit (for sound or television) are placed in the order corresponding with the direction of transmission (instead of alphabetical order).

[1] It might happen that a telephone circuit, for example London–Oslo M9, is designated as a reserve section for a part of a voice-frequency telegraph link, for example, New York–Oslo T1. The complete designation of the telephony circuit to be used as a reserve section would then include an indication of the normal voice-frequency telegraph link concerned, that is, using the examples above, the London–Oslo telephone circuit would be designated " London–Oslo M9 (New York–Oslo ST1) " or, if it were a general reserve for a number of voice-frequency telegraph sections, it would be designated " London–Oslo M9 (ST) ".

Examples : circuit transmitting only in the direction Montreal–Wellington:
Montreal–Wellington/NZ/R1

circuit transmitting only in the direction
Wellington–Montreal:
Wellington/NZ/–Montreal R1

If it is of interest to distinguish any broadcasting or television authority that may be involved, this may be done by inserting, after the place name, a suitable abbreviation in brackets (. . . . .) to identify the authority.

Where it is necessary for sound-programme circuit designations to include an indication of the bandwidth, this is done by adding in brackets the top nominal frequency in kHz, in which case it is to be assumed that the lower limit of the frequency band effectively transmitted is 50 Hz, or below.

Examples : London–Montreal R1 (10 kHz)
London–Sydney R1 (8 kHz), etc.

Exceptionally, when the lowest frequency is above 50 Hz, a special mention of this should be made on the circuit record (circuit layout).

2. Private circuits

Special circuits for private services or particular purposes (e.g. military, diplomatic, meteorological, civil aviation, electric power distribution, banks, permanent service circuits between repeater stations, permanently-used control circuits for sound or television broadcasting, etc.) are distinguished by the letter P.

The designation of the different categories of private circuits are described in paragraphs 2.1 and 2.2 below. In special cases in which C.C.I.T.T. Recommendations cannot be followed, agreement should be reached among the administrations and private operating agencies involved (terminal and transit) concerning the designation.

If it is of interest or useful to distinguish any private operating agency, broadcasting, or television authority that is involved, this may be done by inserting, after the place name, a suitable abbreviation in brackets (. . . . .) to identify the agency. Examples of this are given in various places in this section.

The various categories of private circuit are as follows:

2.1 *Private circuits connecting only two locations*

2.1.1 *Private circuit used wholly for telephony*

The circuit number preceded by the letter P follows immediately after the two terminal place names arranged in alphabetical order.

Example : Paris–Wellington P1

2.1.2 *Private circuit used wholly for voice-frequency telegraphy*

These are distinguished by the letters TP.

Example : Bern (RS)–New York (RCA) TP1

2.1.3 *Private circuit used wholly for data transmission*

These are distinguished by the letters DP.

Examples : London–Paris DP3
New York (PAA)–Rome (PAA) DP1

2.1.4 *Private circuit used wholly for phototelegraphy or facsimile*

These are distinguished by the letters FP.

Examples : London–Paris FP2
London–New York (AP) FP2

2.1.5 *Private circuit used wholly for sound-programme transmission*

The letters RP are used in the case of a unidirectional sound-programme circuit and the letters RRP in the case of a reversible sound-programme circuit. The names of the terminals in the designation for a unidirectional circuit are placed in the order corresponding to the direction of transmission (instead of the alphabetical order if this is different).

Examples : circuit transmitting in the direction Montreal to Wellington
Montreal–Wellington/NZ/ RP1

circuit transmitting in the direction Wellington to Montreal
Wellington/NZ/–Montreal RP1

Where it is necessary for sound-programme circuit designations to include an indication of the bandwidth this is done by adding in brackets the top nominal frequency in kHz in which case it is to be assumed that the lower limit of the frequency band effectively transmitted is 50 Hz or less.

Examples : London–Montreal RP1 (10 kHz)
London–Sydney RP1 (8 kHz)

2.1.6 *Private circuit used wholly for television transmission*

Similar in principle to the designations for sound-programme circuits except that the letters VP and VVP are used.

2.1.7 *Private circuit used for services other than those designated in 2.1.1 to 2.1.6 above or used for combinations of services*

In this category are circuits used for different transmissions at different times or circuits in which the bandwidth is divided into two or more bands thus providing two or more derived circuits which may be used for different types of transmissions.

These specialized circuits are distinguished by the letters XP.

Example : Bruxelles–Paris XP8

2.2 *Private circuits connecting three or more locations*

Into this category fall multi-terminal circuits of various types and configurations. They are distinguished by the letter M (indicating the multiplicity of locations served) added to the designatory letters recommended in paragraphs 2.1.1 to 2.1.7 above.

This leads, in principle, to the categories PM, TPM, DPM, FPM, RPM, RRPM, VPM, VVPM and XPM.

The circuit number, preceded by the appropriate designatory letters follows immediately after the two place names which are at the end of the longest path provided by the circuit, the place names being arranged in alphabetical order.

Example : the designation of a telephone circuit interconnecting Aachen, Bruxelles, Edinburgh, Marseille and Paris would be Edinburgh–Marseille PM1

The designation of a branch of such a circuit is the two terminal place names distinguishing the branch in alphabetical order placed in brackets and preceded by the circuit designation.

Example : the Paris–Bruxelles branch of the example above would be Edinburgh–Marseille PM1 (Bruxelles–Paris)

3. International groups, supergroups, etc.

The numbering of a group, supergroup, etc. is applied between the point where it is assembled to the point where it is broken down, independently of the position it occupies in the band of line frequencies.

3.1 *Groups : 8-channel groups, 12-channel groups etc.*[1]

Groups should be designated by a number whose first figure(s) indicates the number of circuits in the groups, as follows:

Examples : 801, 802, 803, . . . 898, 899, 8100, 8101, 8102, . . . for 8-channel groups;

1201, 1202, 1203, . . . 1298, 1299, 12 100, 12 101, 12 102, . . . for 12-channel groups;

1601, 1602, 1603, . . . 1698, 1699, 16 100, 16 101, 16 102, . . . for 16-channel groups;

and in general:

*X*01, *X*02, *X*03, . . . *X*98, *X*99, *X*100, *X*101, *X*102, . . . for *X*-channel groups.

[1] See the definitions in Recommendation M.30.

3.2 *Supergroups* [1]

Supergroups are designated by the numbers 6001, 6002, 6003, ... (for example, Amsterdam–London 6001), this series being reserved exclusively for the numbering of supergroups.

3.3 *Mastergroups* [1]

International mastergroups should be designated in a numerical sequence 30 001, 30 002, etc.

Example : Bruxelles–London 30 001

3.4 *Supermastergroups* [1]

International supermastergroups should be designated in the numerical sequence 90 001, 90 002, etc.

Example : Amsterdam–Paris 90 001

3.5 *Other designations*

The designatory letters, T, D, F, R, V, and X as defined in 2.1.1 to 2.1.7, placed immediately after the number, may be used to identify groups, supergroups, etc., used for purposes other than telephony. Such groups, supergroups, etc., take their place in the normal numbering sequence and do not constitute a numbering sequence of their own.

Example : London–Montreal 1201D
London–Paris 6001D

The above designations may be used in conjunction with the various designatory letters given in paragraphs 1.2, 1.3 and 1.4 as appropriate. If the link is provided for private service then the letter P should additionally be used.

Example : A supergroup link provided between renter's premises in London and Paris devoted to data transmission should be designated as shown below:
London–Paris 6001DP

4. International group and supergroup links

It may be that a group or supergroup link is not connected to terminal equipment and that no group or supergroup as defined in Recommendation M.30 is set up on that link. Nevertheless, for designation purposes the link will be numbered as though groups or supergroups had been set up. Such links are included in the nominal numbering sequence of groups and supergroups and are not given a separate numbering sequence.

[1] See the definitions in Recommendation M.30.

When a group or supergroup link is used only part time with terminal translating equipment (to provide a conventional group or supergroup) it should also be designated in accordance with paragraph 3 above followed by the letter X.

Examples : Amsterdam–London 1206X
London–Paris 6003X

5. Unidirectional groups and supergroups routed via multiple-access satellite systems

5.1 *Multiple destination unidirectional groups and supergroups*

The unidirectional path will be designated by the name of the sending terminal station followed by a dash and the letters MU (*M*ultiple destination *U*nidirectional) in brackets. This will be followed by the number of the group or supergroup.

Examples : A supergroup from London to Bogota, Lusaka and Ottawa, would be designated:

London–(MU) 6001

The next such supergroup from the same point of origin to whatever destinations would take the next number in the series, for example, the second supergroup from London would be designated:

London–(MU) 6002

but might go, for example, to Tokyo, Hawaii and Melbourne.

A supergroup from Ottawa to London, Lusaka and Paris would be designated:

Ottawa–(MU) 6001

Note. — Groups and supergroups routed via a multiple-access satellite system may be provided for exclusive use between two terminal stations only, in which case the normal designations given in the sections above will apply.

5.2 *Single destination unidirectional groups and supergroups*

The unidirectional path will be designated by the name of the sending terminal station followed by a dash and the letter U (*U*nidirectional) in brackets. This will be followed by the name of the receiving terminal station and the number of the group or supergroup.

Example : A unidirectional group transmitting in the direction from Paris to Etam, which in the reverse direction of transmission is assigned to a multiple-destination unidirectional (MU) group from Etam to Paris and Rio de Janeiro, would be designated as:

Paris–Etam (U) 1201

The next group between these locations, Paris and Etam, if bidirectional, would be designated in the normal manner as:

Etam–Paris 1202

Note. — Groups and supergroups routed via a multiple-access satellite system may be provided on a bidirectional basis for exclusive use between two terminal stations only, and in this case the normal designations given in the sections above will apply.

RECOMMENDATION M.15

ROUTINE MAINTENANCE PROGRAMME

1. Preparation

In order to reduce to a minimum the correspondence and discussions required for the organization of routine maintenance measurements on the international network, Study Group IV, or a regional group of its members on which all the countries concerned should be represented, meets each year to prepare a Routine Maintenance Programme and to discuss questions arising from the execution of this programme.

So far as possible, the programme is drawn up on the principle of batch measurements of circuits in a given relation. It shows simply the days (and not the times) when the routine maintenance tests should be carried out; it gives the days for testing international circuits (telephone, telegraph, sound and television programme circuits), as well as the days for testing international group, supergroup or mastergroup, etc. links.

The days for tests fixed in the Routine Maintenance Programme are determined according to the rules for the periodicity of tests on international circuits or on carrier systems. These rules are given in Part I, sections 2 and 3, of the Maintenance Recommendations.

Circuits on groups or supergroups the terminals of which coincide with those of the circuits have a single date of test shown only for the group under consideration. All other circuits, together with their dates of test, are shown separately subsequently. Those of the circuits which are in the main established over international groups and supergroups, etc. are, as far as possible, tested on the date of test of the group concerned.

The Routine Maintenance Programme is sent to the technical services of the different administrations concerned and by them to the control and sub-control stations and to the control and sub-control I.T.M.C.s.

The programme is supplemented by a " List of International Circuits " which is likewise sent to the operating services.

Note. — The attention of administrations is drawn to the possibility of substituting for the Routine Maintenance Programme dealt with in this Recommendation a Programme using a sampling method according to Recommendation M.63.

2. Presentation

2.1 *Routine Maintenance Programme*

The following rules are used in the presentation of the Routine Maintenance Programme.

2.1.1 *Name of transit countries*

When indicating the name of the country (or countries) of transit, the full name is not given, a code indication being used instead. A list of these codes is published in the Routine Maintenance Programme (see Recommendation M.15).

2.1.2 *Order of groups and circuits in the lists*

2.1.2.1 *Groups, supergroups, etc.*

The groups are listed in descending order of importance (e.g. supermastergroups, supergroups, groups).

In each category, they are listed in ascending numerical order and in alphabetical order.

They are mentioned only if they carry circuits having the same terminals as the groups.

2.1.2.2 *Circuits*

Those circuits which are not established over single groups are listed in the Programme in ascending numerical order and in alphabetical order and in accordance with the provisions of Recommendation M.14. So far as possible, they are also grouped into suitable batches. The control stations are underlined.

In order to standardize the order of the various types of circuits between two points in the national lists, the circuits are arranged in the following order:

a) one-way automatic circuits (including semi-automatic) . . . . (Z)
b) both-way automatic circuits (including semi-automatic) (No special indication)
c) manual circuits . . . . (M)
d) voice-frequency telegraph links . . . . (T)
e) data circuits . . . . (D)
f) facsimile circuits, etc. . . . . (F)
g) private (rented) circuits . . . . (P)

Example :	Düsseldorf – Rotterdam Z1, Z3	Z73
	Rotterdam – Düsseldorf Z2, Z4	Z82
	Düsseldorf – Rotterdam 1,2	9
	Düsseldorf – Rotterdam M1, M2	M9
	Düsseldorf – Rotterdam T1, T2	etc.
	Düsseldorf – Rotterdam P1	etc.
	Düsseldorf – Rotterdam DP1	etc.

Automatic or semi-automatic circuits operated in reverse alphabetical order (Z2, Z4, etc.) should be put directly after the circuits operated in alphabetical order, so that the size of the whole group of circuits may be appreciated at a glance.

2.1.3 *Comprehensive list of supermastergroups, mastergroups, supergroups and groups*

After the circuits, a complete list is given of all the supermastergroups, mastergroups, supergroups and groups in service between the two countries concerned; these are listed in decreasing order of importance (supermastergroups, mastergroups, supergroups, groups). Within each category the groups are arranged in ascending numerical order and in alphabetical order.

The control station is underlined.

Those stations which do not transmit a regulating pilot over the given group are marked with an asterisk.

2.2 *List of international circuits*

The " List of International Circuits " is an annexed document with a different presentation from that of the Programme. The Programme uses the double-entry system while the List is a single-entry document, that is each circuit appears in it once only. It is divided into sections, with each section containing a list of all the circuits existing between two given countries. Each group of two countries is given in alphabetical order. The sections are arranged in alphabetical order.

In each section, the circuits are listed in accordance with the procedure followed for the Programme (see paragraph 2.1.2.2). A column is set aside for circuits used occasionally for specific purposes. In this column only the numbers of the circuits are repeated and an indication of their usage is shown in brackets.

Example : 3 (ST1), Z14 (F1) . . . . etc.

3. Modifications

The days for testing new international links or circuits as well as modifications to the days for testing existing international links or circuits are determined by the technical service to which the control station or control I.T.M.C. is responsible, in agreement with other interested technical services. If the technical service responsible for a sub-control station or sub-control I.T.M.C. considers it necessary to alter the testing days for an international link or circuit, it should ask the technical service of the control country to make the necessary arrangements.

4. Indications

The Routine Maintenance Programme also gives the names, exact postal address, telegraphic addresses and also telephone numbers of the controlling services to which broadcasting authorities should make application for circuits (see Recommendation E.330).

1.2 — Transmission stability

RECOMMENDATION M.16

VARIATION OF OVERALL LOSS AND STABILITY OF TRANSMISSION

1. *Variation of circuit overall loss*[1] *with time*

1.1 *For all circuits*, the difference between the mean value of the transmission loss and the nominal value should not exceed 0.5 dB or 0.6 dNp.

1.2 *For category A circuits*, which, for some time, will continue to use older type equipment, the objectives should be as follows:

a) For a circuit routed over a single channel of a group the standard deviation of the variation of overall loss between the circuit access points for that circuit should not exceed 1.0 dB or 1.15 dNp.

b) For a circuit routed over channels of two or more groups in tandem, the standard deviation of the variation of overall loss between the circuit access points for that circuit should not exceed 1.5 dB or 1.73 dNp.

1.3 *For all circuits using modern type equipment and in general for category B circuits*, the objective is that the standard deviation of the variations of overall loss should not exceed 1.0 dB or 1.15 dNp.

The method for achieving the above objective values is left to the discretion of administrations (better maintenance, fitting of automatic regulators, etc.).

2. *Re-line-up of circuits, groups, supergroups, etc.*

When a circuit, group, supergroup, etc. has its routing or composition changed over part or all of its length, it is essential to ensure that a complete line-up of the circuit, group, etc., is made in accordance with the relevant line-up Recommendations since the re-routing constitutes a re-establishment of the circuit, group, etc.

This procedure is necessary in order to maintain the transmission performance and stability of the network[2].

3. *Basic factors for transmission stability*

The C.C.I.T.T. recommends that the following basic factors should be taken into account for achieving a stable network:

[1] " Circuit access points " are defined in Recommendation M.64.

[2] The pressing needs of the operating services should not be allowed to prevent these measurements from being properly carried out, since this could only result in a degradation of the stability and performance of the circuits in the network.

3.1 *Staff training*

The importance of this factor cannot be over-emphasized.

The staff should understand why level variations are to be kept to a low value and should be made fully aware of the results of incorrect adjustments. It is important that adjustments should be made only when absolutely necessary and an adjustment should never be made to cover up a fault.

The staff must realize the possible effects of a brief interruption in an automatic or semi-automatic telephone circuit, a voice-frequency telegraph link or a phototelegraph circuit.

3.2 *Design of installations*

Installations should be such that sudden interruptions are avoided. For example, this may be achieved by:

a) the arrangement of transmission equipment to facilitate maintenance, patching out, the replacement of valves, etc.;

b) the design of carrier generators with a view to great reliability;

c) the design of power supplies; attention is particularly drawn to the importance of the judicious choice and grading of protective devices (fuses, circuit-breakers) in the power feeds to repeater station racks. In the event of a protective device becoming short-circuited, the anode potential on neighbouring racks might drop to a point where the operation of amplifiers and oscillators is interrupted. Although the anode potential is restored on these neighbouring racks when the fuse has interrupted the short-circuit current, the transients that occur result in short breaks in transmission of the order of a millisecond.

3.3 *Careful organization of work in international exchanges, repeater stations, and on the external plant used in the international network*

Experience has shown that operations carried out on exchange and repeater station equipment and on the external plant (underground cables, etc.) are a major cause of attenuation and phase variations and of interruptions to service in the international network.

All work liable to cause interference should therefore be carried out, when possible, at times of light traffic. It must be recognized that for very long routes it will become increasingly difficult to find suitable periods of light traffic, bearing in mind the time differences which will exist between the terminal countries on such routes. This will require good co-ordination and co-operation between administrations. In particular, the control stations should be consulted well in advance.

3.4 *Careful organization of maintenance*

The same reasons for transferring working operations to times of light traffic apply to maintenance operations.

It is desirable to avoid all equipment changeovers which are not absolutely necessary.

Note. — See in this connection Recommendations G.231 and G.335 in Volume III of the *White Book*.

It is also desirable to guard against maintenance operations which appear harmless but which may, however, result in short interruptions and which are all the more dangerous if they affect common units (e.g. changeover of master oscillators).

3.5 *Power supplies*

a) Too frequent changeover of power supplies for routine maintenance must be avoided. It should be possible to make partial tests to check that the standby motor-generator starts, without changing over the power supplies.

b) The instruction or training of staff during the day on working power supplies should be forbidden.

c) Changeover of power supplies should be carried out at times of light traffic and as far as possible at night.

d) To ensure that circuits in the international network are not interrupted owing to the failure of public power supplies, repeater stations in the international network should have power-continuity arrangements which ensure that the transmission equipment continues to operate, *without any interruption*, in the event of a failure of the public power supply.

1.3 — Action to improve transmission stability

The C.C.I.T.T. strongly recommends the application of the arrangements described in Recommendations M.17, M.18 and M.19 for improving transmission stability and for ensuring satisfactory operation of transmission equipment.

RECOMMENDATION M.17

VIBRATION TESTING

Vibration tests, using the principles described in Supplement 2.9, should be made:

a) when equipment is put into service;

b) as a routine measure for preventive maintenance.

The periodicity of vibration tests made as a routine measure (e.g. once a year or once every two years) will be determined by the administration concerned and other tests will be made at other times if there are special reasons for doing so.

Concerning point a, the urgent requirements of the operating services have sometimes resulted in equipment being put into service (for audio and carrier circuits) before it has been sufficiently tested (in particular for faulty soldered joints, faulty valve contacts, etc.).

In these cases the equipment must be temporarily taken out of service and a thorough inspection made as soon as possible to remove all hidden causes of faults.

Equipment should not be put into service until after the most thorough inspection and this should always include vibration testing. It is necessary to ensure that the pressing needs of the operating services do not result in these tests being omitted or hastily done.

The vibration testing foreseen under a and b above naturally necessitates sufficient technical staff being available, but this is the only way that an international service with a satisfactory quality of transmission can be guaranteed.

RECOMMENDATION M.18

AUTOMATIC REGULATION BY PILOTS

1. *General*

In carrier systems, the presence of *pilots* (line pilots, group pilots, supergroup pilots, etc.) enables transmission to be supervised and an alarm to be given if there are large variations in level.

Regulation using pilots and the way such regulation (manual or automatic) is carried out has a decisive effect on transmission stability. Automatic line pilot regulation is normally used in wideband carrier systems. As regards regulation of group and supergroup links, C.C.I.T.T. studies show that automatic regulation is necessary in the following cases.

2. *Regulation of a supergroup link*

In order to maintain the stability of supergroup links, it will be necessary to equip such links with an automatic regulator at the receiving end of the link, when, after it has been ensured that no fault exists, the magnitude of the level variations at the end of the link is such that the required stability cannot be obtained.

The limit for such level variation should be such that:

— the mean deviation from the nominal value does not exceed $\pm$ 0.3 dB or $\pm$ 3 cNp;

— the standard deviation about the mean value is not greater than 0.5 dB or 6 cNp.

The automatic regulator may be dispensed with when:

— each of the five groups of which the supergroup is made up has an automatic group regulator at the point at which the supergroup ends and the mean deviation from the nominal value is within $\pm$ 0.3 dB or $\pm$ 3 cNp, and the standard deviation of the level of the supergroup pilot is smaller than 1.5 dB or 1.7 dNp.

Complex supergroups may need regulation at one or more through-connection points, so as to keep the nominal level within permissible limits at such points, and also so as not to overload the sections further down the line. In particular, an automatic regulator should be inserted:

— at an intermediate point if measurements show that the standard deviation from the nominal value of the input level to the following system is greater than 1.3 dB (1.5 dNp), it having been ensured that no fault exists;

— at the through-connection point nearest to the frontier, when the supergroup link uses at least two regulated line sections before it reaches the frontier.

3. *Regulation of a group link*

There should be an automatic regulator at the end of a group link:

— when, after it has been ensured that no fault exists, the magnitude of the level variations at the end of the link is such that the required stability cannot be obtained.

The limit for such level variations is that:

— the mean deviation from the nominal value does not exceed $\pm$ 0.3 dB or $\pm$ 3 cNp;

— the standard deviation about the mean value is not greater than 0.5 dB or 6 cNp;

— to replace the supergroup link regulation when the group link ends at the same point as the supergroup;

— when the group link is of category B.

When an international group link comprises several group sections within the territory of one country, automatic regulation (in the outgoing direction) will in general be necessary at the through-connection point nearest to the frontier.

In addition, it is desirable for pilot recordings to be taken, whenever possible, so as to be able to identify short breaks in transmission and to investigate their causes.

RECOMMENDATION M.19

READJUSTMENT TO THE NOMINAL VALUE

For *readjustment to the nominal value* after a routine maintenance measurement, care must be taken to follow the instructions:

— in Recommendation M.51 for regulated line sections;

— in Recommendation M.53 for supergroup and group links;

— in Recommendation M.62 for telephone circuits, distinction being made between:

a) circuits that are at audio-frequencies throughout (on loaded cables);

b) circuits on one channel of one group throughout;

c) more complicated circuits.

SECTION 2

SETTING-UP AND MAINTENANCE OF INTERNATIONAL CARRIER SYSTEMS

2.1 — Definitions [1]

RECOMMENDATION M.30

DEFINITIONS CONCERNING INTERNATIONAL CARRIER SYSTEMS

(*Note.*—Figure 1/M.30 refers to definitions 2 to 13. Figures 2, 3 and 4/M.30 refer to definitions 1 to 18.)

In the maintenance of international carrier systems, the following definitions should be used. These definitions apply to the combination of " go " and " return " directions of transmission unless otherwise indicated.

The use of multi-destination unidirectional groups, supergroups, etc., routed over multi-destination communication satellite systems may require that distinctions be made between the directions of transmission.

1. line link (using symmetric pairs, coaxial pairs, radio-relay link, etc.)

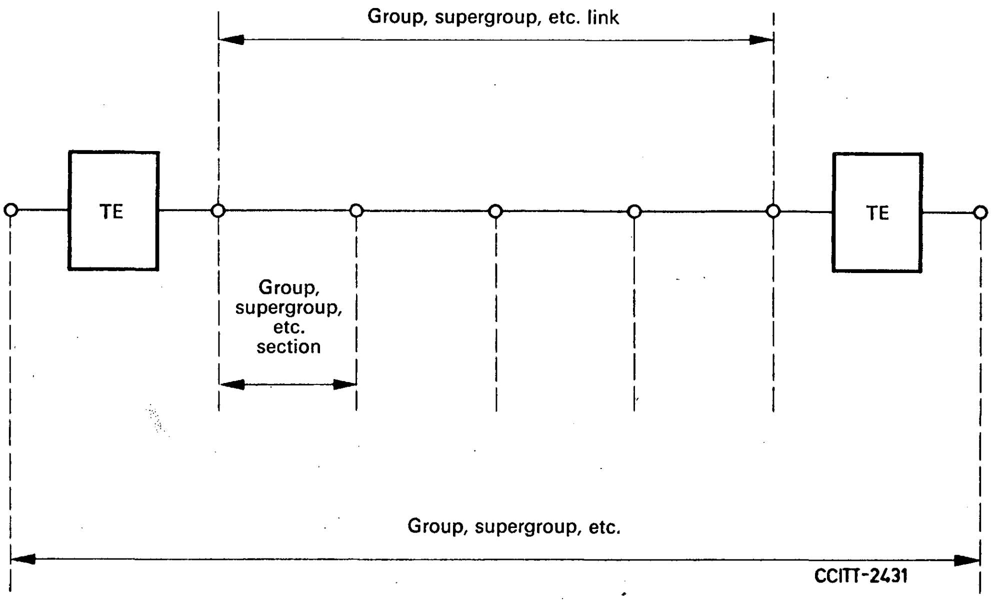
A transmission path however provided, together with all the associated equipment, such that the bandwidth available, while not having any specific limits, is effectively the same throughout the length of the link.

There is no frequency translation nor direct line filtration of groups, supergroups, etc., within the link, and the terminal stations for the link are those where the transmitted signals are changed in some way.

2. group link

The whole of the means of transmission using a frequency band of specified width (48 kHz) connecting two group distribution frames (or equivalent points). It can be made up of a number of group sections. When terminal equipments are connected to both ends, it becomes a constituent part of a group for carrying telephony channels or data or facsimile, etc.

[1] *Note.*—The IVth Plenary Assembly of the C.C.I.T.T. (Mar del Plata) decided that these definitions should be studied and, if necessary, revised during the study period 1968-1972 in a co-operation between Study Groups IV and XV (See Question 4/IV (27/XV).)



TE = terminal equipment for telephony, data, facsimile transmission, etc.

FIGURE 1/M.30

3. group section

The whole of the means of transmission using a frequency band of specified width (48 kHz) connecting two consecutive group distribution frames (or equivalent points) and, at least at one end, connected to through-group connection equipment. It always forms part of a group link.

4. group

A group consists of a group link connected at each end to terminal equipment. These terminal equipments provide for the setting-up of a number of telephony channels (generally 12), one or more data transmission or facsimile channels, etc.

It occupies a 48-kHz frequency band. Figures 1/M.32, 2/M.32, 3/M.32 show various possible arrangements of telephony channels in a basic group A (12 to 60 kHz) or basic group B (60 to 108 kHz).

5. supergroup link

The whole of the means of transmission using a frequency band of specified width (240 kHz) connecting two supergroup distribution frames (or equivalent points). It can be made up of a number of supergroup sections. When terminal equipments are connected to both ends, it becomes a constituent part of a supergroup for carrying telephony channels or data or facsimile, etc.

6. supergroup section

The whole of the means of transmission using a frequency band of specified width (240 kHz) connecting two consecutive supergroup distribution frames (or equivalent points), and, at least at one end, connected to through-supergroup connection equipment. It always forms part of a supergroup link.

7. supergroup

A supergroup consists of a supergroup link connected at each end to terminal equipments. These terminal equipments provide for the setting-up of five group links or sections occupying adjacent frequency bands in a 240-kHz band or for one or more data transmission or facsimile channels, etc.

The basic supergroup occupies the band 312 to 552 kHz. Figure 1/M.33 shows the position of groups and channels within the supergroup.

8. mastergroup link

The whole of the means of transmission using a frequency band of specified width (1232 kHz) connecting two mastergroup distribution frames (or equivalent points). It can be made up of a number of mastergroup sections. When terminal equipments are connected to both ends, it becomes a constituent part of a mastergroup for carrying telephone channels or data or facsimile, etc.

9. mastergroup section

The whole of the means of transmission using a frequency band of specified width (1232 kHz) connecting two consecutive mastergroup distribution frames (or equivalent points) and, at least at one end, connected to through-mastergroup connection equipment. It always forms part of a mastergroup link.

10. mastergroup

A mastergroup consists of a mastergroup link terminated at each end by terminal equipments. These terminal equipments provide for the setting-up of 5 supergroup links or sections occupying frequency bands separated by 8 kHz in a 1232-kHz band.

The basic mastergroup consists of supergroups 4, 5, 6, 7 and 8 within the band of frequencies 812 kHz to 2044 kHz (see Figure 1/M.34).

11. supermastergroup link

The whole of the means of transmission using a frequency band of specified width (3872 kHz) connecting two supermastergroup distribution frames (or equivalent points). It can be made up of a number of supermastergroup sections. When terminal equipments are connected to both ends, it becomes a constituent part of a supermastergroup for carrying telephony channels or data or facsimile, etc.

12. supermastergroup section

The whole of the means of transmission using a frequency band of specified width (3872 kHz) connecting two consecutive group distribution frames (or equivalent points) and, at least at one end, connected to through-supermastergroup connection equipment. It always forms part of a supermastergroup link.

13. supermastergroup

A supermastergroup consists of a supermastergroup link connected at each end to terminal equipment. These terminal equipments provide for the setting-up of 3 mastergroup links or sections separated by two free spaces of 88 kHz and occupying a band whose total width is 3872 kHz. The basic supermastergroup is composed of mastergroups 7, 8 and 9 occupying the frequency band 8516-12 388 kHz. (See Figure 1/M.35.)

14. 15-supergroup assembly link

The whole of the means of transmission using a frequency band of specified width (3716 kHz) connecting two 15-supergroup assembly distribution frames (or equivalent points). It can be made up of a number of 15-supergroup assembly sections. When terminal equipments are connected to both ends, it becomes a constituent part of a 15-supergroup assembly for carrying telephony or telegraphy channels or data or facsimile, etc.

15. 15-supergroup assembly section

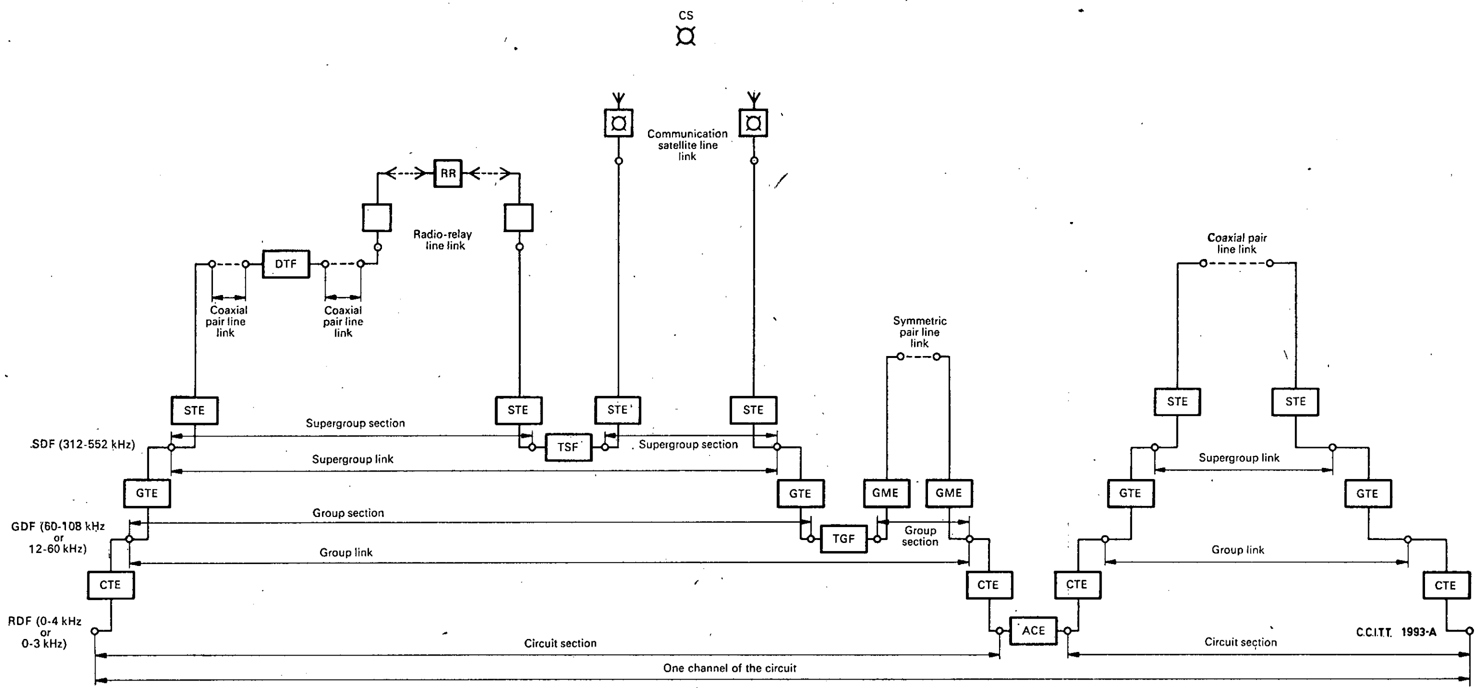
The whole of the means of transmission using a frequency band of specified width (3716 kHz) connecting two consecutive 15-supergroup assembly distribution frames (or equivalent points) and connected, at least at one end, to through-15-supergroup assembly connection equipment. It always forms part of a 15-supergroup assembly link.

16. 15-supergroup assembly

A 15-supergroup assembly consists of a 15-supergroup assembly link terminated at each end by terminal equipments. These terminal equipments provide for the setting-up of 15-supergroup links or sections separated by free spaces of 8 kHz and occupying a band whose total width is 3716 kHz. The basic 15-supergroup assembly is made up of supergroups 2 to 16 occupying the frequency band 312-4028 kHz.

17. through-group connection point

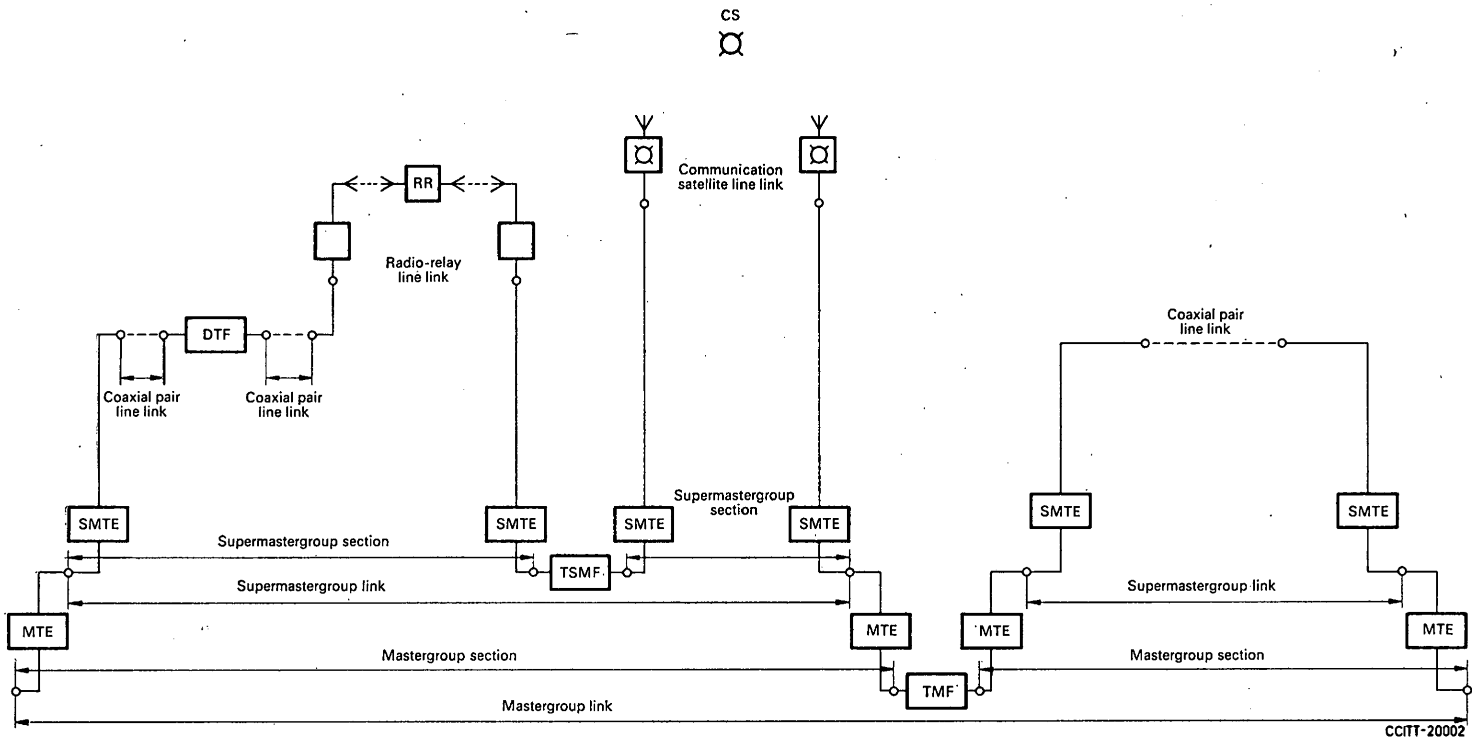
When a “ group link ” is made up of several “ group sections ”, they are connected in tandem by means of “ through-group filters ” at points called “ through-group connection points ”.



ACE — Audio connecting equipment
CTE — Channel translating equipment (translation of the audio band into the basic group or vice versa)
GTE — Group translating equipment (translation of the basic group into the basic supergroup)
STE — Supergroup translating equipment (translation of the basic supergroup into the line frequency on coaxial cable, or radio-relay system or vice versa)
GME — Group modulating equipment

DTF — Direct through-connection filter
TSF — Through-supergroup filter
TGF — Through-group filter
RDF — Repeater distribution frame
GDF — Group distribution frame
SDF — Supergroup distribution frame
RR — Radio-relay station
CS — Communication satellite

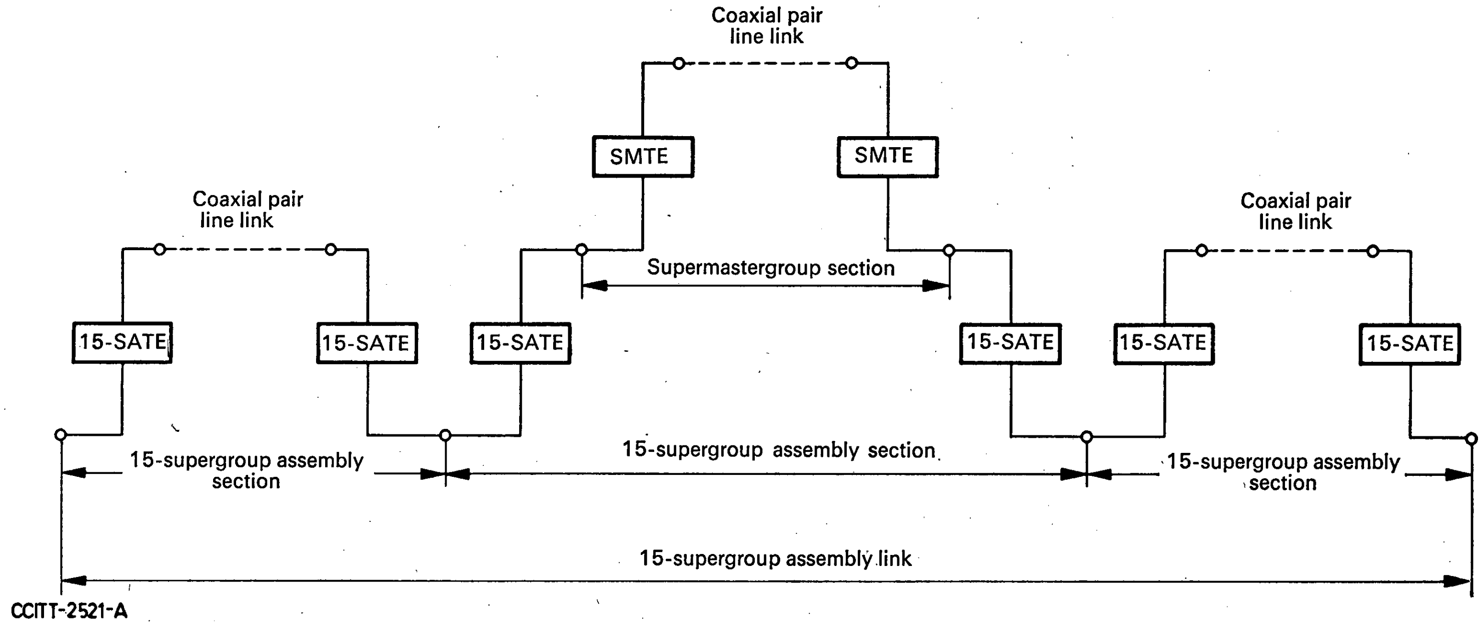
FIGURE 2/M.30. — **Channel of a group set-up on several line links in tandem**



MTE — Mastergroup translating equipment
SMTE — Supermastergroup translating equipment
TMF — Through-mastergroup filter
TSMF — Through-supermastergroup filter

DTF — Direct through-connection filter
RR — Radio-relay
CS — Communication satellite

FIGURE 3/M 30. — **Mastergroup link**



SMTE — Supermastergroup translating equipment

15-SATE — 15-supergroup assembly translating equipment

FIGURE 4/M.30. — **15-supergroup assembly link**

18. through-supergroup connection point

When a " supergroup link " is made up of several " supergroup sections ", they are connected in tandem by means of " through-supergroup filters " at points called " through-supergroup connection points ".

19. through-mastergroup connection point

When a " mastergroup link " is made up of several " mastergroup sections ", they are connected in tandem by means of " through-mastergroup filters " at points called " through-mastergroup connection points ".

20. through-supermastergroup connection point

When a " supermastergroup link " is made up of several " supermastergroup sections ", they are connected in tandem by means of " through-supermastergroup filters " at points called " through-supermastergroup connection points ".

21. through-15-supergroup assembly connection point

When a " 15-supergroup assembly link " is made up of several " 15-supergroup assembly sections ", these sections are interconnected in tandem by means of " through-15-supergroup assembly filters " at points called " through-15-supergroup assembly connection points ".

Note.—In a country normally using mastergroup and supermastergroup arrangements 15-supergroup assembly can be through-connected without difficulty at the supermastergroup distribution frame by means of through-supermastergroup filters. In this case, the 15-supergroup assembly is through-connected to position *3* (8620-12 336 kHz) instead of position *1* (312-4028 kHz) as required by the definition of the through-connection point of such an assembly. The point where this through-connection is made is a " mastergroup through-connection point " and not a " 15-supergroup assembly through-connection point ".

22. regulated line section (symmetric pairs, coaxial pairs or radio-relay links)

In a carrier transmission system, a line section on which the line-regulating pilot or pilots are transmitted from end to end without passing through an amplitude-changing device peculiar to the pilot or pilots.

23. national section

The group, supergroup, etc. sections between a station with control or sub-control functions and a frontier station within the same country are termed comprehensively a " national section ". A national section will usually comprise several group, supergroup, etc. sections. The group, supergroup, etc. sections between the two stations with control functions within one country also constitute a national section.

24. international section

The group, supergroup, etc. sections between two adjacent frontier stations in different countries constitute an " international section ". Some international sections may be a single group, supergroup, etc. section routed over long submarine cable carrier systems.

If the international group, supergroup, etc. is routed via intermediate countries without demodulation to the basic frequency band, the frontier stations at the ends of the international group, supergroup, etc. section are still considered to be " adjacent ".

25. main section

The sections into which the group, supergroup, etc. link is divided by the group, supergroup, etc. control and sub-control stations are called " main sections ". A main section is the portion of the group, supergroup, etc. link between two adjacent stations having control functions. In many cases these two stations are in different countries. In the case of a country which has elected to have more than one station with control functions a main section will lie wholly within that country. (See Figure 1/M.46.)

26. major section

In the case of a very long international group, supergroup, etc. made up of more than three main sections it may be necessary to combine adjacent main sections into larger units termed " major sections ". (See Figure 1/M.46.)

Note.—Figures 2/M.30 to 4/M.30 explain the constitution of a channel of a long carrier group set up on several tandem-connected carrier systems on symmetric pairs or coaxial cable or on a radio-relay link or satellite system. These figures show the use of the terms defined above for the component parts of the group.

2.2 Numbering of channels, groups, supergroups, mastergroups and supermastergroups in carrier transmission systems

RECOMMENDATION M.32

NUMBERING OF THE CHANNELS IN A GROUP

1. *General*

The position of a channel within a group is identified by a number starting from 1, the numbers of the different channels being taken in order of frequency in the basic group frequency band.

A channel is said to be " erect " within a group when the frequencies in the group-frequency band corresponding to the audio-frequencies in the channels " ascend " in the same relative order as those in the channels forming the group.

Similarly, a channel is said to be " inverted " within a group when the frequencies in the group-frequency band descend in the same relative order as the ascending order of the frequencies in the channels.

A group, supergroup, etc., is said to be erect when all of its channels are erect and is said to be inverted when all of its channels are inverted.

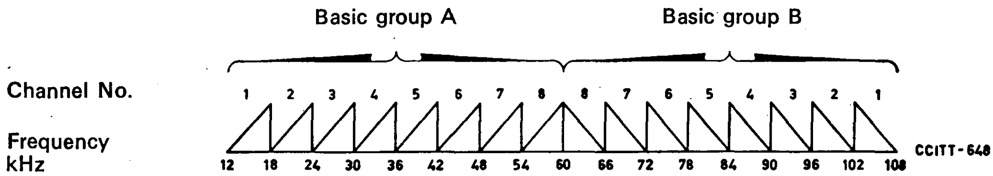


FIGURE 1/M.32. — **Numbering of channels in 8-channel groups**

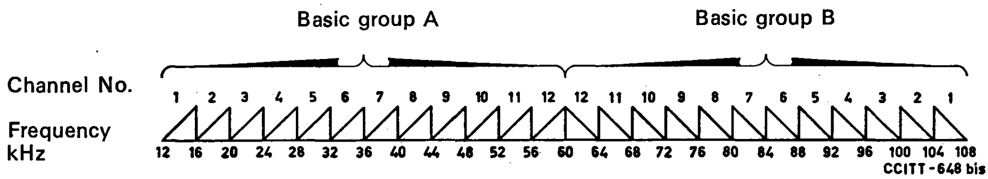


FIGURE 2/M.32. — **Numbering of channels in 12-channel groups**

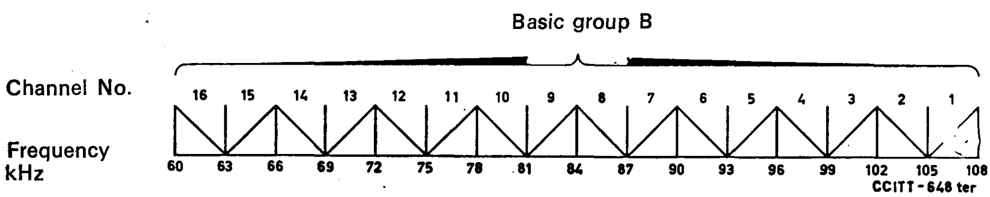


FIGURE 3/M.32. — **Numbering of channels in 16-channel groups**

1.1 *8-channel group*

a) Basic group A is " erect ". The channels will be numbered from 1 to 8 in ascending order of frequency within the group-frequency range.

b) Basic group B is " inverted ". The channels will be numbered from 1 to 8 in descending order of frequency within the group-frequency range. (See the recommended arrangement in Recommendation G.234.)

The numbering is as shown in Figure 1/M.32.

1.2 *12-channel group*

a) Basic group A is " erect ". The channels will be numbered from 1 to 12 in ascending order of frequency within the group-frequency range.

b) Basic group B is " inverted ". The channels will be numbered from 1 to 12 in descending order of frequency within the group-frequency range.

The same applies to groups C, D, E considered in Recommendation M.39.

The numbering is as shown in Figure 2/M.32.

1.3 *16-channel group*

Channels of a 16-channel group are normally assembled in the basic group B frequency range. The channels are numbered from 1 to 16 in descending order of frequency within the basic group B frequency band, the odd-numbered channels being " erect " and the even-numbered channels being " inverted ". It is therefore not possible in this case to speak of an " erect " or " inverted " group.

The numbering is as shown in Figure 3/M.32.

RECOMMENDATION M.33

NUMBERING OF GROUPS WITHIN A SUPERGROUP

The position occupied by a group within a supergroup is identified by a number in the series from 1 to 5, the numbers being allocated in ascending order of frequency in the basic supergroup 312 kHz to 552 kHz and in descending order of frequency in the other supergroups. (See Figure 1/M.33.)

If all the groups comprising the supergroup are erect

— the basic supergroup is said to be " erect ";

— the other supergroups are said to be " inverted ".

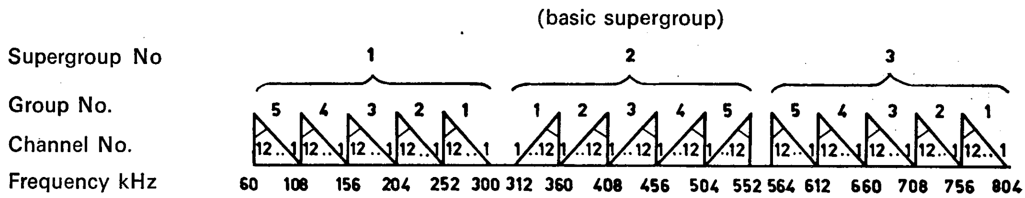


FIGURE 1/M.33. — **Numbering of 12-circuit groups and channels in supergroups**

RECOMMENDATION M.34

NUMBERING OF SUPERGROUPS WITHIN A MASTERGROUP

The position of a supergroup within a mastergroup is identified by a number in the series from 4 to 8 which refers to one of the numbers of the supergroups constituting the basic mastergroup in the supergroup arrangement of the standard 4-MHz coaxial system.

The numbering is shown in Figure 1/M.34.

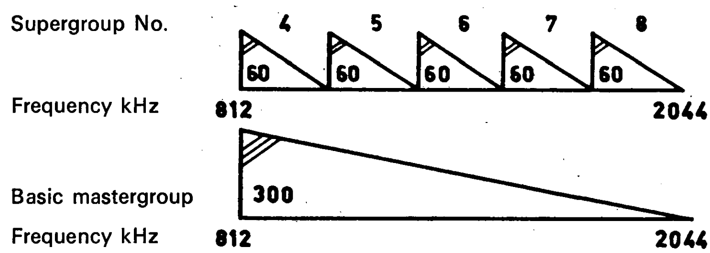


FIGURE 1/M.34. — **Numbering of supergroups within the basic mastergroup**

RECOMMENDATION M.35

NUMBERING OF MASTERGROUPS WITHIN A SUPERMASTERGROUP

The position of a mastergroup within a supermastergroup is identified by a number in the series from 7 to 9 which refers to one of the numbers of the mastergroups constituting the basic supermastergroup.

The numbering is shown in Figure 1/M.35.

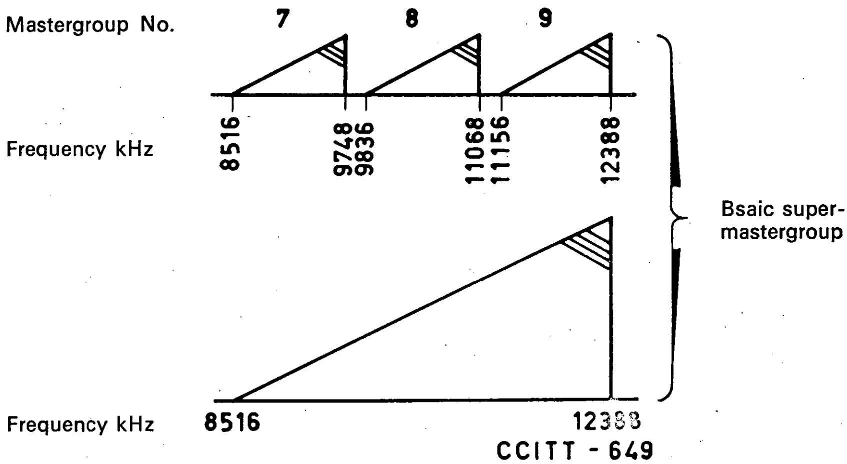


FIGURE 1/M.35

RECOMMENDATION M.38

NUMBERING IN COAXIAL SYSTEMS

1. NUMBERING OF GROUPS, SUPERGROUPS, ETC., AND OF CHANNELS IN COAXIAL SYSTEMS

1.1 *Numbering of a supermastergroup or of a 15-supergroup assembly*

The supermastergroups and 15-supermastergroup assemblies of a coaxial system are identified by numbers giving their respective position in the frequency spectrum transmitted on the line. The numbering is shown in Figures 1, 2 and 3/M.38.

1.2 *Numbering of a mastergroup*

The mastergroups of a coaxial system are identified by numbers giving their respective position in the frequency spectrum transmitted on the line. The numbering is shown in Figures 1, 2, 4, 8 and 10/M.38.

Alternatively, when a mastergroup is regarded as being part of a supermastergroup, the position of the mastergroup can be indicated by the number of that supermastergroup followed by the number of the mastergroup within the basic supermastergroup (for example, in Figure 1/M.38, the 5652-6884-kHz mastergroup in a 12-MHz system with supermastergroup frequency allocation is designated by the two numbers 2 and 8).

1.3 *Numbering of a supergroup*

The supergroups of a coaxial system are identified by numbers giving their respective position in the frequency spectrum transmitted on the line. The numbering is shown in Figures 2, 5, 6, 7 and 9/M.38.

The position of a supergroup that is part of a mastergroup is designated by the number of that mastergroup followed by the number of the supergroup within the basic mastergroup (examples: in Figure 1/M.38, the 5652-5892-kHz supergroup in a 21-MHz system with supermastergroup frequency allocation is designated by the three numbers 2, 8 and 4; in Figure 8/M.38, the 4332-4572-kHz supergroup in a 6-MHz system with mastergroup frequency allocation is designated by the two numbers 4 and 4).

The position of a supergroup that is part of a 15-supergroup assembly is designated by the number of that 15-supergroup assembly followed by the number of the supergroup within the basic 15-supergroup assembly (for example, in Figure 3/M.38, the 10 356-10 596-kHz supergroup in a 12-MHz system with frequency allocation by 15-supergroup assemblies is designated by the two numbers 3 and 9).

1.4 *Numbering of a group*

The position of a group is designated by the number of the supergroup in which it is placed followed by the number of the group within that supergroup (examples: in Figure 1/M.38, the 5844-5892-kHz group in a 12-MHz system with supermastergroup frequency allocation is designated by the four numbers 2, 8, 4 and 1; in Figure 8/M.38, the 4924-4972-kHz group in a 6-MHz system with mastergroup frequency allocation is designated by the three numbers 4, 6 and 3).

1.5 *Numbering of a channel*

The position occupied by a channel is designated by the number of the group to which it belongs followed by the number of the channel within that group (examples: in Figure 1/M.38, the 5884-5888-kHz channel in a 12-MHz system with supermastergroup frequency allocation is designated by the five numbers 2, 8, 4, 1 and 2; in Figure 8/M.38, the 4936-4940-kHz channel in a 6-MHz system with mastergroup frequency allocation is designated by the four numbers 4, 6, 3 and 9).

Note.—In this system of numbering, the order of the numbers corresponds to a decreasing bandwidth, that is to say, number of supermastergroup (if any) followed by the numbers of the mastergroup, supergroup, group and channel.

2. STANDARD FREQUENCY ALLOCATIONS ON 2.6/9.5-mm COAXIAL PAIRS

The C.C.I.T.T. has recommended various methods for allocating supermastergroups, mastergroups, supergroups and 15-supergroup assemblies on 2.6/9.5-mm coaxial pairs. The method for each standard system is given below. The identification numbers are shown in each figure to facilitate application of the rules set forth above.

2.1 *12-MHz systems using valves or transistors*

The frequency allocation for 12-MHz systems is in conformity with Scheme 1A, 1B or 2 shown in Figures 1, 2 and 3/M.38.

The C.C.I.T.T. has also recommended the frequency-allocation scheme in Figure 4/M.38 for the simultaneous transmission of telephony and television.

2.2 *4-MHz systems*

Figure 5A/M.38 shows the frequency-allocation scheme used in this case. The 2604-kHz pilot is used only in the 2.6-MHz system described below in paragraph 2.3.

The 4287-kHz pilot is recommended only for 4-MHz systems on 1.2/4.4-mm coaxial pairs.

2.3 *2.6-MHz systems*

The frequency-allocation scheme for a 2.6-MHz system uses the scheme in Figure 5/M.38 retaining only supergroups 1 to 10 inclusive.

The pilots are: 60 or 308 kHz and 2604 kHz.

3. STANDARD FREQUENCY ALLOCATIONS ON 1.2/4.4-mm COAXIAL PAIRS

The C.C.I.T.T. has recommended various methods for allocating supermastergroups, mastergroups, supergroups and 15-supergroup assemblies on 1.2/4.4-mm coaxial pairs. The method for each standard system is given below. The identification numbers are shown in each figure to facilitate application of the rules set forth above in paragraph 1.

3.1 *12-MHz systems*

The frequency-allocation schemes are the same as for 2.6/9.5-mm pairs (see Figures 1, 2 and 3/M.38).

3.2 *6-MHz systems*

The frequency allocation for 6-MHz systems is in conformity with Scheme 1, 2 or 3 shown in Figures 6, 7 and 8/M.38.

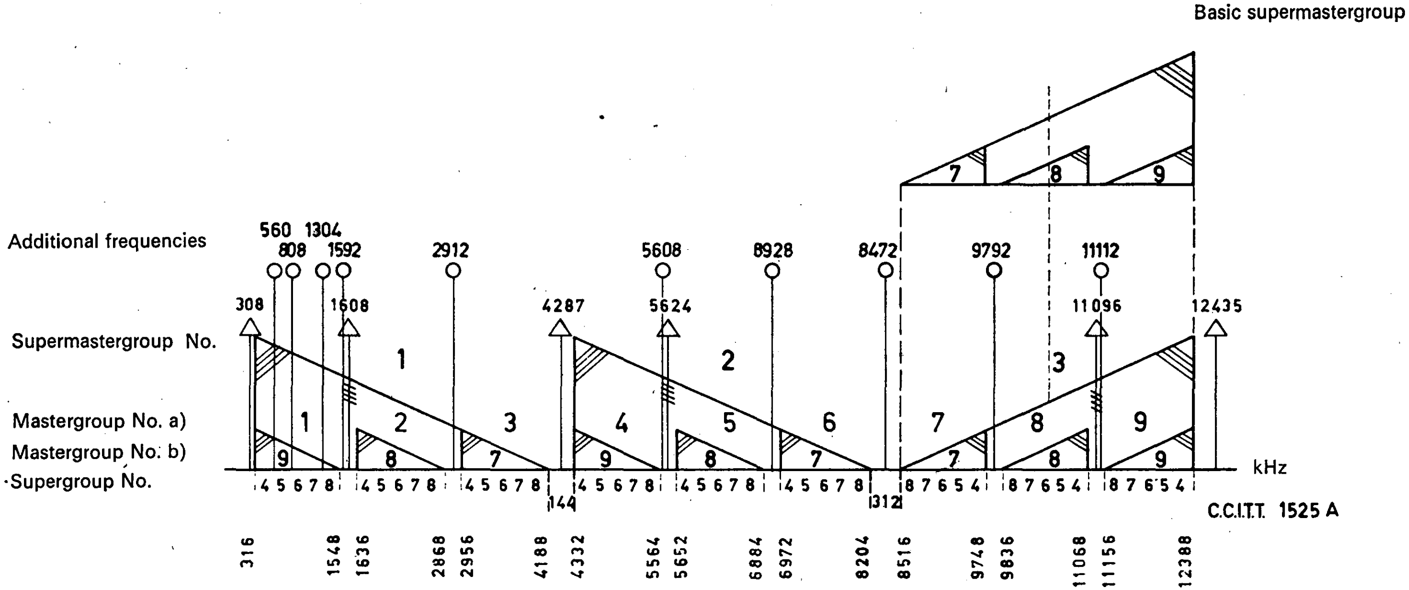
3.3 *4-MHz systems*

The line-frequency allocation scheme shown in Figure 5A/M.38 is the same as for 2.6/9.5-mm pairs. However, the 4287-kHz pilot must be transmitted continuously if one of the administrations concerned so requests

Figure 5B/M.38 shows the line-frequency allocation scheme used for mastergroups.

3.4 *1.3-MHz systems*

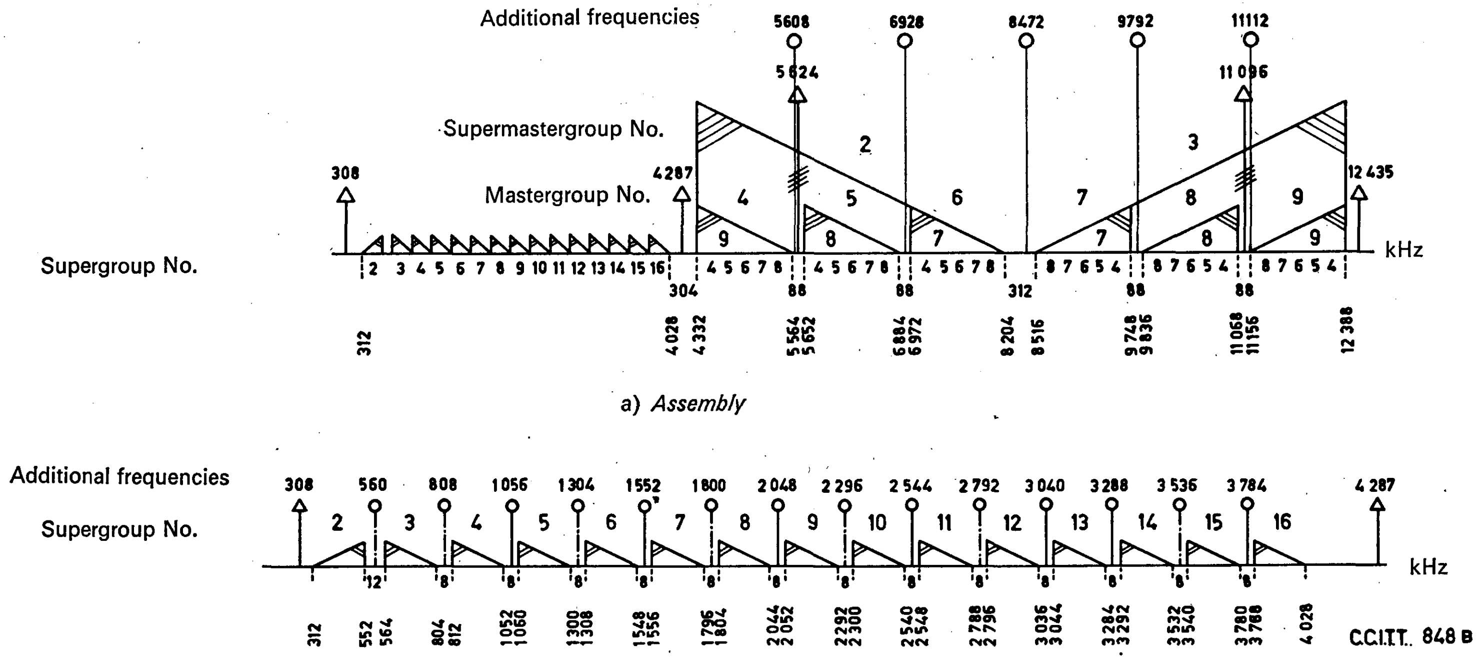
The line-frequency allocation scheme is in conformity with one of the schemes shown in Figures 9 and 10/M.38).



a) Numbering of mastergroups transposed to line

b) Numbering of mastergroups transposed within the supermastergroups

FIGURE 1/M.38. — **Frequency allocation (Scheme 1A) for 12-MHz systems**



b) *Frequencies below 4287 kHz*

FIGURE 2/M.38. — **Frequency allocation (Scheme 1B) for 12-MHz systems**

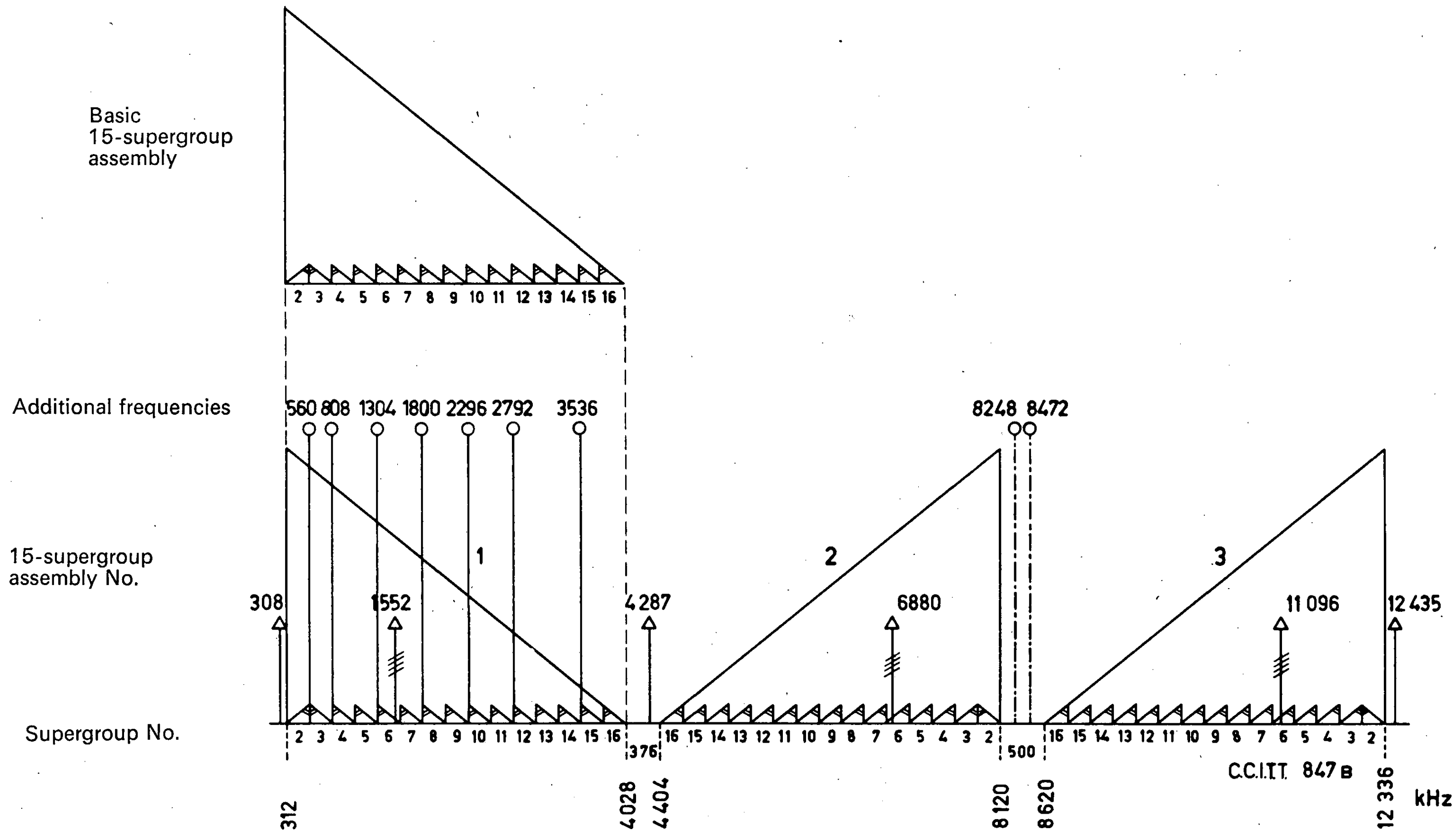


FIGURE 3/M.38. — **Frequency allocation (Scheme 2) for 12-MHz systems**

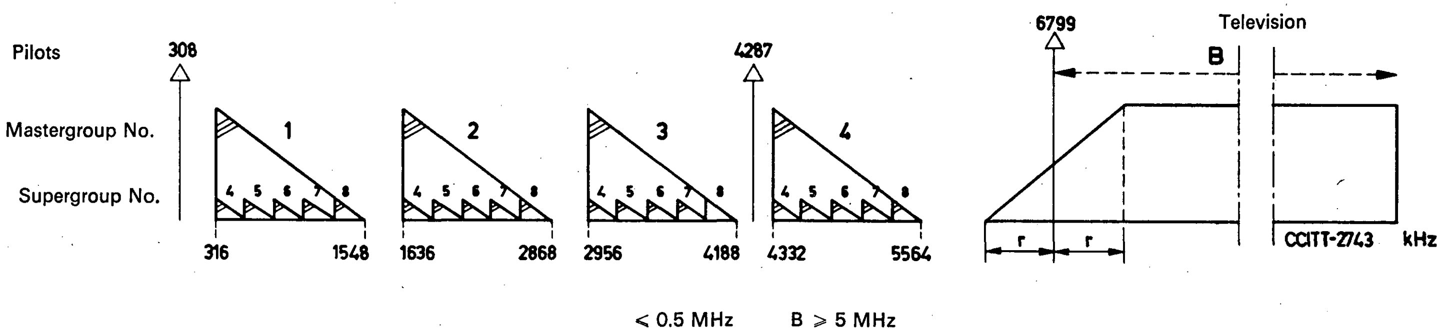


FIGURE 4/M.38. — **Line-frequency allocation for 12-MHz systems (simultaneous transmission of telephony and television)**

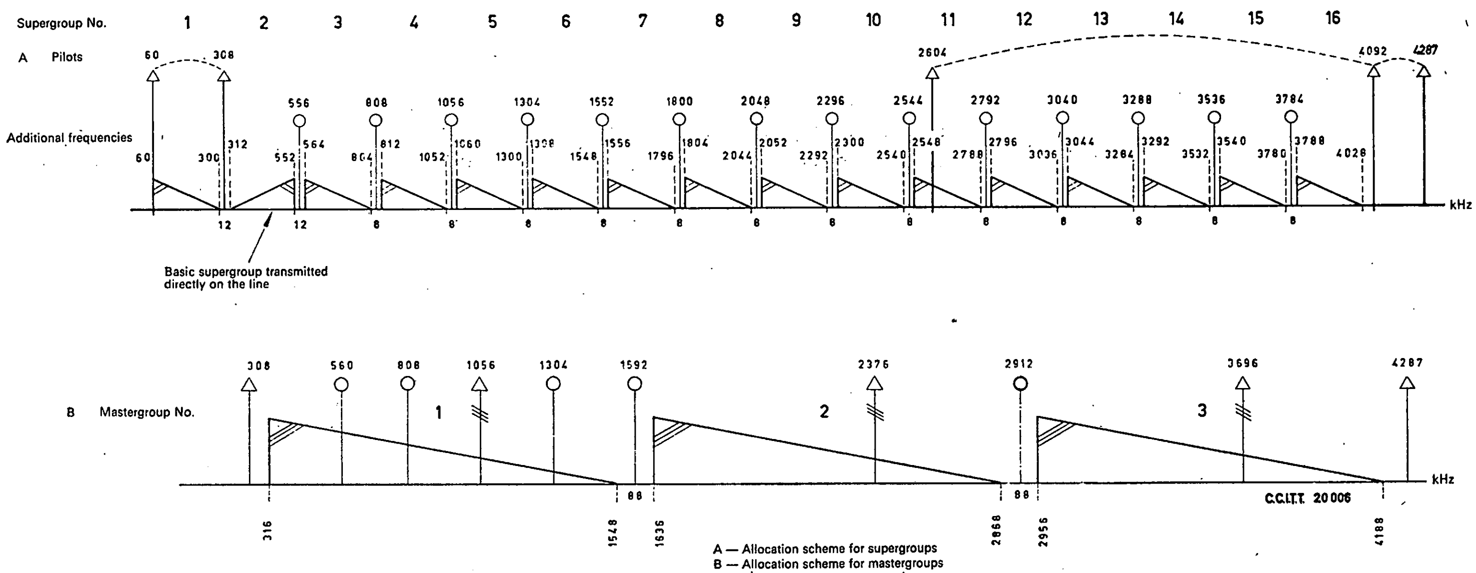


FIGURE 5/M.38. — **Line-frequency allocation for 4-MHz systems**

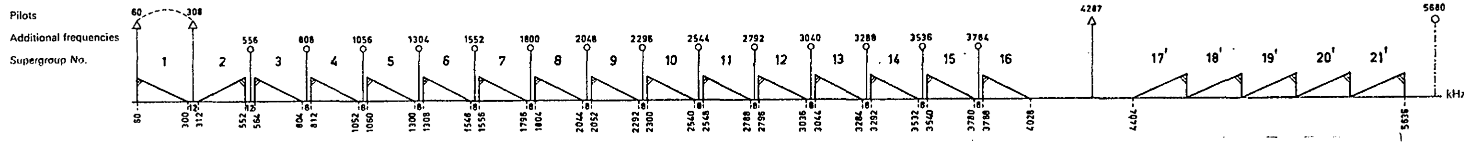


FIGURE 6/M.38. — **Line-frequency allocation for 6-MHz systems (Scheme 1)**

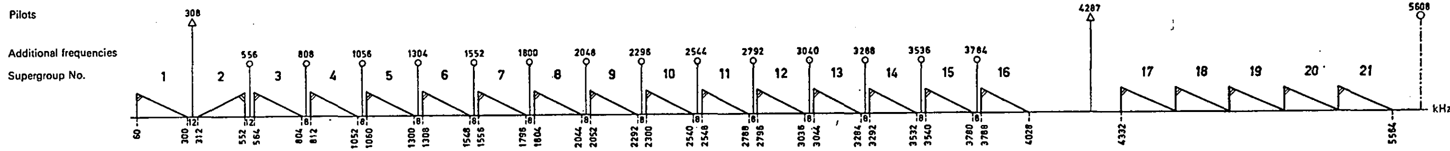


FIGURE 7/M.38. — **Line-frequency allocation for 6-MHz systems (Scheme 2)**

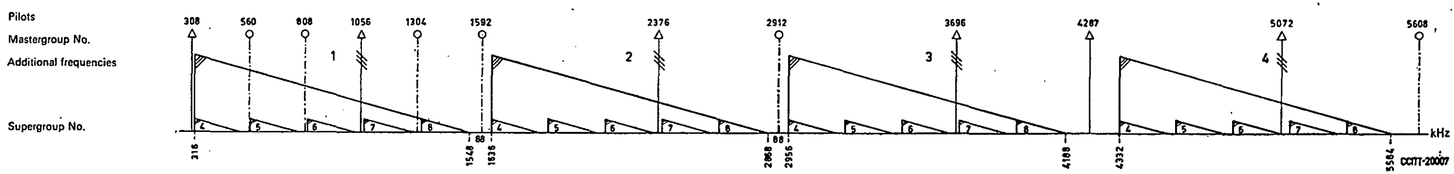


FIGURE 8/M.38. — **Line-frequency allocation for 6-MHz systems (Scheme 3)**

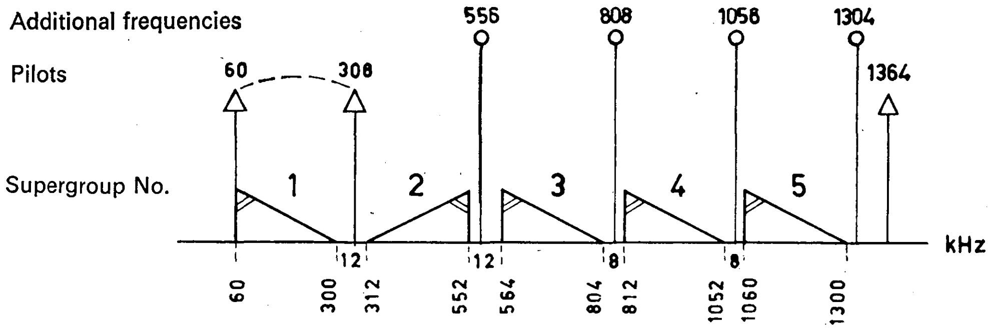


FIGURE 9/M.38. — **Line-frequency allocation for 1.3-MHz systems (Scheme 1)**

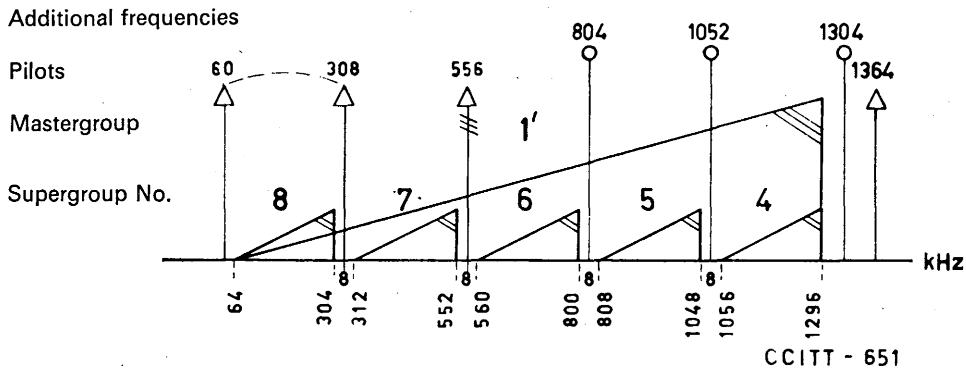


FIGURE 10/M.38. — **Line-frequency allocation for 1.3-MHz systems (Scheme 2)**

RECOMMENDATION M.39

NUMBERING IN SYSTEMS ON SYMMETRIC PAIR CABLE

1. *Systems providing 12 telephone carrier circuits on a symmetric pair in cable (12+12) systems*

In systems of the 12+12 type, 12 go and 12 return channels constitute one 12-circuit group.

For the arrangement of the line frequencies transmitted for 12+12 cable systems using transistors, the administrations and private operating agencies concerned in setting-up such an international system can make their choice from Scheme 1 or Scheme 2 of Figure 1/M.39 (Figure 49 of the *Blue Book*, Volume III). Systems using Scheme 2 can use only pilot frequencies of 54 kHz or 60 kHz.

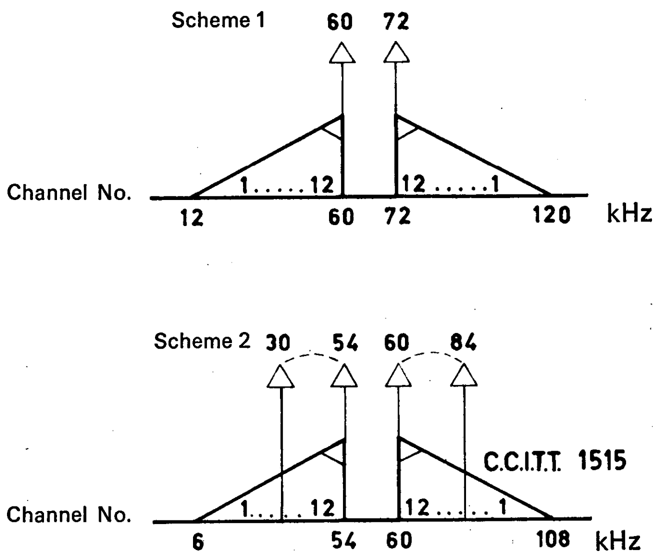


FIGURE 1/M.39

Figure 1/M.39 below also applies to (12+12) systems using valves, provided that in the case of Scheme 2 the indicated line-regulating pilots of 54 kHz and 60 kHz, or 30 kHz and 84 kHz, can be chosen as pilot frequencies.

2. *Systems providing five groups or less*

The rules outlined below apply to systems with five groups or less. They apply also to two supergroup systems on symmetric pair cables.

2.1 *Numbering in systems where there is a basic group A*

Where there is more than one group, the basic group A is erect and all the others are inverted.

a) *Designation of groups*

The following indications are used to define the position of the group on the line, as shown in Figure 2/M.39:

A : 12-60-kHz group; B : 60-108-kHz group;
C : 108-156-kHz group; D : 156-204-kHz group;
E : 204-252-kHz group.

(groups A and B are the basic groups A and B defined by the C.C.I.T.T.).

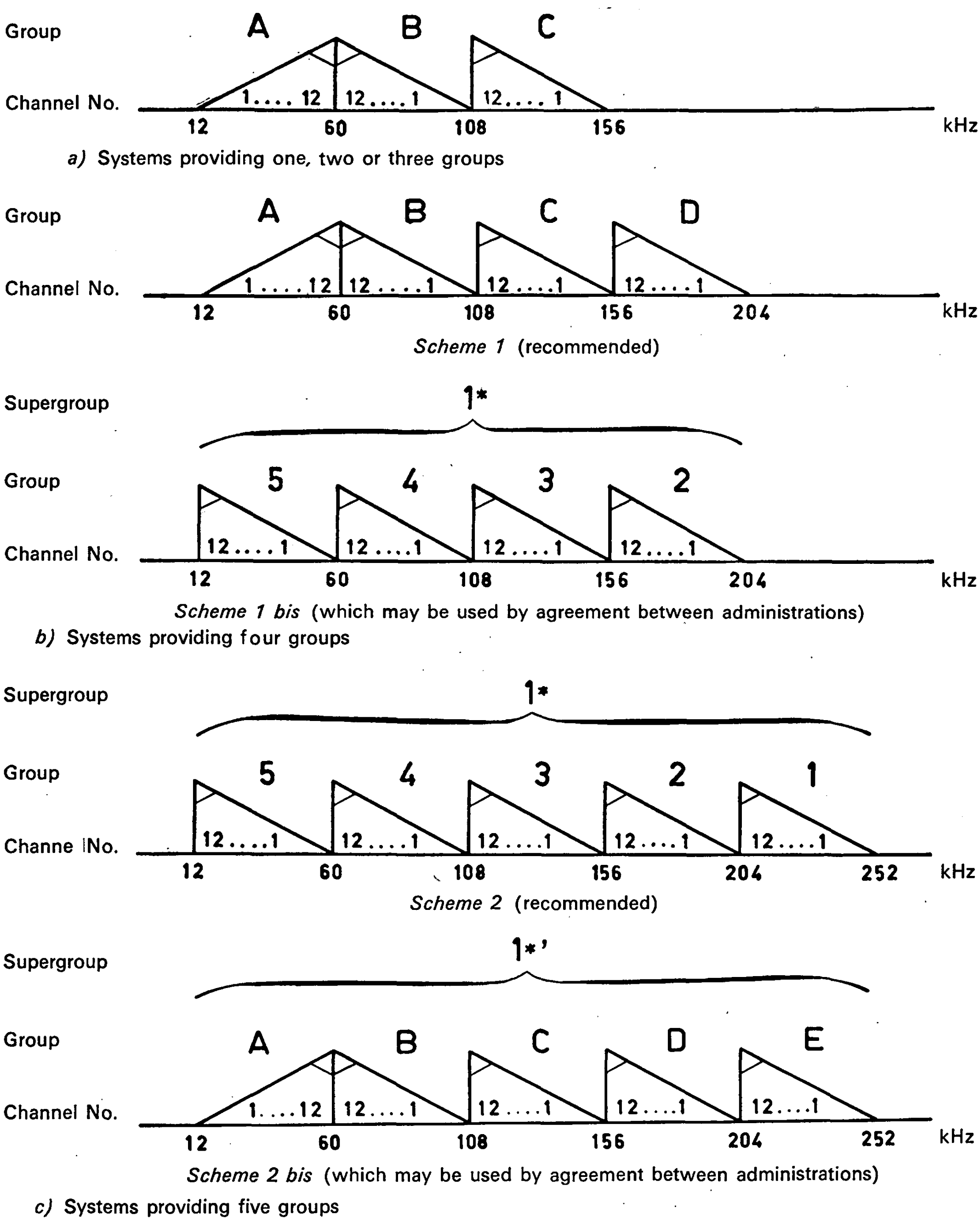


FIGURE 2/M.39. — **Line-frequency allocation and arrangement of sidebands for carrier systems on symmetric pair cables**

Note. — This figure also shows the channel numbering in the case of 12-channel groups. For the channel numbering of 8-channel and 16-channel groups respectively, see Figures 1 and 3 of Recommendation M.32.

b) *Designation of channels*

The position occupied by a telephone channel of a carrier system is designated by means of a letter giving the position of the group (transmitted on the line) containing the channel and by means of the number of the channel within this group.

The designation of a channel on such carrier system is therefore of the form A-7, C-9, D-4, etc. (i.e. group A, channel 7, etc.).

2.2 *Numbering in systems without basic group A*

In this case, all the groups are in the same sense. For systems with five groups on symmetric pair cable, this is the normal arrangement which is as shown in Scheme 2 in Figure 2/M.39 c).

a) *Numbering of the groups*

The five groups, all in the same sense, are numbered in the direction of ascending frequency, 5, 4, 3, 2, 1 and the assembly constitutes a supergroup having a displacement by 48 kHz towards the lower frequencies of supergroup 1 of 4-MHz coaxial system. For this reason the assembly of groups in the figure is designated by the number 1*, in order to integrate this supergroup with the general numbering for supergroups.

b) *Numbering of channels*

The place occupied by a telephone channel in such a carrier system is also designated by three numbers, e.g. 1*-4-11 (i.e. supergroup 1, 12-channel group 4, channel 11).

2.2.1 *Systems with four groups*

By agreement between the administrations concerned, one group of supergroup 1* may be omitted, but the above numbering of the groups and channels in the groups should be retained as if no group had been omitted (see Scheme 1 *bis* of Figure 2/M.39 b).

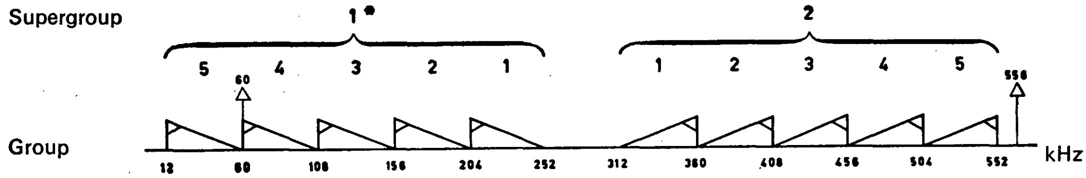
3. *Systems providing two supergroups*

3.1 *Alternative frequency arrangements*

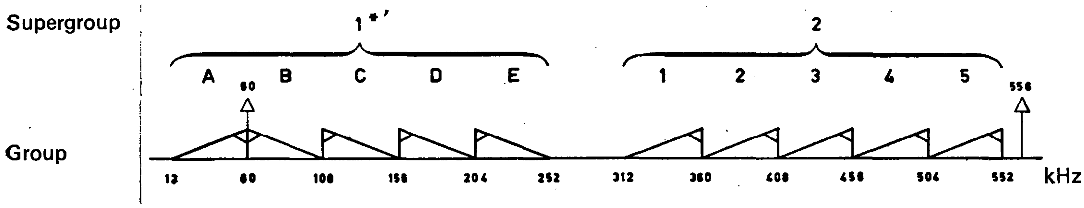
The two recommended frequency arrangements are shown in Scheme 3 and Scheme 4 of Figure 3/M.39. In Scheme 4, the line-frequency allocation is the same as that for coaxial cable systems, and permits satisfactory interconnection at basic supergroup frequencies (312-552 kHz) between supergroups in these coaxial systems and the two supergroups on symmetric pair cable systems.

In Scheme 3, the line-frequency allocation for supergroup 1* is the same as that recommended for a 5-group system on symmetric pair cables (Scheme 2, Figure 2/M.39 c).

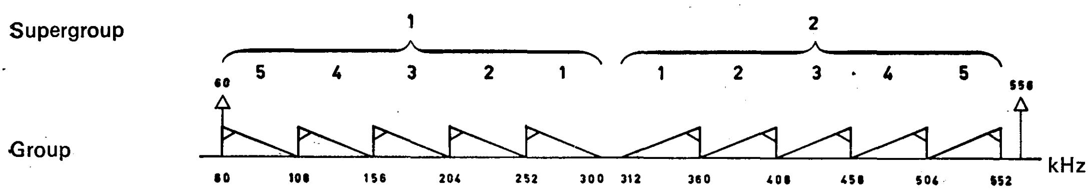
The frequency allocation shown for supergroup 1* in Scheme 3 *bis* may be used by agreement between administrations where interconnection with existing systems having five groups or less is required.



Scheme 3 (recommended)



Scheme 3 bis (may be used by agreement between administrations)



Scheme 4 (recommended)

FIGURE 3/M.39. — **Line-frequency allocation for carrier systems providing two supergroups on symmetric pair cables**

3.2 *Numbering of supergroups, groups and channels*

a) The numbering of the groups and channels on a 2-supergroup system follows the principles given in Recommendations M.32 and M.33.

b) For supergroup 2 in each scheme and for supergroup 1 in Scheme 4 the numbering used is that given in Recommendations M.32 and M.33 for coaxial systems.

c) For supergroup 1* and 1*' the numbering used is the same as that shown for Scheme 2 and Scheme 2 *bis* in Figure 2/M.39 c.

RECOMMENDATION M.40

NUMBERING IN RADIO-RELAY LINKS OR OPEN-WIRE LINE SYSTEMS

For numbering in a radio-relay link using frequency division multiplex, the channels, groups, supergroups, etc. are considered in the position they occupy in the baseband to be transmitted by that link.

In the interests of direct interconnection the C.C.I.R. and C.C.I.T.T. have collaborated in drawing up Recommendation G.423 from which it follows that the numbering of the telephony channels, groups and supergroups, etc., of the radio-relay link is as described in Recommendations M.32 to M.39.

The same rules are applied to carrier systems on open-wire lines providing at least one group having 12 telephone channels.

2.3 Bringing new carrier systems into service. Setting-up and lining-up. Reference measurements

RECOMMENDATION M.45

BRINGING A NEW INTERNATIONAL CARRIER SYSTEM INTO SERVICE

1. *Preliminary exchange of information*

As soon as administrations or private telephone operating agencies have decided to bring a new international carrier system into service, the necessary contacts are made between their technical services for the exchange of information. Those services jointly select the control and sub-control stations for the new system (see Recommendations M.8 and M.9).

The technical services of each administration are responsible for arranging for setting-up and lining-up the line sections on their own territory and must make the adjustments and tests required.

To set up a line section which crosses a frontier, administrations should arrive at bilateral arrangements on the basis of C.C.I.T.T. Recommendations and, for radio-relay sections, the Recommendations of the C.C.I.R.

2. *Setting-up sections crossing a frontier*

a) *Radio-relay section*

Details of the following points will have been settled by a bilateral agreement between the technical services of administrations:

— geographical position of the radio-relay station nearest to the frontier;

— contour of the terrain of the radio section crossing the frontier, with details of the height of the antennae above normal level;

— directivity characteristic and gain of the antennae;

- radio-frequency channel arrangement (centre frequency, polarization intermediate frequency);
- provision of supervisory system;
- radio equipment line-regulating pilots (if any);
- continuity pilots, used for supervising the radio-relay link, in accordance with the C.C.I.R. Recommendations on the frequency and frequency deviation of this signal, each country transmitting the pilot required by the system in the receiving country;
- noise measurement channels outside the transmitted baseband;
- total noise for the radio-relay section;
- frequency deviation of the telephony channel the level of which at the centre frequency is unaffected by pre-emphasis (either of the telephony channel itself or of the radio-frequency channel of the system);
- pre-emphasis characteristics of the radio-frequency channel;
- service, supervisory and remote channel circuits;
- level, frequency and coding of the signals transmitted over these lines;
- protective switching equipment;
- interconnection points T, R, T′, R′ (see Figure 1/M.45) defined in Recommendation G.213 (C.C.I.T.T. *White Book*, Volume III). (See also the Annex to C.C.I.R. Recommendation 380-1) and especially the return loss at points R and R′ if required (see C.C.I.R. Recommendation 380-1 for values).

b) *Coaxial pair line section*

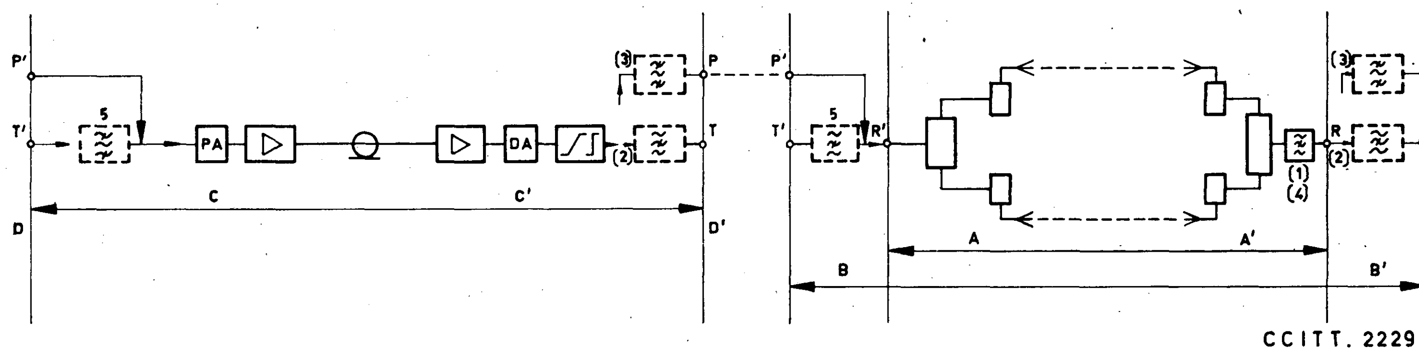
Details of the following points will have been settled by bilateral agreement between the technical services of the administrations:

- the choice of the frequency arrangement to be adopted;
- the pilot signals to be used for regulating the line, in accordance with C.C.I.T.T. recommendations on the frequency and level of such signals, each country transmitting the pilot signals required by the equipment of the other country [1];
- service, supervisory and remote control circuits;
- repeater identification method and frequencies for fault location and monitoring on transistorized systems;
- provisions for remote power feeding, where a section of the supply line crosses the frontier;
- the regulation systems used by each country;
- the nominal level at various frequencies, at the output of the frontier repeater.

Concerning this last item, at the incoming point, each administration should as far as possible accept the conditions usual for the system of the other country.

During the lining-up tests, the relative power level measured at the output of the repeater in the unburied repeater station nearest to the frontier should not differ, for any

[1] See the table in Recommendation M.54 indicating the pilot frequencies for various systems.



A, A′ — Radio equipments
B, B′ — System via radio
C, C′ — System via cable
D, D′ — Boundary of the high-frequency line equipment
Point P′ — Provided for possible injection of regulating pilots
Between T and T′ — Telephony translating equipment and/or direct through-connection equipment
DA — De-emphasis network
PA — Pre-emphasis network
(1) — Blocking of continuity pilots and, if necessary, of regulating pilots
(2) — Blocking, if necessary, of line-regulating pilots, and of pilots that must not go beyond the line link
(3) — Through-connection filter for line-regulating pilots, if necessary. A through-connection filter for telephone groups can, if necessary, be inserted
(4) — Blocking of unspecified pilots or supervisory signals
(5) — Filter for blocking any unwanted frequency sector injecting a pilot ensuring with (2) the requisite protection against a pilot (or other frequency) coming from another regulated line-section (system B or C, as the case may be)

FIGURE 1/M.45. — **Interconnection points T, R, T′, R′**

frequency, by more than $\pm$ 2 dB or $\pm$ 2 dNp from the nominal value (as defined by a graph drawn up beforehand and based on the characteristics of the system in question).

The frequencies used in lining-up the line are determined by agreement between the administrations concerned. Experience shows that, provided the number of test frequencies required is not too large, it is useful to make these tests at frequencies lying very close to each other at the edges of the frequency band, or at points where irregularities have to be corrected, and at frequencies less close to each other elsewhere in the band.

c) *Symmetric-pair line section*

The following points will have been settled by bilateral agreement between the administrations:

— frequency allocation;
— pilots [1];
— service, supervisory or remote control lines, etc.;
— repeater identification method and frequencies for fault location and monitoring on transistorized systems;
— provisions for remote power feeding, where a section of the supply line crosses the frontier.

When a symmetric-pair line section crossing a frontier section is first set up, tests should be made at clearly defined frequencies to determine the insertion loss/frequency characteristic. For example, frequencies spaced at the following intervals could be used, except at the edges of the band, where more closely spaced measuring frequencies are desirable:

4 kHz between 12 kHz and 60 kHz,
8 kHz between 60 kHz and 108 kHz,
12 kHz between 108 kHz and 252 kHz,
24 kHz between 288 kHz and 552 kHz.

The conditions for making measurements at line-pilot frequencies should be agreed by the technical service concerned.

Level measurements at the frequencies chosen will be made at each line amplifier at the unburied repeater station nearest to the frontier. The nominal value of the amplifier output level at each frequency should be as given below, except where special cables, such as submarine cables, are concerned or where special equalization is used, for example pre-equalization.

High gain systems, using valves

+4.5 dB or +5.0 dNp for systems with one, two or three groups;
+1.75 dB or +2.0 dNp for systems with four or five groups or two supergroups.

High gain systems, using transistors

Systems in accordance with the indication given in Recommendation G.323.

[1] See the table in Recommendation M.54 indicating the pilot frequencies for various systems.

Low gain systems using transistors

−11 dB or −13 dNp for systems with one, two or three groups;

−14 dB or −16 dNp for systems with four or five groups or two supergroups.

Low gain (12+12) systems using transistors

−15 dB or −17 dNp at points of direct line interconnection.

The relative power level measured at any of the frequencies chosen should not differ by more than ±2.0 dB or ±2.0 dNp from the nominal value for both valve and transistor type amplifiers.

3. *Overall reference measurements for the line*

The sections across frontiers and national sections having been set up and connected, reference measurements are made between the high-frequency line terminals of the carrier system, excluding the terminal equipment.

3.1 *Level measurements*

These are made at the following frequencies:

a) *Radio-relay line section*

When a radio-relay section is put into service, measurements and adjustments in accordance with the C.C.I.R. Recommendations for the radio-relay system concerned are first made of:

— the frequency at which the level is unchanged by pre-emphasis and the deviation of that frequency;

— the level and frequency of the *characteristic radio frequency*;

— the *central position of the intermediate frequency* (if necessary);

— check and adjustment of input and output levels baseband/baseband (see C.C.I.R. Recommendation 380-1 for values);

— measure of overall loss/frequency characteristic using additional measurement frequencies [1].

b) *Coaxial line section*

Line-regulation pilots and any other test frequencies available. The highest possible number of frequencies should be selected from the following:

i) *For a 1.3-MHz system:* 60, 308, 556, 808, 1056, 1304, 1364 kz;H

ii) *For a 2.6-MHz system:* 60, 308, 556, 808, 1056, 1304, 1552, 1800, 2048, 2296, 2604 kHz;

iii) *For a 4-MHz system:*

— frequency allocation with supergroups:
60, 308, 556, 808, 1056, 1304, 1552, 1800, 2048, 2296, 2544, 2792, 3040, 3288, 3536, 3784, 4092, 4287 kHz;

[1] Reference measurements should be made at several frequencies in both directions of transmission between accessible measuring points corresponding as nearly as possible to points R and R′ as defined in Recommendation G.213. These measurements should be made at the frequencies specified in paragraph b) below for each transmitted bandwidth.

— frequency allocation with mastergroups:
Figure 5/M.38 (Scheme 2):
308, 560, 808, 1304, 1592, 2912, 4287 kHz.

iv) *For a 6-MHz system :*

— frequency allocation with supergroups:
308, 556, 808, 1056, 1304, 1552, 1800, 2048, 2296, 2544, 2792, 3040, 3288, 3536, 3784, 4287 (5680) [1] kHz,

— frequency allocation with mastergroups:
Figure 8/M.38 (Scheme 3):
308, 560, 808, 1304, 1592, 2912, 4287, 5608 [1] kHz

v) *For a 12-MHz system :*

— at frequencies below 4 MHz:
if frequency allocation without mastergroups is used: *308*, *560*, *808*, 1056, *1304*, 1552, *1800*, 2048, *2296*, 2544, *2792*, 3040, 3288, *3536* and *3784* kHz (the frequencies are those at which the measurements must always be made);
if frequency allocation with mastergroups is used:
308, 560, 808, 1304, 1592 and 2912 kHz.

— at frequencies above 4 MHz:
4287, 5608, 6928, 8248 [2], 8472, 9792, 11 112 and 12 435 kHz.

c) *Symmetric-pair line section*

Frequency of the line pilot or pilots, and frequencies showing the insertion loss/frequency characteristic of the line, for example, frequencies spaced at:

4 kHz between 12 kHz and 60 kHz
8 kHz between 60 kHz and 108 kHz
12 kHz between 108 kHz and 252 kHz
24 kHz between 288 kHz and 552 kHz

3.2 *Loss/frequency distortion*

The overall loss/frequency distortion of the regulated line section (symmetric pair, coaxial or radio-relay link) shall be such that the relative level at any frequency does not differ by more than ± 2 dB or ± 2 dNp from the nominal level appropriate to the system concerned.

Reference measurements at the frequencies chosen will be made at all attended stations at the output of each amplifier and also at the unburied station nearest the frontier.

Reference tests at unattended stations other than frontier stations are left to the discretion of each administration.

The setting of equalizers should be noted and recorded during the reference measurements as well as the temperature of the cable, or the resistance of one of the conductors, from which the temperature could be deduced.

[1] This may be 5640 kHz.

[2] The frequency 8248 kHz will perhaps be used for other purposes, such as radio-relay systems. This problem is being studied.

3.3 *Measurement of noise power*

Measurements of noise power shall be made by sending a uniform continuous spectrum signal in the transmitted frequency band; this signal or conventional load and also the channels to be used for the measurements shall be in accordance with Recommendation G.228 in Volume III of the C.C.I.T.T. *White Book* and C.C.I.R. Recommendation 399 [1].

3.4 *Complementary measurements*

If the administrations find it necessary, the following measurement could also be made:

— check of near-end crosstalk with artificial loading of radio channels;

— check of power supply modulation, etc. [2];

— check of stability using a level recorder.

3.5 *Line-up record*

The results of the reference measurements made at the line terminals and at the output of frontier repeaters will be entered in a " line-up record ", specimens of which are included as examples in Appendices I (coaxial or radio-relay regulated line section line-up record) and II (symmetric-pair regulated line section line-up record) below.

[1] Measurements should also be taken outside the baseband on the noise measurement channels indicated in C.C.I.R. Recommendation No. 398-1. These noise values will serve as reference values for subsequent maintenance measurements.

[2] Including checking of the baseband for the presence of interfering signals from radio-frequency sources outside the system.

APPENDIX I
(to Recommendation M.45)

Line-up record for a coaxial pair regulated-line section *

Technical Service of	France	Resistance of conductors used for temperature reference	(Neuchâtel–Morteau: 1632 ohms)
Designation of link	Bern–Besançon	Issue	5 May 1963
Date of measurements	15 April 1963		

Distance between stations (km)	Station	Relative level at frequencies (kHz) **								
		60	308	556	808	1056	1304	1552	1800	2048
		Direction of transmission: Bern–*Besançon* [4]								
	Bern [1]	−5.75	−5.45	−5.20	−5.03	−4 86	−4.71	−4.57	−4.45	−4.33
44.9										
	Neuchâtel [2]	−4.70	−4.70	−4.62	−5.58	−4.61	−4.68	−4.66	−4.61	−4.60
16.0										
	La Baume [1]	−5.90	−5.52	−5.28	−4.98	−4.85	−4.78	−4.62	−4.44	−4.30
7.25										
	Villers-le-Lac [3]	−3.95	−3.87	−3.70	−3.63	−3.52	−3.56	−3.50	−3.38	−3.34
8.6										
	Morteau [2]	−4.54	−4.57	−4.55	−4.55	−4.56	−4.58	−4.57	−4.58	−4.60
60.5										
	Besançon [2]	−4.61	−4.64	−4.50	−4.53	−4.52	−4.60	−4.55	−4.50	−4.52
		Direction of transmission: Besançon–*Bern*								
	Besançon [3]	−4.00	−3.95	−3.90	−3.83	−3.78	−3.75	−3.73	−3.68	−3.65
60.5										
	Morteau [2]	−4.60	−4.59	−4.58	−4.59	−4.58	−4.59	−4.56	−4.55	−4.56
8.6										
	Villers-le-Lac [3]	−3.80	−3.67	−3.65	−3.64	−3.63	−3.61	−3.55	−3.55	−3.54
7.25										
	La Baume [1]	−5.85	−5.50	−5.28	−5.00	−4.82	−4.73	−4.62	−4.45	−4.33
16.0										
	Neuchâtel [2]	−4.62	−4.59	−4.61	−4.57	−4.56	−4.63	−4.60	−4.58	−4.56
44.9										
	Bern [2]	−4.63	−4.60	−4.64	−4.64	−4.59	−4.70	−4.66	−4.68	−4.62

* Can also be used for a radio-relay link regulated-line section.

** See following page (also for other footnotes).

Station	Relative level at frequencies (kHz)									Equalizers		Remarks [5]
	2296	2544	2792	3040	3288	3536	3784	4032	4092	CT	dN	
					Direction of transmission: Bern–*Besançon*							
Bern	−4.22	−4.15	−4.04	−3.97	−3.87	−3.82	−3.75	−3.70	−3.68	—	—	N (*t*)
Neuchâtel	−4.60	−4.64	−4.64	−4.66	−4.67	−4.64	−4.62	−4.66	−4.65	2	1	N (*p*)
La Baume	−4.20	−4.12	−4.05	−4.00	−3.91	−3.83	−3.73	−3.73	−3.72	1	2	N (*t*)
Villers-le-Lac	−3.36	−3.34	−3.32	−3.30	−3.28	−3.26	−3.25	−3.26	−3.28	1	2	N (*t*)
Morteau	−4.58	−4.61	−4.62	−4.62	−4.57	−4.55	−4.60	−4.64	−4.62	1	1	N (*p*)
Besançon	−4.53	−4.57	−4.56	−4.54	−4.50	−4.46	−4.53	−4.58	−4.63	4	1	N (*p*)
					Direction of transmission: Besançon–*Bern*							
Besançon	−3.61	−3.56	−3.52	−3.49	−3.48	−3.47	−3.47	−3.46	−3.45	—	—	N (*t*)
Morteau	−4.57	−4.57	−4.57	−4.56	−4.56	−4.56	−4.55	−4.57	−4.59	4	2	N (*p*)
Villers-le-Lac	−3.54	−3.53	−3.49	−3.44	−3.39	−3.36	−3.35	−3.33	−3.35	1	2	N (*t*)
La Baume	−4.21	−4.12	−4.04	−3.97	−3.88	−3.81	−3.73	−3.73	−3.70	1	1	N (*t*)
Neuchâtel	−4.59	−4.57	−4.56	−4.54	−4.53	−4.53	−4.51	−4.55	−4.56	1	2	N (*p*)
Bern	−4.66	−4.70	−4.68	−4.63	−4.60	−4.58	−4.57	−4.59	−4.63	2	0	N (*p*)

[1] 600-ohm through level measurements at the output of the repeater equipment.

[2] 75 ohms absolute power levels at the special measuring point where the nominal relative level is −3.40 N(*p*), giving −4.60 N for additional measuring frequencies.

[3] 600-ohm through level measurements at amplifier outputs.

[4] The control station is in italics.

[5] The appropriate indication to be given in the " Remarks " column for each station, using the following abbreviations:
N = nepers *t* = " niveau relatif de tension " or 600-ohm through level, when 0.775 volt is applied to the (two-wire) sending end.
dB = decibels *p* = relative power level (dBr).

APPENDIX II

(to Recommendation M.45)

Line-up record for a symmetric pair line

Technical Service of . .	Netherlands	Date of measurements . . .	10 October 1959
Designation of link . .	Antwerpen–Rotterdam	Issue	22 March 1960

	Direction: Antwerpen–*Rotterdam* [3]				Direction: Rotterdam–*Antwerpen* [3]			
Distance in (km)	15.8	17.7		72.4	72.4	17.7		15.8
Test frequencies kHz	Antwerpen	Brasschaat	Zundert	Rotterdam	Rotterdam	Zundert	Brasschaat	Antwerpen
12	+1.75	+1.75	+1.80	+1.85	+1.75	+1.65	+1.65	+1.65
16		1.75	1.80	1.90		1.65	1.70	1.65
20		1.75	1.80	1.90		1.70	1.70	1.70
24		1.80	1.85	1.95		1.70	1.70	1.70
28		1.85	1.85	1.90		1.70	1.65	1.75
32		1.85	1.90	1.90		1.75	1.65	1.80
36		1.85	1.90	1.85		1.75	1.70	1.80
40		1.80	1.90	1.85		1.75	1.70	1.85
44		1.80	1.85	1.85		1.80	1.75	1.90
48		1.75	1.85	1.80		1.80	1.75	1.90
52		1.75	1.85	1.75		1.75	1.70	1.90
56		1.75	1.80	1.75		1.75	1.75	1.85
60		1.80	1.80	1.75		1.70	1.65	1.85
68		1.75	1.75	1.75		1.70	1.65	1.85
76		1.70	1.75	1.80		1.70	1.60	1.80
84		1.70	1.80	1.80		1.70	1.65	1.75
92	Sending station	1.75	1.80	1.85	Sending station	1.65	1.65	1.75
100		1.80	1.80	1.85		1.65	1.70	1.75
108		1.80	1.85	1.85		1.65	1.70	1.70
120		1.85	1.85	1.90		1.70	1.75	1.70
132		1.85	1.85	1.95		1.70	1.80	1.70
144		1.85	1.90	1.95		1.75	1.85	1.75
156		1.80	1.90	1.95		1.80	1.85	1.80
168		1.80	1.90	1.90		1.85	1.90	1.80
180		1.85	1.85	1.90		1.85	1.95	1.85
192		1.90	1.85	1.85		1.90	1.90	1.80
204		1.85	1.80	1.80		1.90	1.85	1.80
216		1.80	1.75	1.75		1.95	1.80	1.80
228		1.75	1.75	1.70		2.00	1.80	1.75
240		1.75	1.70	1.65		2.00	1.80	1.75
252		1.70	1.70	1.65		1.85	1.80	1.70
256		1.70	1.65	1.60		1.70	1.75	1.70
60-kHz line pilot	−13.2	−13.1	−13.1	−13.2	−13.2	−13.2	−13.3	−13.1
Additional measuring frequencies [1]	—	—	—	—	—	—	—	—
Equalizers	—	0	+1	0	—	+1	+1	+1
Temperature or resistance	—	391 Ω	221 Ω	+4.7°C	—	+4.5°C	226 Ω	392 Ω
Remarks [2]	dB	dB	dB	dB	dB	dB	dB	dB

[1] Indicate frequencies of these pilots.

[2] The appropriate indication to be given in the "Remarks" column for each station, using the following abbreviations:
N = nepers *t* = "niveau relatif de tension" or 600-ohm through level, when 0.775 volt is applied to the (two-wire) sending end.
dB = decibels *p* = relative power level (dBr).

[3] The control station is in italics.

RECOMMENDATION M.46

BRINGING INTERNATIONAL GROUP, SUPERGROUP, ETC., LINKS INTO SERVICE

1. *Preliminary exchange of information*

The technical services concerned nominate the control and sub-control stations for the link to be brought into operation in accordance with Recommendations M.8 and M.9.

The technical services should indicate the routing to be followed and the method given in Recommendation M.57 may be applied. In the case of group or supergroup links, they will mutually agree on the pilot or pilots to be used.

In determining the routing of group links, in order to avoid interference between the pilots on two supergroup links, the technical services will try to arrange that position No. 3 is not occupied by the same group link on two supergroup links. (Where this is impossible, the supergroup pilot should be blocked at the through-group connection point.)

The information will be entered on a " routing form " [1] giving the following details:

- — routing of the group;
- — names of control and sub-control stations;
- — through-connection points (particularly those nearest the frontiers);
- — nominal level at the measuring point in terminal through-connection stations;
- — points where regulators are inserted and the type of regulator (manual or automatic);
- — frequency(ies) of the link pilots.

The overall routing form for the entire link is drawn up by the control station on the basis of information furnished by each sub-control station for the sections for which it is responsible. The technical services for the control station will send two copies of the routing form, as quickly as possible, to all the services responsible for sub-control stations (one copy for the technical services and one for the sub-control station).

Routing forms for the links should be exchanged only when the group or supergroup link consists of two or more sections.

2. *Frequencies and levels of group, supergroup, etc., pilots*

2.1 Details of the recommended frequency and level of pilots are given in Table 1 below:

[1] See specimens in Appendix I (supergroup routing form) and Appendix III (A or B) (group routing form) of this Recommendation.

TABLE 1

Group, supergroup and mastergroup pilots for	Frequency (kHz)		Power level [1]	
	8 ch. and 12 ch.	16 ch.	dBm0	dNm0
Basic Group A	35.860 35.920	36 —	−25 −20	−29 −23
Basic Group B	84.080 84.140 104.080	84 [2] — —	−20 −25 −20	−23 −29 −23
Basic supergroup	411.860 411.920 547.920		−25 −20 −20	−29 −23 −23
Basic mastergroup	1552		−20	−23
Basic supermastergroup	11 096		−20	−23
Basic 15-supergroup assembly	1552 [3]		−20	−23

[1] To avoid errors in interpreting measurement results, the results of measurements on pilots will be stated in terms of the departure from the nominal pilot level in dBm at that particular point.

[2] A pilot of 84 kHz is normally used. A different frequency can be used by agreement between administrations.

[3] This pilot after modulation appears at frequency 11.096 kHz, which is the frequency of the 15-supergroup assembly No. 3 pilot. This implies that the pilot may have dual functions.

The specifications of terminal equipments provide that for every group or supergroup two pilots can be simultaneously transmitted. This is the normal case, but by agreement between the administrations concerned (including those of transit countries) one only of the two can be transmitted.

2.2 *Level tolerances for transmitted pilots*

a) At the point where a pilot is injected, its level should be so adjusted that its measured value is within ±0.1 dB or ±0.1 dNp of its nominal value. The measuring equipment used or making this measurement must give an accuracy of at least ±0.1 dB or ±0.1 dNp.

b) The change in output level of the pilot generator with time (which is a factor included in equipment specifications) must not exceed ±0.3 dB or ±0.3 dNp.

c) The total maximum variation resulting from points a) and b) above will be ±0.5 dB or ±0.5 dNp. It is advisable to have a device to give an alarm when the variation at the generator output exceeds these limits, the zero of the warning device being aligned as accurately as possible with the lining-up level of the transmitted pilot.

2.3 *Frequency tolerances for transmitted pilots*

The permissible frequency tolerances for transmitted pilots are as follows:

— 84 kHz (or other frequencies) (for 16-channel systems only) not specified
— 84.080 kHz and 411.920 kHz pilots... ± 1 Hz
— 84.140 kHz and 411.860 kHz pilots... ± 3 Hz
— 104.080 kHz and 547.920 kHz pilots... ± 1 Hz
— 1552 kHz pilot... ± 2 Hz
— 11 096 kHz pilot... ±10 Hz

3. *Setting-up and lining-up a Category A international group, supergroup, etc. link*

3.1 *Setting-up the link*

3.1.1 Once the route has been agreed, the supermastergroup, mastergroup, supergroup or group link control station will direct the operations needed to set up the link.

All the repeater stations concerned—i.e. the stations at the ends of each supermastergroup, mastergroup, supergroup, or group section that will make up the link—should make setting-up tests and check the equipment to be used, such as the through mastergroup, supergroup, and group filters, etc. The check should include a general visual inspection and vibration tests, particularly if the equipment has remained unused for some time since acceptance tests were carried out after installation.

3.1.2 Each country sets up the national part within its territory, each international supermastergroup, mastergroup, supergroup or group section is set up by the stations at the ends of this section in the two countries concerned (which are the supermastergroup, mastergroup, supergroup or group through-connection stations closest to the frontier) and these national and international supermastergroup, mastergroup, supergroup or group sections are interconnected by through mastergroup, through supergroup or through-group filters, as may be appropriate. The sub-control stations inform the control station when each interconnection is completed.

3.2 *Lining-up the link*

3.2.1 Before beginning the initial line-up of the link as a whole, the control station must inform the station at the other end of the link. In general, time will be saved if arrangements are made for simultaneous line-up of both directions of transmissions.

3.2.2 The relative levels for each section are then measured at the following frequencies:

— mastergroup link: 814, 1056, 1304, 1550, 1800 and 2042 kHz;

— supergroup link: 313, 317, 333, 381, 412, 429, 477, 525, 545, and 549 kHz;
— group link: frequencies spaced at 4 kHz in the group frequency band, to be determined by agreement between administrations [1].

The measured values for each purely national group, supergroup, or mastergroup section must be forwarded to the sub-control station for the country in question. This station checks that the measured values are satisfactory.

3.2.3 The frequencies shown in paragraph 3.2.2 above are sent from the group, supergroup or mastergroup distribution frames at the end of the link or from an equivalent point, and the level is measured at each intermediate group, supergroup, or mastergroup through-connection station and at the group, supergroup, or mastergroup distribution frame at the end of the link. The total variation in the loss/frequency characteristic of the link (maximum spread between the two horizontals at the limits of the loss/frequency characteristic) should not exceed:

— for a mastergroup: 4 dB or 4 dNp
— for a supergroup; 4 dB or 4 dNp
— for a group: 3 dB or 3.5 dNp.

The same tolerances should apply to the last through-connection point before the frontier in the direction of transmission concerned.

3.2.4 The pilot is applied at the beginning of the link under ordinary working conditions, especial care being taken to see that it is at its nominal level [2] (see paragraph 2 above).

The level of the pilot (or of the test signal) is measured at the through-connection stations adjacent to frontiers and at the intermediate sub-control stations. Appropriate adjustments are made to bring the level as near as possible to the nominal value. On their own territory, administrations setting up a link can make more detailed reference measurements for the national and frontier sections. These measurements could be useful in finding the exact location of a fault within the national territory.

3.2.5 The measuring points must be those at which routine maintenance measurements or reference measurements will be made later (for rapid checks in locating faults). It is recommended that there be but one of these measuring points in each station. Administrations can make reference measurements at other points to assist exact location of faults, but to avoid any possible errors this information should not be entered on the line-up record kept by the control station.

---

[1] If the group-measuring frequencies are generated by applying 800 Hz to the input of channel modulating equipment, special precautions will have to be taken at the receiving end to prevent carrier leak from affecting the readings of the measuring equipment. In these circumstances, the measuring device must be of the selective kind.

[2] Should this pilot not be available, a test signal shall be sent at the following frequencies:

— supergroup: 412 kHz
— group: 84 kHz (or 36 kHz).

The level of this test signal will be 0 dBm0 (test level used for a telephone channel). However, by agreement between the administrations concerned, a lower level may be used, e.g. − 10 dBm0.

3.3 *Reference measurements for a link*

The measurements described above for lining-up also constitute reference measurements. The following data must be recorded at every group, supergroup, or mastergroup sub-control station and in the through-connection stations adjacent to frontiers:

— the level measured (and the reference voltage);
— the points of measurement;
— the impedance at each such point;
— the test equipment used.

Every station concerned forwards this information to the control station, which draws up the " line-up record " [1], summarizing all these data and sends it to its own technical service. The technical services in the other countries request copies of this information if they so desire.

3.4 *Reliability tests on the link*

When the initial overall lining-up measurements have been made on a link, and the automatic regulators (if any) have been installed, it is as well to check the working of the link before putting it into service by testing it over a period (a minimum period of 24 hours, which has to be extended if the results observed during the 24 hours are not fully satisfactory). The checking is done using the pilot (or, if there is none, using a test signal at about the same frequency), the level of which is continuously recorded during the test, at the far end of the link. The recording device should be able to record short interruptions in addition to recording the level.

All variations in level should be investigated and all faults should be cleared before lining-up the channels of a group, or the group or supergroup sections of the supergroup or mastergroup link.

3.5 *Setting-up lower order sections after line-up of the higher order links*

The different orders of section have to be set up in sequence.

3.5.1 Thus, when a supermastergroup link, mastergroup link or supergroup link has been lined up, each end of it is connected to the appropriate translating equipment (supermastergroup link to mastergroup translating equipment, mastergroup link to supergroup translating equipment, and supergroup link to group translating equipment) and the corresponding lower order sections are then set up.

3.5.2 The translating equipment, before it is connected to the ends of the link, must be checked and adjusted to ensure that it meets C.C.I.T.T. Recommendations and other relevant specifications.

[1] For example, see Appendix II (supergroup link line-up record) and Appendix IV (A or B) (group link line-up record) of this Recommendation.

3.5.3 To adjust mastergroup sections, a 1552-kHz test signal issent over each mastergroup section in turn, at a leve lof 0 dBm0 [1]. At the sending end the mastergroup translating equipment is adjusted so that the level sent on each mastergroup section at the ouput of the translating equipment is as close as possible to the nominal value. At the receiving end, the mastergroup translating equipment is adjusted so that the output level of each mastergroup is as close as possible to the nominal value.

3.5.4 To adjust supergroup sections, a 412-kHz test signal is sent over each supergroup section in turn, at a level of 0 dBm0 [1]. At the sending end the supergroup translating equipment is adjusted so that the level sent on each supergroup section at the output of the translating equipment is as close as possible to the nominal value. At the receiving end, the supergroup translating equipment is adjusted so that the output level of each supergroup is as close as possible to the nominal value.

3.5.5 To adjust group sections, an 84-kHz test signal is sent over each group section in turn, at a level of 0 dBm0 [1]. At the sending end the group translating equipment is adjusted so that the level sent on each group section at the output of the translating equipment is as close as possible to the nominal value. At the receiving end, the group translating equipment is adjusted so that the output level of each group is as close as possible to the nominal value.

3.5.6 When the lower order sections have been set up in the above manner, they are interconnected as necessary to form links, as described in paragraph 3.1, and the appropriate link line-up procedure as detailed in paragraph 3.2 is then applied.

4. *Setting-up and lining-up a category B international group, supergroup, etc. link.*

4.1 *Organization of the control of an international group, supergroup, etc. (Category B)*
(This organization may also be suitable for Category B *circuits.*)

4.1.1 *Classes of station*

As far as international co-operation is concerned, only two classes of through-connection stations need be designated by any country:

a) stations which exercise control functions, i.e. group, supergroup, etc. control stations and group, supergroup, etc. subcontrol stations;

b) stations with a permanent staff nearest the frontier, which in this recommendation are referred to as " frontier stations ".

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[1] However, by agreement between the administrations concerned, a lower level may be used, e.g. −10 dBm0.

In accordance with Recommendations M.8 and M.9 the station at each end of the group, supergroup, etc. is the " control station" for the receiving direction of transmission and the terminal sub-control station for the sending direction. Stations having control functions in intermediate countries are " group, supergroup, etc., intermediate sub-control stations ". Other stations involved in international maintenance are frontier stations.

In general, a transit country will have one station with control functions or one with subcontrol functions and two frontier stations. A country in which the group, supergroup etc. terminates has only one frontier station. In some countries, a station with control functions or subcontrol functions and a frontier station will be the same.

4.1.2 *Classes of group, supergroup, etc. section*

A " main section " is the portion of the link between two adjacent stations having control functions. In many cases these two stations are in different countries. In the case of a country which has elected to have more than one station with control functions a main section will lie wholly within that country.

A section between a station with control functions and a frontier station within the same country is a " national section ". A national section will usually comprise several group, supergroup, etc. sections as defined in Recommendation M.30. A section between she two stations with control functions within one country also constitutes a national tection.

A section between two adjacent frontier stations in different countries constitutes an " international section ". In some instances, an international section may consist of a single group, supergroup, etc. section routed over a long submarine cable carrier system. If the international group, supergroup, etc. is routed via intermediate countries without demodulation to the appropriate basic frequency band, the frontier stations at the ends of the section are considered to be " adjacent " and the section constitutes an international section.

It will be seen that a main section may comprise either:

— two national sections and one international section; or
— one national section and one international section; or
— one national section; or
— one international section.

The stations with control functions at the end of a main section are termed " main section control stations ".

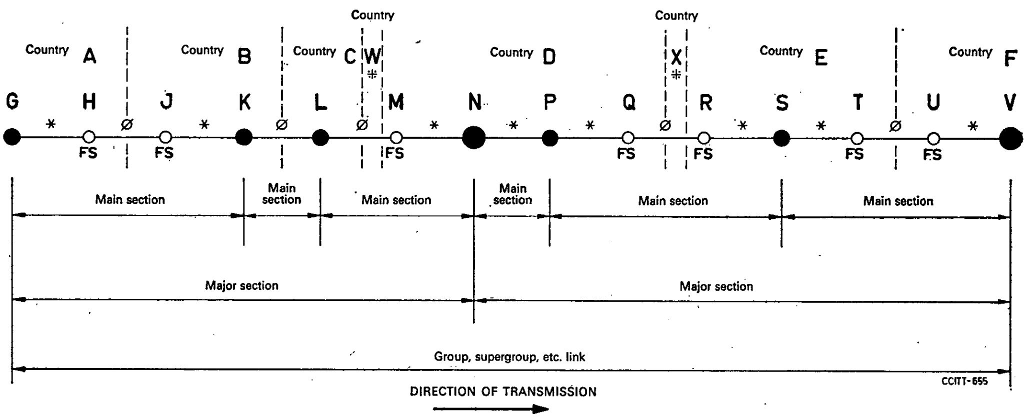
In the case of a very long international group, supergroup, etc. comprising more than three main sections, it may be necessary to combine adjacent main sections into larger units termed " major sections ". Suitable groupings for links with various numbers of main sections are shown in Table 2 below:

TABLE 2

Total number of main sections	Number of major sections	Suitable groupings to form the major sections
FOUR	2	TWO + TWO
FIVE	2	TWO + THREE
SIX	2	THREE + THREE
SEVEN	3	TWO + THREE + TWO
EIGHT	3	THREE + TWO + THREE
NINE	3	THREE + THREE + THREE

The stations with control functions at the ends of major sections are termed " major section control stations ".

All these various terms are illustrated in Figure 1/M.46.



∗ = National section

Ø = International section

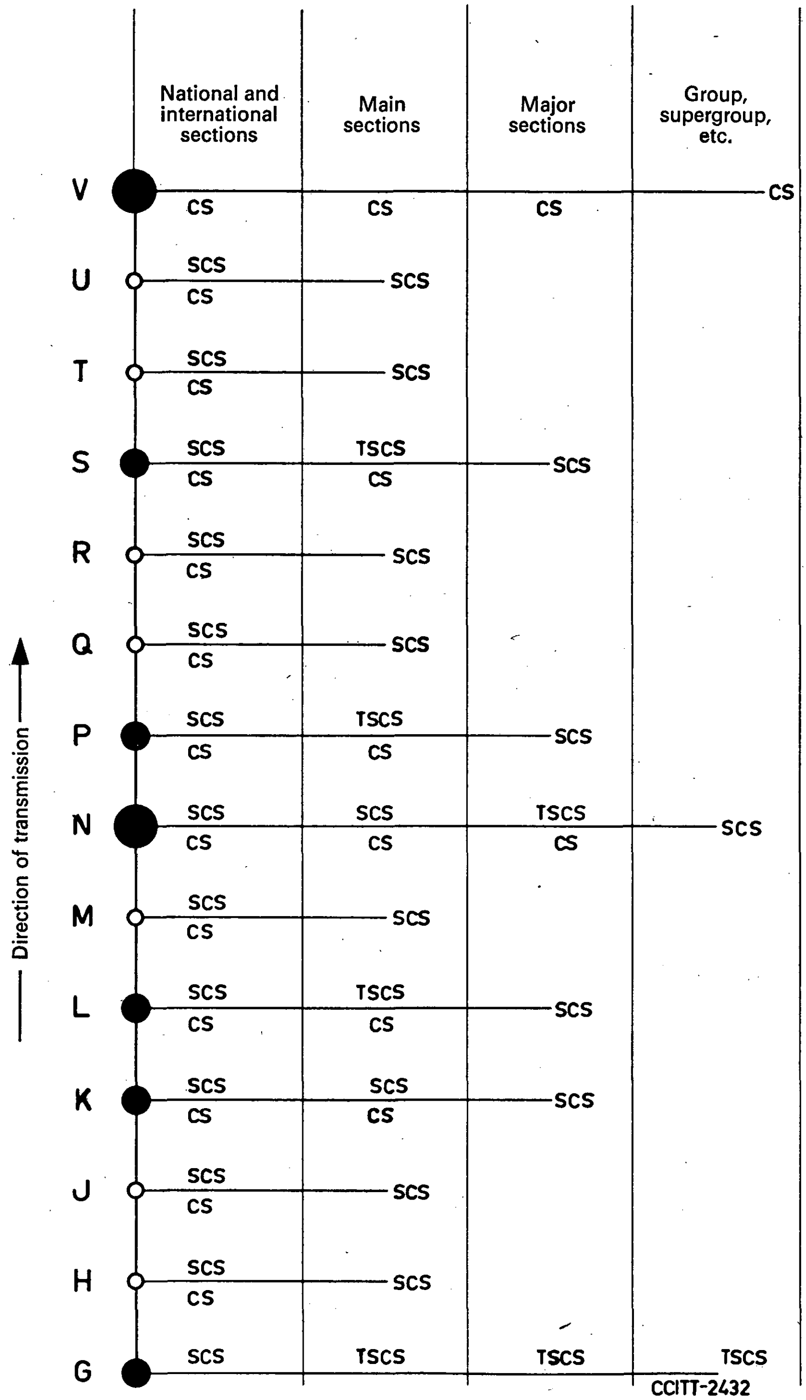
⁜ = The group, supergroup, etc., passes through countries W and X without being reduced to the appropriate basic frequency band. There are thus no control or frontier stations for the group, supergroup, etc., in these countries.

○ ● ⬤ Stations

FS = Frontier station

FIGURE 1/M.46 [1]. — **Example of a category B international link showing how it may be divided into sections of control for lining-up and maintenance**

[1] *Note.* — For control and sub-control functions, see Figure 2/M.46.



CS = control station
SCS = sub-control station
TSCS = terminal sub-control station

FIGURE 2/M.46. — **Table showing the control functions of the stations shown in Figure 1/M.46**

As a consequence of the definitions in Recommendation M.30 of national, international, main and major sections and of the contents of this present Recommendation, some stations on a long group, supergroup, etc. will be nominated for more than one control or subcontrol function.

For example, station S in Figure 1/M.46 is

— a subcontrol station for the major section N-V,

— the control station for the main section P-S,

— the terminal subcontrol station for the main section S-V,

— the control station for the national section R-S,

— the subcontrol station for the national section S-T.

Figure 2/M.46 shows these functions and those of the other stations illustrated in Figure 1/M.46.

4.2 *Lining-up*

For lining-up a category B international group, supergroup, etc. link, the frequencies and levels of the testing frequencies [1] and of the pilots are as given in this present Recommendation in paragraphs 2.1 and 3.2.2. The procedure for lining-up is described below and the responsibilities of the various stations are described in Recommendations M.8 and M.9.

At each stage of the operation the measuring points in the stations should be chosen so that the apparatus at the outgoing and incoming ends of the section being measured is included. The operations involved are described below and illustrated in Figure 3/M.46.

Reference should be made to Recommendation M.121 for operations involved in lining-up multi-destination unidirectional groups and supergroups routed over multi-destination communication-satellite systems.

4.2.1 *Operation 1 (Figure 3/M.46)—Lining-up national and international sections*

a) When the national and international sections are lined-up the loss-frequency characteristic of each section should be measured and recorded as terminated-level measurements. The limits are:

i) *Sections which are not main sections:*

Losses at all frequencies to be within ±1 dB or ±1 dNp of the nominal value.

Loss at the appropriate mid-band frequency [1] (or the appropriate reference pilot frequency, if available) to be within ±0.5 dB or ±0.5 dNp of the nominal value.

ii) *Main sections:*

Losses at all frequencies to be within ±1 dB or ±1 dNp of the nominal value.

Loss at the appropriate mid-band frequency [1] (or the appropriate reference pilot frequency, if available) to be within ±0.1 dB or ±0.1 dNp of the nominal value. Any

[1] Appropriate mid-band frequencies are:

for a group . . .	84 kHz
for a supergroup.	412 kHz

equalizers that may be necessary to achieve these limits are considered to be part of the section.

b) The results for each section are forwarded to the receiving end main section control stations for record purposes and the sections are connected together.

4.2.2 *Operation 2 (Figure 3/M.46)—Lining-up main sections*

a) The main section having been constituted, the two main section control stations co-operate to line it up. The loss/frequency characteristic should be equalized at the receiving end main section control station so that the loss at the appropriate mid-band frequency [1] (or the appropriate reference pilot frequency if available) is within ± 0.1 dB or 0.1 dNp of the nominal value and the loss at any other frequency is within ± 1 dB or ± 1 dNp of the nominal value. The equalizer [2], called a " main section equalizer ", is not considered to be part of a national or international section.

Note.—Because of the way in which a main section has been defined and because of the limits imposed on a national or international section the unequalized characteristic should lie within $+3$ dB or $+3$ dNp of the nominal value and, in addition, the loss of the appropriate mid-band frequency [1] (or at the appropriate group reference pilot frequency, if available) should be within $+1.5$ dB or $+1.5$ dNp of nominal. If such a spread cannot be equalized at the main section control station an intermediate equalizer may be needed at the preceding frontier station. Such equalizers are main section equalizers and are not part of the sections on the two sides.

b) The loss-frequency characteristic of each main section is recorded from terminated-level measurements made by the receiving end main section control station. Through-level measurements are made and recorded at the sending station and at the frontier station(s) to provide a future maintenance record. The sending station measurements are recorded for comparison with future maintenance measurements.

c) When the link comprises three main sections or less, the record of the terminated-level measurements made at the receiving end main section control stations should be forwarded to the appropriate control station. The link can now be lined-up as described below in 4.2.4 a) and b).

d) When the link comprises four or more main sections the record of the terminated-level measurements made at the receiving end main section control stations should be forwarded to the major section control stations. The major sections can now be lined-up as described below in paragraph 4.2.3.

4.2.3 *Operation 3 (Figure 3/M.46)—Lining-up the major sections*

(This procedure involves only the main section control stations.)

a) For purposes of lining-up and equalization, adjacent main sections are grouped together in twos or threes. Suitable groupings for links with various numbers of main sections are shown in Table 1 in 4.1.2 above, such groupings forming " major sections ".

---

[1] Appropriate mid-band frequancies are:

for a group . . .	84 kHz
for supergroup .	412 kHz

[2] It is to be understood that throughout this Recommendation the various equalizers referred to should be provided only if they are necessary for attaining the recommended limits.

b) A major section comprising two main sections is lined-up by connecting the two main sections together at the intermeditate main section control station and lining-up to the station at the end of the two sections, at which an additional equalizer is fitted, if required, to equalize the loss/frequency characteristic to main section standards (i.e. losses at all frequencies to be within ±1 dB or ±1 dNp of the nominal value and the loss at the appropriate mid-band frequency (or the appropriate reference pilot frequency, if available) to be within ±0.1 dB or ±0.1 dNp of the nominal value). This additional equalizer is called a " major section equalizer " to distinguish it from the main section equalizer.

c) A major section comprising three main sections is lined-up in two successive stages. The first two main sections are connected together and lined-up as described in 4.2.3 b) above. The third section is then added and the combination of three is lined-up to main section standards. An additional equalizer may be needed at the major section control station. This additional equalizer is also a major section equalizer.

d) The record of the terminated-level measurements made at the receiving end major section control stations should be forwarded to the appropriate receiving-end control station.

4.2.4 *Operation 4 (Figure 3/M.46)—Lining-up the group, supergroup, etc. link*

a) If the link comprises two main sections, it is lined-up by connecting the two main sections together at the intermediate main section control station and lining-up to the terminal station at which an additional equalizer is fitted if required to equalize the loss/frequency characteristic to main section standards (i.e. losses at all frequencies to be within ±1 dB or ±1 dNp of the nominal value and the loss at the appropriate mid-band frequency (or the appropriate reference pilot frequency, if available) to be within ±0.1 dB or ±0.1 dNp of the nominal value). This additional equalizer is called a " link equalizer " to distinguish it from any other equalizer that may have been fitted at this station.

b) If the link comprises three main sections, it is lined-up in two successive stages. The first two main sections are connected together and lined-up as described in 4.2.4 a) above. The third section is then added and the completed link lined-up to main section standards. An additional equalizer may be needed at the control station. This equalizer is a link equalizer and is not considered part of the main section.

c) If the link comprises two major sections, it is lined-up by connecting the two major sections together at the intermediate major section control station and lining-up to the terminal station, at which an additional equalizer is fitted, if required, to equalize the loss/frequency characteristic to main section standards (i.e. losses at all frequencies to be within ±1 dB or ±0.1 dNp of the nominal value and the loss at the appropriate mid-band frequency (or the appropriate reference pilot frequency, if available) to be within ±0.1 dB or ±0.1 dNp of the nominal value). This additional equalizer is called a " link equalizer " to distinguish it from any other equalizer that may have been fitted at this station.

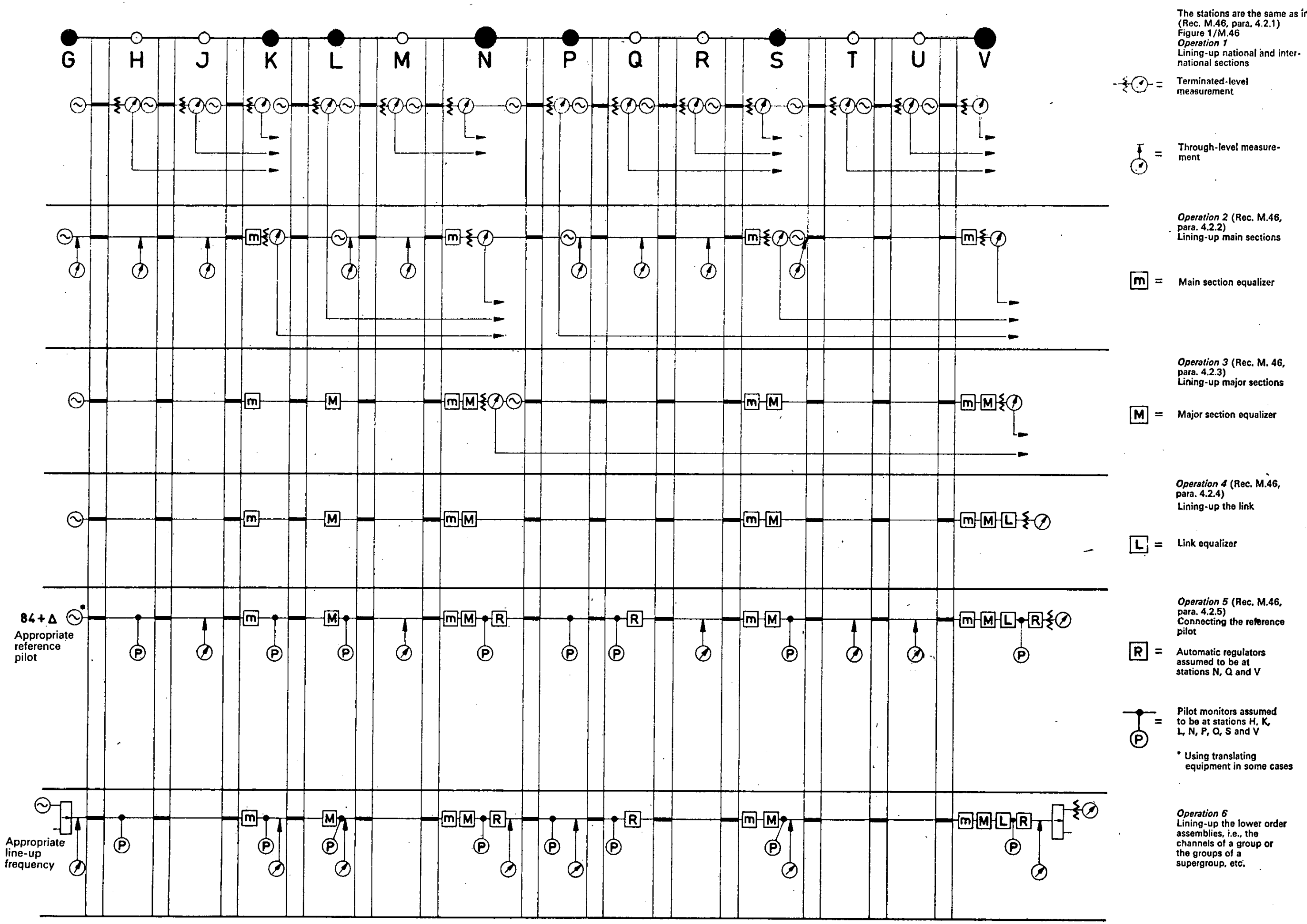


FIGURE 3/M.46. — **Diagram illustrating the line-up procedure for a Category B international group, supergroup, etc. (see Recommendation M.46, paragraph 4)**

d) If the link comprises three major sections, it is lined-up in two successive stages. The first two major sections are connected together and lined-up as described in 4.2.4 c) above. The third section is then added and the completed link is lined-up to main section standards. An additional equalizer may be needed at the control station. This equalizer is a link equalizer and is not considered part of the major section.

4.2.5 *Operation 5 (Figure 3/M.46)—Connecting the group, supergroup, etc. reference pilot*

Control stations, sub-control stations and frontier stations may be equipped with reference pilot monitors fitted with limit alarms. In addition, there may be automatic devices at these stations in accordance with Recommendation M.18. Pilot monitors should be provided at the input to the automatic regulator.

The settings of such pilot monitors and automatic regulators at different stations are interdependent and the devices must be set up successively.

a) The sending terminal station should connect the reference pilot at a level that is within ±0.1 dB or ±0.1 dNp of the nominal value. (This sometimes requires an appropriate translating equipment to be connected at this stage.)

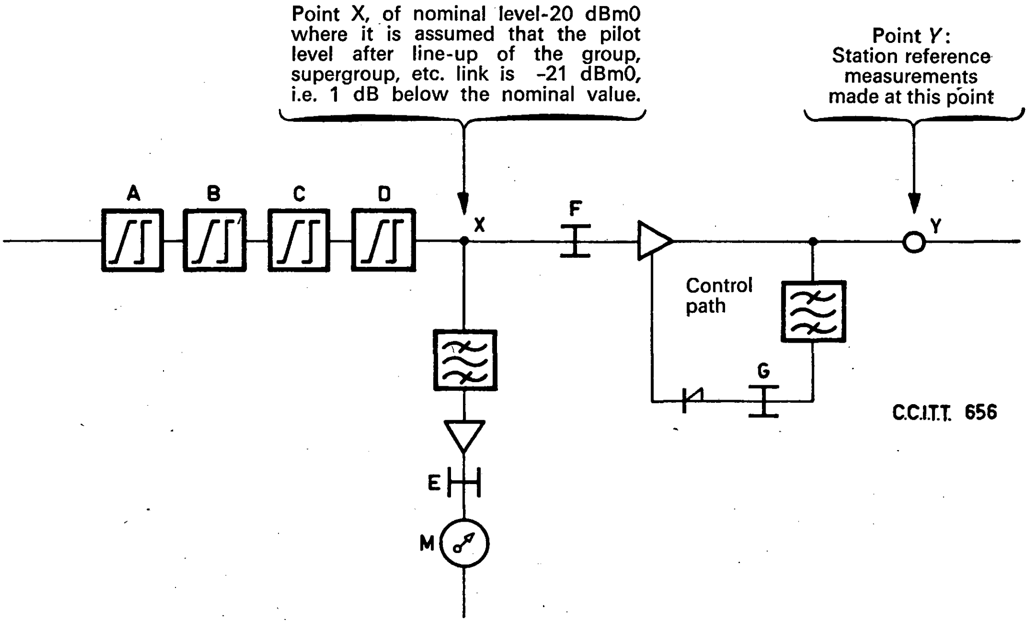
b) The frontier stations and the control station of the first main section should be successively asked to check the level of the reference pilot and, where appropriate, to adjust any pilot monitors, automatic regulators or other devices associated with the link.

i) The level at the frontier stations and at the main section control station should be checked to verify that there is nothing obviously wrong. (In general, small variations in level are to be expected and no limits can be given. Automatic regulation devices are installed to compensate for these small changes, which must therefore be accepted.)

ii) The pilot monitors should be adjusted so that they subsequently indicate departures from the line-up value, that is to say, they should be adjusted to indicate 0 dB under line-up conditions (see in Figure 4/M.46 an example of a typical arrangement of pilot monitor and automatic regulator equipment, with guidance as to how these devices may be adjusted). Stations not equipped with pilot monitors should measure and record the level of the group reference pilot.

iii) At stations where automatic regulation devices are fitted they should be arranged to operate symmetrically about the line-up level. At main section control stations they should be adjusted, where appropriate, so that the output level of the reference pilot is within ±0.1 dB or ±0.1 dNp of the nominal value of the reference pilot level.

c) The sending terminal station should inform the control station of the next main section that the line-up of the first main section has been completed, and that work can now proceed in the second main section. The control station of the second main section follows the procedure outlined in 4.2.5 b), i)—iii) above, the sending terminal station leaving the reference pilot connected.



A = international or national section equalizer
B = main section equalizer
C = major section equalizer
D = group, supergroup, etc. link equalizer

not all of these may be fitted

Line-up of pilot monitor: Attenuator E enables meter M to be made to indicate 0 dB when the group link has been lined-up.

Line-up of automatic regulator: With the control path disabled, F is adjusted so that the level of the pilot at the reference measurement point Y is the same as the level at X for which meter M has been adjusted to zero, i.e. −21 dBm0 in this example. With the control path restored, G is adjusted so that the level of the pilot at Y is again −21 dBm0.

FIGURE 4/M.46. — **Example of a typical terminal station or through-connection station, equipped with equalizers, pilot monitor and automatic regulator**

d) When the second main section has been dealt with, the second main section control station should inform the control station of the third main section, which again follows the procedure of 4.2.5 b), i)—iii) above, and so on until the whole of the link has been lined-up.

4.3 *Reliability tests on the link*

See paragraph 3.4 above.

5. *Setting-up and lining-up links for wideband transmission (data, facsimile, etc.)*

When the whole bandwidth of a group, supergroup, etc. link is used for wideband transmission (data, facsimile, etc.) the transmission characteristics are those of the relevant Recommendations of Volume III of the *White Book*. In particular, Recommendation H.41 concerns such group links.

Appendix I
(to Recommendation M.46)

Routing form * for a supergroup (Category A or B)

1.	Date of issue	1 December 1963
2.	Technical Service of	United Kingdom
3.	Supergroup designation	Bruxelles–London 6001
4.	Length	385 km
5.a)	Control stations for supergroup	London, Bruxelles
5.b) i)	Sub-control stations in the direction London to Bruxelles . .	London, Canterbury, Ostende
5.b) ii)	Sub-control stations in the direction Bruxelles to London . .	Bruxelles, Canterbury, Ostende
6.	Stations where automatic regulators are fitted	London
7.	Supergroup pilot frequency(ies)	411.92 kHz

Stations and designation of cable [1]	Length of section (km)	Section in cable				Section on radio link		Nominal levels at supergroup measuring points		Remarks [2, 3]
		Symmetrical pair sections		Coaxial pair sections		Designation of radio link	Position of supergroup	↓	↑	
		Pair number	Position of supergroup	Member of coaxial system	Position of supergroup					
A	B	C	D	E	F	G	H	J	K	L
London L-XN No. 4	123			A	4			−30	−30	dB
Canterbury CU-OS No. 1	140			A	1			−35	−30	dB submarine cable CU-OS 60-300 kHz
Ostende No. 1	24							−35	−30	dB OS-CU 924-1164 kHz
Brugge No. 3	45							−35	−30	dB 60-channel carrier
Gent No. 3	53							−30	−35	dB 60-channel carrier
Bruxelles										

* A diagram can be associated in complicated cases.

[1] Underline through-supergroup points.

[2] Mention any special types of carrier system, e.g. submarine cable system. In such cases state the frequency band for the two directions of transmission. Show type of through-supergroup equipment and supplementary information if necessary.

[3] Give the appropriate indication in the " Remarks " column for each station, using the following abbreviations:

N = nepers.
dB = decibels.
t = " niveau relatif de tension " or 600 ohms through level when 0.775 volt is applied to the (two-wire) sending end.
p = relative power level (dBr).

APPENDIX II
(to Recommendation M.46)

Line-up record for a supergroup link (Category A or B)

Date of issue	24 June 1963
Technical Service of	United Kingdom
Supergroup designation	Bruxelles–London 6001
Length	385 km
Control station	Bruxelles
Sub-control stations	Canterbury, Ostende, London
Date of measurements	15 June 1963
Direction	London–Bruxelles

Distance (in km)	Stations	Relative levels [1, 4] Test frequencies kHz 313	317	333	381	429	477	525	545	549	Pilot A [1]	Pilot B [1]	Measuring point	Measuring equipment [2]	Nominal relative level at measuring point [3]	Impedance at measuring point (ohms)	Remarks [3, 4]
	London	0	0	0	0	0	0	0	0	0	0		S.D.F.	Sel.	−35	75	dB
123																	
	Canterbury	−1.3	−1.3	−0.5	−0.6	−0.1	+0.3	+0.4	−0.3	−1.6	−0.3		TSF	Sel.	−35	75	dB
140																	
	Ostende	−4.3	−1.3	−0.8	−1.7	−0.9	−0.6	−1.0	−1.5	−3.7	−1.2		TSF	Sel.	−35	75	dB
122																	
	Bruxelles	−4.0	−0.4	+1.3	+1.2	+0.7	+0.2	−0.3	−0.5	−6.0	+1.4		S.D.F.	Sel.	−30	73	dB

Frequency (kHz) of supergroup reference pilot: 411.920 kHz.
Absolute power level dBm (referred to 1 mW) of supergroup reference pilot at a zero relative level point: −20 dB.

[1] Show in these columns the differences relative to the nominal values.
[2] State if the equipment is selective or not.
[3] Indicate the presence of supergroup automatic gain control (AGC).
[4] Give the appropriate indication in the " Remarks " column for each station, using the following abbreviations:

dB = decibels
N = nepers
t = " niveau relatif de tension " or 600 ohms through-level when 0.775 volt is applied to the (two-wire) sending end
p = relative power level (dBr)

Appendix III (A)

(to Recommendation M.46)

Routing form * for a group (Category A)

1.	Date of issue	1 December 1963
2.	Technical Service of	United Kingdom
3.	Group designation	London–Rotterdam 1203
4.	Length	475 km
5.a)	Control stations for group	London, Rotterdam
5.b)i)	Sub-control stations in the direction London to Rotterdam .	London, Bourne Hill, Aldeburgh, Domburg
5.b)ii)	Sub-control stations in the direction Rotterdam to London .	Rotterdam, Domburg, Aldeburgh, Bourne Hill
6.	Stations where automatic regulators are fitted	London
7.	Group pilot frequency(ies)	84.080 kHz

Stations and designation of cable [1]	Length of section (km)	Group section [2]		Supergroup sections [3]		Nominal levels at through-group points		Remarks [4, 5]
		Pair numbers	Position (A B C D E) of group	Super-group-number	Position of the supergroup followed by the position of the group in the supergroup	↓	↑	
A	B	C	D	E	F	G	H	J
London								
1 and 2	115	15	B			−37	−8	dB 24 channels
Bourne Hill								
3 and 4	45	3	A					12 channels
<u>Aldeburgh</u>						−37	−8	submarine cable
				1	3			ADB-DBG 120-168 kHz
	153							dB
<u>Domburg</u>						−37	−8	DBG-ADB 408-456 kHz
5	38	5	B					48 channels
Goes								
1	53	1	B					48 channels
Roosendaal	25	1	B					48 channels
1								
Breda								
4	46	4	B					48 channels
Rotterdam								

* A diagram can be associated in complicated cases.

[1] Underline the through-group points.

[2] Sections in cable, open-wire or radio link not providing a supergroup.

[3] Sections in cable or radio links with at least one supergroup.

[4] Mention the type of carrier system: 12, 24 . . . , 12 + 12 , . . channels and if not underground cable state: open-wire, radio link, submarine cable. In such cases give the frequency bands for the two directions of transmission. Show the type of through-group equipment.

[5] Give the appropriate indication in the " Remarks " column for each station, using the following abbreviations:

dB = decibels
N = nepers
t = " niveau relatif de tension " or 600 ohms through-level when 0.775 volt is applied to the (two-wire) sending end
p = relative power level (dBr)

APPENDIX III (B)
(to Recommendation M.46)

Routing form * for a group (Category B)

1.	Date of issue	June 1964
2.	Technical Service of	United Kingdom
3.	Group designation	London–Sydney 1201
4.	Length	25 779 km
5.a)	Control stations for group	London, Sydney
5.b)i)	Sub-control stations in the direction London to Sydney	London, Oban, Cornerbrook, Montreal, Vancouver, Port Alberni, Suva, Hawaii, Auckland
5.b)ii)	Sub-control stations in the direction Sydney to London	Sydney, Auckland, Hawaii, Suva, Port Alberni, Vancouver, Montreal, Cornerbrook, Oban
5.c)	Major section control stations	London, Montreal, Vancouver, Sydney
6.	Stations where automatic regulators are fitted . .	London, Sydney
7.	Group pilot frequency(ies)	84.0 kHz

Stations and constitution [1, 4]	Length of section (km)	Group sections [2]		Supergroup sections [3]		Nominal levels at through-group points dBr		Remarks [4, 5]
		Pair number	Position of group	Super-group number	Position of supergroup followed by position of the group in the supergroup	↓	↑	
A	B	C	D	E	F	G	H	J
London	962		*			−37	− 8	* Three routes are used between London and Oban, comprising coaxial and carrier routes with automatic group link switching.
Oban						−37	−37	Oban–Cornerbrook
CANTAT submarine cable	3844		3					360-608 kHz GO 60-300 kHz RET
Cornerbrook						−41	−41	
CANTAT submarine cable	1425		3					
Montreal/C.O.T.						−37	−37	
microwave link	4425		3					
Vancouver						−44	−44	Vancouver–Port Alberni
COMPAC submarine cable	150		3					360-608 kHz GO 60-300 kHz RET
Port Alberni						−44	−44	Port Alberni–Hawaii
COMPAC submarine cable	4700		3					360-608 kHz GO 60-300 kHz RET
Hawaii						−44	−44	Hawaii–Suva
COMPAC submarine cable	5580		3					60-300 kHz GO 360-608 kHz RET
Suva						−37	−37	Suva–Auckland
COMPAC submarine cable	2337		3					306-608 kHz GO 60-300 kHz RET
Auckland						−37	−37	Auckland–Sydney
COMPAC submarine cable	2356		3					60-300 kHz GO 360-608 kHz RET
Sydney						− 8	−37	

* A diagram can be associated in complicated cases.
[1] Underline the through-group points.
[2] Sections in cable, open wire or radio link not providing a supergroup.
[3] Sections in cable or radio links with at least one supergroup.
[4] Mention the type of carrier system: 12, 24 . . ., 12 + 12 . . . channels and if not on underground cable, state: open-wire, radio link, submarine cable. In such cases give the frequency bands for the two directions of transmission. Show the type of through-group equipment.
[5] dB = decibels; N = nepers; t = " niveau relatif de tension " or 600-ohms through-level when 0.775 volt is applied to the (two-wire) sending end; p = relative power level dBr.

APPENDIX IV (A)
(to Recommendation M.46)

Line-up record for a group link (Category A)

Date of issue	1 February 1964
Technical Service of	United Kingdom
Group designation	London–Rotterdam 1203
Length	475 km
Control station	Rotterdam
Sub-control stations	Bourne Hill, Aldeburgh, Domburg, London
Date of measurement	14 January 1964
Direction	London–Rotterdam

Distance (km)	Stations	Relative levels [1, 4]											
		Test frequencies in kHz (4-kHz spacing)											
		62	66	70	74	78	82	86	90	94	98	102	106
	London	0	0	0	0	0	0	0	0	0	0	0	0
113													
	Bourne Hill	+0.7	+1.0	+0.8	+0.7	+0.8	+0.6	+0.8	+1.0	+1.0	+1.2	+1.1	+1.1
45													
	Aldeburgh	−0.5	−0.5	−0.5	−0.4	0	−0.3	−0.2	−0.4	−0.8	−0.7	−0.3	0
153													
	Domburg	−0.8	−0.4	0	+0.4	+0.5	−0.2	−0.6	−1.4	−3.3	−2.4	−1.9	−2.0
162													
	Rotterdam	−1.0	−0.4	0	+0.5	+0.6	0	−0.5	−1.2	−2.2	−2.4	−1.9	−1.9

Stations	Pilot A [1]	Measuring point	Measuring equipment [2]	Nominal relative level at measuring point [4]	Impedance at measuring point	Remarks [3, 4]
London	0	G.D.F.	Non-select.	−37 dB	75 ohms	dB
Bourne Hill	+0.6	G.D.F.	Non-select.	−37 dB	75 ohms	dB
Aldeburgh	−0.2	G.D.F.	Non-select.	−37 dB	75 ohms	dB
Domburg	−0.4	G.D.F.	Non-select.	−37 dB	75 ohms	dB
Rotterdam	+0.6	G.D.F.	Non-select.	− 8 dB	75 ohms	dB

Frequency of group reference pilot in kHz: 84.080 kHz.
Absolute power level dBm (referred to 1 mW) of group reference pilot at a point of zero relative level: −20 dB.

[1] Show in these columns the differences relative to the nominal values.
[2] State if the equipment is selective or not.
[3] Indicate the presence of group automatic gain control (AGC).
[4] Give the appropriate indication in the " Remarks " column for each station, using the following abbreviations:

dB = decibels t = " niveau absolu de puissance " or 600 ohms through-level when 0.775 volt is applied to the (two-wire) sending end.
N = nepers p = relative power level (dBr).

Appendix IV (B)
(to Recommendation M.46)

Line-up record for a group link (Category B)

Date of issue . . . . June 1964
Technical Service of . . . . United Kingdom
Group designation . . . . London–Sydney 1201
Group length . . . . 25 779 km
Control station . . . . Sydney
Sub-control stations . . . . London, Oban, Cornerbrook, Montreal, Vancouver, Port Alberni, Suva, Hawaii, Auckland
Major section control stations . . . . Montreal, Vancouver, Sydney
Date of measurement . . . . 10 February 1964
Direction . . . . London–Sydney

Distance in km	Stations	Relative levels [1] — Test frequencies in kHz (4-kHz spacing): 62	66	70	74	78	82	86	90	94	98	102	106	84.0 kHz pilot [1]	Measuring point	Measuring equipment [2]	Nominal relative level at measuring point [4]	Impedance at measuring point	Remarks [3,4]
	London	0	0	0	0	0	0	0	0	0	0	0	0	0	GDF	Selective	−37 dB	75 ohms	dB
6 231	Montreal	−0.8	−0.6	−0.2	−0.6	−0.7	−0.2	−0.1	+0.4	+0.4	+0.2	−0.2	+0.2	+0.1	GDF	Selective	−37 dB	75 ohms	dB
4 425	Vancouver	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	0	0	−0.1	−0.2	−0.3	−0.2	−0.1	GDF	Selective	−37 dB	75 ohms	dB
15 123	Sydney	+0.4	−0.4	−0.1	−0.1	−0.2	+0.1	+0.2	0	+0.1	+0.1	+0.2	+0.3	−0.1	GDF	Selective	− 8 dB	75 ohms	dB (AGC)

Absolute power level dBm (referred to 1 mW) of group reference pilot at a point of zero relative level: −20 dB.

[1] Show in these columns the differences relative to the nominal values.

[2] State if the equipment is selective or not.

[3] Indicate the presence of group automatic gain control (AGC).

[4] Give the appropriate indication for each station, using the following abbreviations: dB = decibels; N = nepers; *t* = "niveau absolu de puissance" or 600 ohms through-level when 0.775 volt is applied to the (two-wire) sending end.

RECOMMENDATION M.47

SETTING-UP AND LINING-UP THE CHANNELS OF AN INTERNATIONAL GROUP

1. *Check of channel-translating equipment*

Before connecting the channel-translating equipment to the ends of a group link, the equipment must be checked and adjusted to ensure that it meets C.C.I.T.T. recommendations. The following limits are recommended:

1.1 *Carrier leak transmitted to line*

The absolute power level (dB referred to 1 mW) at the output of the terminal equipment should not be greater than the following values:

TABLE 1

Number of channels	Absolute power level for each channel [1]		Absolute power level of the total carrier leak for all channels	
	dNm0	dBm0	dNm0	dBm0
8 and 12	−30	−26	−23	−20
			Each sub-group	
16	−80	−70	−69	−60

[1] See Recommendation G.232 for values of channel carrier leak when a group is transmitted wholly, or in part over an open-wire line.

1.2 *Variations with frequency of the transmitting terminal equipment output power level*

In the graph in Figure 1/M.47 showing the limits for each channel of an 8- and 12-channel translating equipment and that in Figure 2/M.47 giving similar limits for 16-channel equipment:

— the value N is the relative power level in decibels measured at a frequency produced by an audio frequency of 800 Hz on the channel in question;

— for simplicity, the frequencies shown as abscissae are the audio frequencies applied to that channel, and not the corresponding frequencies after modulation.

1.3 *Crosstalk*

The crosstalk ratio (intelligible crosstalk only) should be better than 65 dB or 7.5 Np for 8-, 12- and 16-channel equipment under the following two conditions:

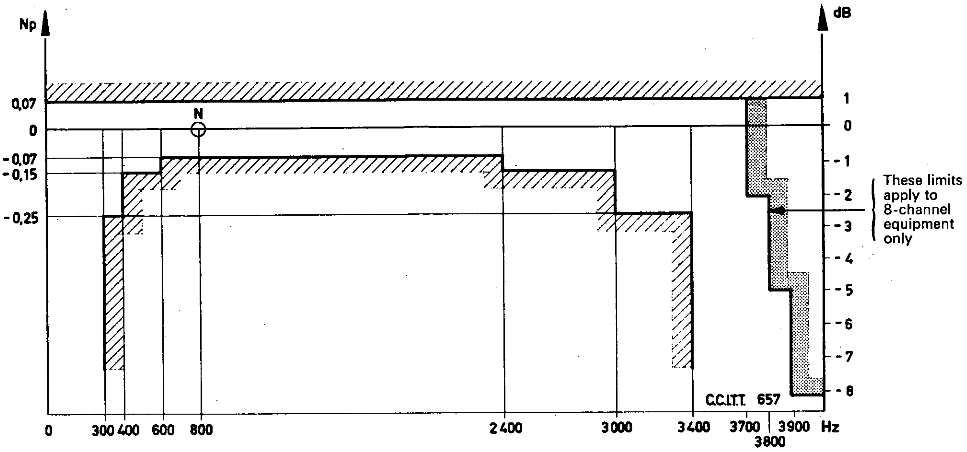


FIGURE 1/M.47. — **Limits for 8-channel and 12-channel equipment. Permissible limits for the variation with frequency of the output power level from a channel terminal equipment, relative to the input level, and referred to the value of relative level (N) at a sideband frequency corresponding to 800 Hz**

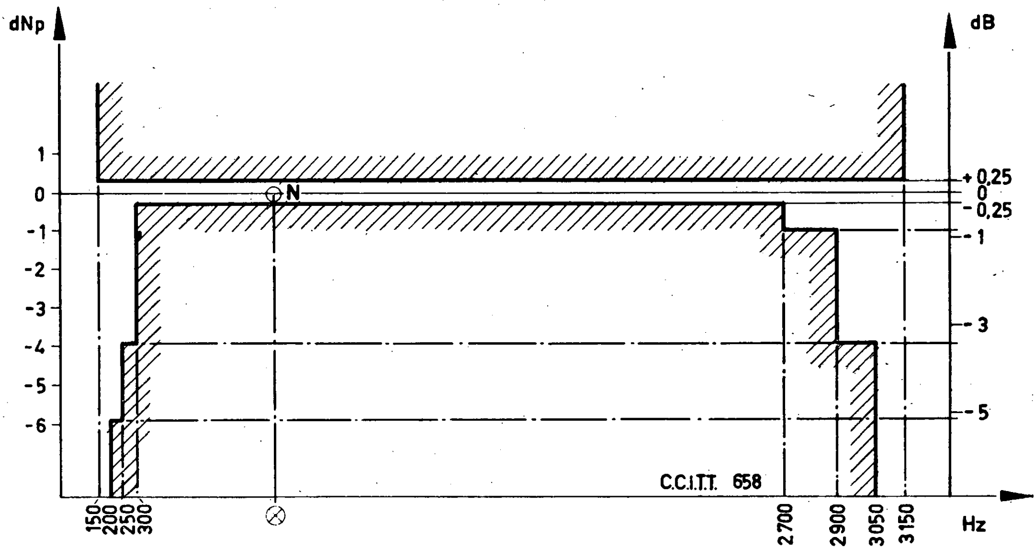


FIGURE 1/M.47. — **Limits for 16-channel equipment. Permissible limits for the variation with frequency of the output power level from a channel terminal equipment, relative to the input level. The values are referred to the value of relative level (N) at a sideband frequency ⊗ corresponding to 800 Hz or 1000 Hz**

a) between two different channels of the same equipment, the sending output being looped to the receiving input (with suitable arrangement of the relative levels) and the disturbing voltage being applied to the sending input of any channel, measurement being made in succession on the various receiving outputs of the other channels;

b) between the two directions of transmission of each channel of the same equipment, the disturbing voltage being applied at the receiving input (HF) and the measurement being made at the sending output (HF).

1.4 *Protection and suppression of pilots*

In view of the various possibilities of interference between pilots and between pilots and telephony, the following requirements must be met.

1.4.1 *Protection and suppression of the group reference pilot*

Pilot frequency	Channel No.	Interference frequency in the channel	Minimum loss (relative to 800 Hz loss)			
			Sending		Receive	
kHz		Hz	dB	dNp	dB	dNp
(1)	(2)	(3)	(4)		(5)	
8-channel terminal equipment						
84.08	4	5920	20	23	20	23
	5	−80	20	23	20	23
84.14	4	5860	20	23	20	23
	5	−140	30	34	20	23
12-channel terminal equipment						
84,08	6	3920	20	23	40	46
	7	−80	20	23	20	23
84.14	6	3860	20	23	35	40
	7	−140	30	34	20	23
104.08	1	3920	20	23	40	46
	2	−80	20	23	20	23

The required attenuation at the equivalent frequencies in column (3) may be obtained by a combination of audio filters, HF channel filters and bandstop filters at the discretion of the administration concerned. The relative losses quoted in columns (4) and (5) of the table above are the total effective losses required after the inclusion of a limiter.

All the attenuation valves indicated above should be obtained over a band of at least ± 3 Hz relative to the nominal pilot frequency for the pilots at 84.08 kHz and 104.08 kHz and ± 5 Hz for the pilot at 84.14 kHz, for both send and receive sides. This bandwidth allows for the tolerances on the pilot and for the possible frequency variations on an international circuit.

In addition, on the send side, the attenuation over a band of ±25 Hz relative to the nominal frequency of the pilot should be such that the total energy of a white noise signal occupying that bandwidth is attenuated by at least 20 dB (23 dNp). Any unwanted signals falling within this band are liable to be within the passband of the pilot pick-off filter and may cause interference with an automatic gain regulator, measuring equipment, etc.

1.4.2 *Protection and suppression of the supergroup reference pilots*

Considerations analogous to those outlined in paragraph 1.4.1 lead to the recommending of identical values but now applying to channels (1 and 2 in the case of 412-ΔkHz pilots and 11 and 12 in the case of a 547.920-kHz pilot) of 12-channel terminal equipment (channel 1 only in the case of 8-channel equipment) (instead of channels 6 and 7 respectively). However, the total attenuation required may be obtained, at the discretion of the administration concerned, either in the channel terminal equipment or in the group-translating equipment (using blocking filters either at 104.140 kHz or 104.080 kHz in group 3 or 64.080 kHz in group 5 of the group-translating equipment or at 411.860 kHz, 411.920 kHz or 547.920 kHz), or as a combination of the two equipments. The precautions to be taken against such interference in the channel equipment have therefore to be determined in relation to the precautions taken in the group equipment (Recommendation G.233, section g)).

The total attenuation required is indicated in the following table:

Pilot frequency	Disturbing frequency in the basic group	Channel No.	Disturbing frequency in the channel	Minimum attenuation relative to 800 Hz			
				Sending		Receiving	
kHz	kHz		Hz	dB	dNp	dB	dNp
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
411.920	104.080	1 2 (12 channels only)	3920 −80	20 20	23 23	40 20	46 23
411.860	104.140	1 2 (12 channels only)	3860 −140	20 30	23 34	35 20	40 23
547.920	64.080	11 12 (12 channels only)	3920 −80	20 20	23 23	40 20	46 23

The same remarks as in paragraph 1.4.1 relative to the frequency bands in which values of attenuation are necessary remain valid in the present case. However, the attenuation in the sending side, within a band of ±25 Hz relative to the nominal frequency of the supergroup pilot, may with difficulty be obtained at other than voice-frequency.

2. *Setting-up and lining-up the channels of an international group of Category A*

2.1 *Measurement and adjustment of levels*

After the group link has been set up, the channel-translating equipment at each end of the group link is connected and checked and the channels are then adjusted as follows.

An 800-Hz test signal is sent over each channel in turn, at a power of one milliwatt at a zero relative level point. At the transmitting end, the channel-translating equipment is adjusted so that the sideband level on each channel at its output is as near to nominal as possible. At the receiving end, the channel-translating equipment should then be adjusted to bring the received level on each channel as near as possible to its nominal value. Should administrations see fit, the insertion loss/frequency characteristic of each telephone channel is then determined, using frequencies chosen from the following list depending on the characteristics of the circuits to be set up:

200, 250, 300, 400, 500, 600, 800, 1000, 1400, 2000, 2400, 2700, 2800, 2900, 3000, 3200, 3050 and 3400 Hz.

2.2 *Measurement of noise*

It is also necessary to check the noise on each channel with a psophometer (see the characteristic curve of the weighting network of the psophometer of the C.C.I.T.T. in Supplement No. 3.2 of Volume IV of the *White Book*). In the absence of a psophometer, an unweighted noise-measuring set will be used. The value of the noise should be recorded. A listening test should also be made.

3. *Setting-up and lining-up the channels of an international group of Category B*

3.1 *Measurement and adjustment of levels*

After the group link has been set up, and the channel-translating equipment at each end of the group link has been connected and checked, the channels are adjusted as follows.

An 800-Hz [1] test signal is sent over each channel in turn at a level of 0 dBm0 [2]. At the transmitting end, the channel-translating equipment is adjusted so that the sideband level on each channel at its output is as near to nominal as possible. At the receiving end, the channel-translating equipment should then be adjusted to bring the received level on each channel as near as possible to its nominal value. When this is done, through-level measurements for each channel should be made at each main section control station. These measurements should be made at well-defined measuring points at the input of the following section (or channel-translating equipment as appropriate) as shown in Figure 3/M.46 and will be used as reference maintenance measurements.

The results of the through-level measurements made at the main section control stations should be compared with those obtained at these same stations during the line-up of the group link (see Recommendation M.46, paragraph 4.2.2 b)). Any differences are to

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[1] For international circuits 800 Hz is the recommended frequency for single-frequency maintenance measurements. However, by agreement between the administrations concerned, 1000 Hz may be used for such measurements, since it is a fact that 1000 Hz is widely used for single-frequency measurements on international circuits.

Multifrequency measurements made to determine the loss/frequency characteristic will include a measurement at 800 Hz, and therefore the reference frequency for such characteristics can still be 800 Hz.

[2] A level of −10 dBm0 may be used by agreement between administrations.

be used as correction factors to be applied to any in-service measurements that may be made at frontier stations. Such measurements will enable subsequent maintenance and fault tracing to be carried out when the group is in service.

3.2 *Checking the channel performance*

For each channel the following parameters should be measured and a careful record made. The limits are given in the appropriate C.C.I.T.T. Recommendation.

a) Loss/frequency characteristic: to be equalized if necessary (paragraph 2.1 above);

b) Group delay/frequency characteristic: to be equalized as necessary if group delay equalization is required, as, for example, if the channel is used to provide a data circuit;

c) Noise (paragraph 2.2 above);

d) Crosstalk between go and return channels (Recommendation M.58);

e) Frequency errors arising from frequency translation. This is particularly important when channel-translating equipments with individual channel oscillators are used. (A suitable method of measuring frequency change is shown in Supplement No. 2.10 of Volume IV of the *White Book*);

f) Go-return propagation time measurements to be made if administrations so desire.

RECOMMENDATION M.48

RECORDS TO BE KEPT IN CONNECTION WITH CATEGORY B LINKS AND CHANNELS

The minimum records that are to be kept for Category B links and channels in addition to local records are as follows:

Main section control stations

a) Terminated-level measurements of national and international sections within the main section.

b) Through-level measurements made as described in paragraph 4.2.2 b) of Recommendation M.46 at frontier stations within the main section.

c) Terminated-level measurements of the main sections under their control.

d) Through-level measurements made as described in paragraph 3.1 of Recommendation M.47.

Major section control stations

e) Records c) and d) above for each main section control station under their control.

f) Terminated-level measurements of the major sections under their control.

g) Through-level measurements made as described in paragraph 3.1 of Recommendation M.47.

Supergroup control stations

h) Records f) and g) for each major section control station.

i) Terminated-level measurements for the supergroup link.

j) Terminated-level measurements for the channels of the individual groups of the supergroup.

Group link control stations

k) Records f) and g) for each major section control station.

l) Terminated-level measurements for the group link.

m) Terminated-level measurements for the individual channels of the group.

n) Measurements made as described in paragraph 3.2 of Recommendation M.47.

2.4 Routine maintenance of an international carrier system

RECOMMENDATION M.50

ROUTINE MAINTENANCE MEASUREMENTS TO BE MADE ON REGULATED LINE SECTIONS

1. *Radio-relay regulated line section*

The following measurements should be made in the radio equipment terminal stations of the radio-relay system. Readjustment should be carried out in accordance with Recommendation M.51.

1.1 Every three months or more often, depending on the stability of the radio-relay system and at the discretion of administrations:

- measurement of the loss/frequency distortion at frequencies in the baseband (additional measuring frequencies) (permissible limits ± 2 dB (± 2 dNp);
- when there is no continuous recording of noise, measurement of the total noise level on the noise-measurement channels outside the baseband in accordance with C.C.I.R. Recommendation No. 398-1 [1], this measurement can be made without causing any interference in the transmission channel.

[1] Where a protection channel is provided, and if administrations so desire, noise measurements may be made on that channel with artificial loading, in accordance with C.C.I.R. Recommendation 399-1.

1.2 When the measurement mentioned in 1.1 gives unacceptably high noise values, or more often, when the reliability of the system makes it desirable, check of the following measurements in accordance with the appropriate C.C.I.R. Recommendations for the radio-relay system concerned, the radio-frequency channel being switched to the standby equipment:

— the deviation of the frequency at which the level is unchanged by pre-emphasis;
— the pilot frequency deviation;
— the control position of the intermediate frequency in the non-modulated condition of the system;
— the level of the radio characteristic frequency (single frequency check);
— the relative level at the radio reference measurement frequencies (multi-frequency check);
— the level of individual interfering signals in the baseband in the non-modulated condition of the system.

1.3 So as to enable the overall limits for the variations of equivalent (see under 1.1 above) to be met, the difference in response between two systems in diversity reception or between a working and stand-by system should not exceed 0.5 dB [1] (0.5 dNp).

2. *Coaxial regulated line section*

Measurements should be made as indicated below:

2.1 *Regulated line section terminal stations :*

a) daily reading of the line pilot level, preferably always at the same time of day;
b) regular readjustment to the nominal value as described in Recommendation M.51;
c) monthly check of noise level on selected channels of the system that terminate at the same point as the coaxial line section, so as to check intermodulation effects on the carrier system.

2.2 *Attended frontier stations :*

a) as in 2.1 a) above;
b) as in 2.1 b) above.

2.3 *Attended stations* (including the terminal stations of the regulated line section):

a) daily reading of the line pilot level (in manually regulated sections);
b) monthly measurement at the additional measuring frequencies and of the two line pilots (manually or automatically regulated sections).

[1] Value to be examined by the C.C.I.R.

2.4 *Unattended stations*

The administrations concerned are left to decide for themselves about measurement at additional measuring frequencies in unattended stations and about checking the operation of the regulators.

Note.—Precautions to be taken with additiona lmeasuring frequencies:

A. When the end of a regulated line section:

— is not the same as the end of a line link (i.e. when all the groups, supergroups, etc. are through-connected from one regulated line section to another without passing via the through-connection equipment to the basic groups),

— is the same as the end of a line link without complete demodulation to the groups, supergroups or mastergroups (i.e. when only part of the groups, supergroups, etc. are through-connected direct from one line link to another, without passing via the through-connection equipment to the basic groups),

the maintenance personnel should:

a) avoid sending a measuring frequency that is the same as a pilot frequency of a following regulated line section (unless the pilot frequency on such a following section is protected by a blocking filter at the beginning of the section);

b) take into account the possibility of attenuation to additional measuring frequencies lying at the edges of the frequency band of a through-connected basic group, supergroup, etc., due to the presence of through-connection filters.

B. Interference between additional measuring frequencies on adjacent coaxial links is possible if precautions are not taken to avoid carrying out simultaneous measurements on adjacent links. For this reason:

a) there should be different dates for routine maintenance measurements on two adjacent links;

b) before making any measurement using an additional measuring frequency, and especially those made when clearing faults, repeater station staff should see to it that measurements are not in progress on an adjacent coaxial link.

3. *Symmetric pair regulated line section*

Measurements should be made as indicated below:

3.1 *Regulated line section terminal stations:*

a) daily reading of the line pilot levels, preferably always at the same time of day;

b) regular readjustment to the nominal value as described in Recommendation M.51;

c) in certain circumstances, measurement at the additional measuring frequencies by agreement between the administrations concerned.

3.2 *Attended frontier stations* :

a) as in 3.1 a) above;

b) as in 3.1 b) above.

3.3 *Attended stations* (including terminal stations):

Measurement of level at the line pilot frequencies at intervals (every week, every fortnight, every month, or at longer intervals) to be decided upon by the administrations concerned and according to the length of the regulated line section and the number of groups to be carried by it.

3.4 *Unattended stations :*

Administrations are left to decide what measurements they think necessary.

RECOMMENDATION M.51

READJUSTMENT TO THE NOMINAL VALUE OF A REGULATED LINE SECTION (ON A SYMMETRIC PAIR LINE, A COAXIAL LINE OR A RADIO-RELAY LINK)

After each routine measurement or clearance of a fault and when it has been ensured that no faults remain on the system, the necessary adjustments should be made to bring the levels of the line pilots and additional measuring frequencies as close as possible to their nominal value.

Making the whole adjustment in the receiving terminal station should be avoided; adjustments should be made where they are necessary, under the direction of the control or sub-control station concerned.

Methodical readjustment should be carried out when the level measured at the terminal station exceeds the design limits for the carrier system. Due allowance should be made for measuring errors and for random effects which may cause slight short-term variation. The tolerance to be allowed depends on the type of system, its length and the periodicity of the measurements.

For example, the following tolerances may be allowed:

a) in the case of a system with continuous gain control, an adjustment should be made only if an improvement of at least 0.3 dB or 0.3 dNp can be obtained;

b) in the case of a system with step-by-step gain control allow a permissible tolerance of $\pm$ (one-half the gain control step ± 0.3 dB or ± 0.3 dNp).

RECOMMENDATION M.52

ROUTINE MAINTENANCE ON INTERNATIONAL GROUP, SUPERGROUP, ETC. LINKS

1. *Links with a pilot*

1.1 *Links without an automatic regulator*

At control stations, sub-control stations and unburied stations nearest to a frontier, a daily reading should be made of the pilot level, preferably at the same time each day.

These readings should be recorded on a suitable form designed for the purpose. Figure 1/M.52 is an example of a form suitable for these records. The records will be used

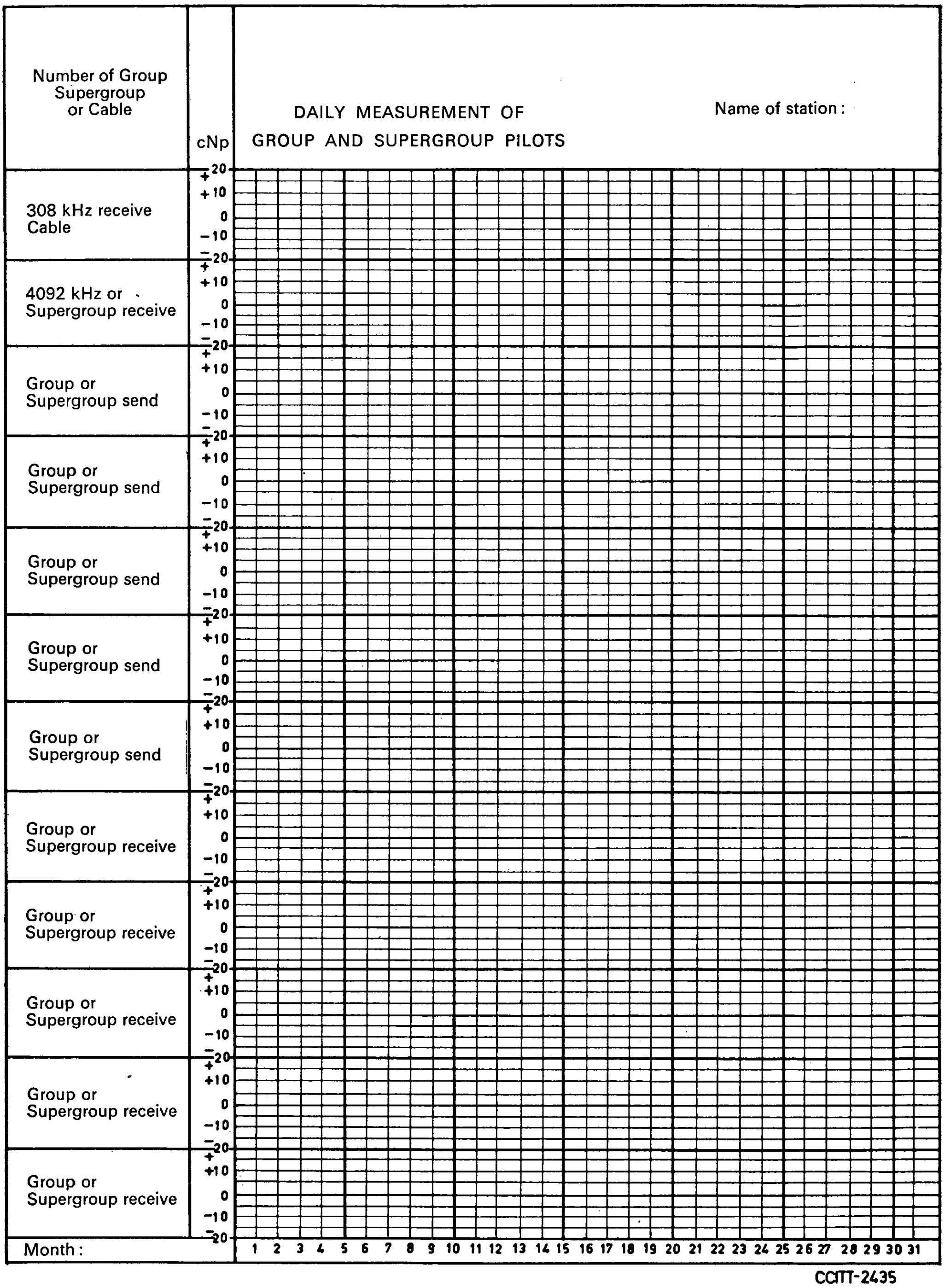
Number of Group
Supergroup
or Cable
cNp
DAILY MEASUREMENT OF
GROUP AND SUPERGROUP PILOTS
Name of station:
308 kHz receive
Cable
4092 kHz or
Supergroup receive
Group or
Supergroup send
Group or
Supergroup send
Group or
Supergroup send
Group or
Supergroup send
Group or
Supergroup send
Group or
Supergroup receive
Group or
Supergroup receive
Group or
Supergroup receive
Group or
Supergroup receive
Group or
Supergroup receive
+20 +10 0 −10 −20
Month:
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
CCITT-2435

FIGURE 1/M.52

to study the performance of the supergroup and group links and in determining the readjustments to be made. The conditions for regular readjustment of links to the nominal value are described in Recommendation M.53.

1.2 *Links with an automatic regulator*

In control stations where a regulator is installed, the level at the input to and the output from the regulator should be read and recorded once a week.

In sub-control stations and in unburied stations nearest to a frontier the pilot level should be measured once a week.

2. *Group links without a line pilot* (applies only to very short, simple group links)

A monthly measurement should be made using an 800-Hz signal at 0 dBm0 channel 6 of the group.

(The Routine Maintenance Programme shows the particular day on which monthly measurements have to be made.)

When the monthly measurement is made, the level in every sub-control station and in every through-connection station at one end of a frontier section will also be measured.

Note.—For ease of maintenance of a group not equipped with a pilot, it would be as well if administrations used channel 6 of such a group only for a circuit ending at the same points as that group.

3. *Supergroup links without a pilot*

The maintenance of these links is left to the administrations or private operating agencies concerned.

4. *Checking through-connection equipment on group, supergroup or mastergroup links*

Through group, supergroup and mastergroup filters are checked by local tests, so that the link can remain in service if the through-group equipment is replaced by reserve equipment.

RECOMMENDATION M.53

REGULAR READJUSTMENT TO THE NOMINAL VALUE OF AN INTERNATIONAL SUPERGROUP OR GROUP LINK

1. *International supergroup links*

Before any adjustment is made to a supergroup link it must first be ensured that each regulated line section or mastergroup link over which the supergroup link is routed is correctly adjusted and that the level of the reference pilot at the transmitting end is correct. No readjustments will be made on the supergroup link except under the direction of the control station, after consideration of the results of the daily measurements.

1.1 *Supergroup links without a regulator*

In accordance with Recommendation M.18, paragraph 2, an automatic regulator may be dispensed with on supergroup links under certain circumstances.

a) For supergroup links which use only one regulated line section, readjustment of levels to values as close as possible to their nominal value must be made systematically after any measurement or clearance of a fault. Any departure in excess of ±2 dB or ±2 dNp from the original line-up at the time the supergroup link was first established must be investigated to ensure that there is no fault.

b) For supergroup links or more complex constitution, no readjustment need be made until the departure from the nominal value exceeds 0.5 dB or 0.5 dNp [1]. When the departure from the nominal value exceeds these limits, adjustment to a value as near as possible to the nominal value should be carried out. Adjustment at the terminal station only is permissible within the following limits of departure from the settings at the time of the previous reference measurements related to the distance to the origin of the supergroup link or to the nearest upstream automatic regulator.

Distance to origin or regulator	Limit for departure from the settings noted for previous reference measurements beyond which the possibility of a fault should be investigated [1]
Up to 1000 km	± 2 dB or ± 2 dNp
1000-2000 km	± 3 dB or ± 3 dNp
above 2000 km	± 4 dB or ± 4 dNp

If, for the distance concerned, adjustment at the terminal station would cause departures greater than those permitted by the table, measurements should be made at all through-connection points to find if a fault exists. If a fault exists, it should be located and cleared. If no fault exists, but the change is due to normal causes, e.g. temperature changes, ageing, etc., adjustments should be made at each through-connection point to bring the level of the reference pilot as near as possible to its nominal value before making a final adjustment at the terminal station.

1.2 *Supergroup links with a regulator*

No readjustment need be made until the departure from the nominal value measured at the input to the supergroup regulator exceeds ±3 dB or ±3 dNp. Any departure in excess of ±3dB or ±3dNp from the nominal value measured at this point must be investigated.

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[1] See the note at the end of this Recommendation.

2. *International group links*

Before any adjustment is made to the group link, it must first be ensured that each regulated line section or each supergroup link is correctly adjusted and that the level of the reference pilot at the transmitting end is correct. No readjustments of the group link will be made except under the direction of the control station after consideration of the results of the daily measurements.

2.1 *Group links without a regulator*

a) For group links which use only one regulated line section, or one supergroup link, readjustment of levels to values as close as possible to their nominal value must be made after each measurement or clearance of a fault if the departure from the nominal value exceeds 0.5 dB or 0.5 dNp. Any departure in excess of ±2 dB or ±2 dNp from the setting of the gain control at the time of the previous reference measurements must be investigated.

b) For group links of more complex constitution, no readjustment need be made until the departure from the nominal value exceeds 0.5 dB or 0.5 dNp. If the departure from the nominal value exceeds 0.5 dB or 0.5 dNp, readjustment at the terminal station only is permissible provided the departure from the settings at the time of the previous reference measurements does not exceed 2 dB or 2 dNp [1]. If adjustment at the terminal station would cause departure from the original settings to exceed the values given in the table in paragraph 1.1 b) above measurements should be made at all through-connection points to determine if a fault exists. If a fault exists it should be located and cleared. If no fault exists but the change is due to normal causes, e.g. temperature changes, ageing, etc., adjustments should be made at each through-connection point to bring the level of the reference pilot as near as possible to its nominal value before making a final adjustment at the terminal station.

2.2 *Group links with a regulator*

No readjustment need be made until the departure from the nominal value measured at the input to the group regulator exceeds ±3 dB or ±3 dNp. Any departure in excess of ±3 dBp or ±3 dNp from the nominal value measured at this point must be investigated.

Note.—In determining the margins within which equipment should be readjusted, it has been found useful to distinguish three ranges about the nominal value into which the received level might fall:

- a relatively small range in which no action need be taken. This enables the staff to avoid waste of time in continually readjusting in order to compensate minor changes;
- a somewhat larger range in which the received level may be readjusted to as near the nominal value as possible by the terminal station, without having to ask intermediate stations to measure and/or readjust. (This is subject to the overriding proviso that the cumulative adjustment made at the terminal station must not exceed a certain amount relative to the settings noted when the last set of reference measurements was made);

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[1] See the note at the end of this Recommendation.

— a range in which it must be assumed that a fault may exist which must be sought and cleared before any readjustment is permitted. After the fault (if any) has been found and all stations, intermediate and terminal, have, if necessary, readjusted their levels to as near the nominal value as possible, the new settings are noted for future reference purposes when making subsequent adjustments.

The three ranges are shown in the following Figure 1/M.53 in relation to a typical distribution of level values.

A suitable value for y in this diagram is considered to be 2 S, where S = the observed standard deviation. This concept is the basis of the table proposed in paragraph 1.1 b) of this Recommendation.

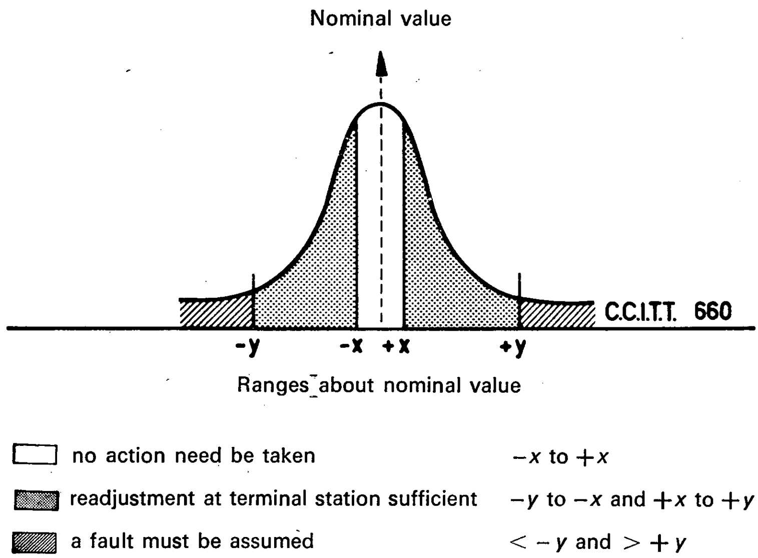

FIGURE 1/M.53. — **Typical distribution of observed values of level, showing ranges in which different action is necessary**

RECOMMENDATION M.54

ROUTINE MAINTENANCE OF CARRIER AND PILOT GENERATING EQUIPMENT

1. If a country has a national frequency standard, it is desirable to use it for checking the frequency of the master oscillators of carrier systems. (See the following table showing the recommended frequency accuracy for various carrier systems.) This frequency standard can be guaranteed to about 1 part in 10^{-8} by means of the three-way frequency comparisons organized by the C.C.I.R.

2. If a country has no national frequency standard, there are two possibilities:

a) to receive by radio the standard signals transmitted in accordance with C.C.I.R. recommendations;

TABLE SHOWING THE RECOMMENDED FREQUENCY ACCURACY FOR REFERENCE PILOTS, CARRIERS, ETC., IN VARIOUS CARRIER SYSTEMS

System		Frequency and accuracy: Reference pilot		Frequency and accuracy: Carrier generator
1		2		3
(1 + 3) open-wire		16.110 kHz 31.110 kHz	2.5×10^{-5}	2.5×10^{-5}
8 circuit open-wire				10^{-5}
12 circuit open-wire		5×10^{-6}		5×10^{-6}
Symmetric pair 1, 2, 3, 4 or 5 groups		Line regulating 60 kHz Auxiliary	 ± 1 Hz ± 3 Hz	
2 supergroups		Line regulating 60 kHz 556 kHz	 ± 1 Hz ± 3 Hz	
	2.6 MHz	Line regulating 2604 kHz	 ± 30 Hz	
Coaxial pair 2.6/9.5 mm	4 MHz	Line regulating 60 kHz 308 kHz 4092 kHz Auxiliary 2792 kHz Additional measuring frequencies: All	 ± 1 Hz ± 3 Hz ± 40 Hz ± 5 Hz ± 40 Hz	Channel virtual carriers of a group $\pm 10^{-6}$ Groups and supergroups $\pm 10^{-7}$
	12 MHz	Line regulating 308 kHz 4287 kHz 12435 kHz Additional measuring frequencies: < 4 MHz > 4 MHz	 $\pm 1 \times 10^{-5}$ ± 40 Hz $\pm 1 \times 10^{-5}$	Mastergroups and supergroups $\pm 5 \times 10^{-8}$
Coaxial pair 1.2/4.4 mm	1.3 MHz	Line regulating 1364 kHz Auxiliary 60 or 308 kHz	 $\pm 1 \times 10^{-5}$ $\pm 1 \times 10^{-5}$	
	4 MHz	Line regulating 60, 308, 4287 kHz	 $\pm 1 \times 10^{-5}$	
	6 MHz	Line regulating 308, 4287 kHz	 $\pm 1 \times 10^{-5}$	

System	Frequency and accuracy	
	Reference pilot	Carrier generator
1	2	3
12 + 12	60 kHz ± 1 Hz Others by agreement between administrations	Error in reconstituted frequency over a 140-km section not to exceed 0.3 Hz (provisional value)
6 MHz		Video carrier 1056 kHz ± 5 Hz
4 kHz spacing. Basic group B and Basic supergroup.	84.080 kHz, 104.080 kHz, 411.920 kHz and 547.920 kHz ± 1Hz 84.140 kHz and 411.860 kHz ± 3Hz	
Basic mastergroup and 15-supergroup assembly.	1552 kHz ± 2Hz	
Basic supermastergroup	11096 kHz ± 10Hz	
3 kHz spacing.	84 kHz or other frequency by agreement	

b) to receive from a neighbouring country, over a metallic circuit, a frequency derived from the national standard of that country.

It may be necessary in some cases to make a direct comparison of the frequency of the master oscillators of the carrier systems of different countries; this comparison will be effected by means of the frequency comparison pilots.

3. The changeover of master oscillators may cause a short interruption of a few milliseconds and a sudden phase-change. Because the effect of these interruptions and phase-changes is felt throughout the carrier system, changeover of master oscillators should be made only when absolutely necessary.

SECTION 3

SETTING-UP AND MAINTENANCE OF INTERNATIONAL TELEPHONE CIRCUITS

3.1 — Bringing an international telephone circuit into service

RECOMMENDATION M.56

OVERALL LOSS [1] OF A CIRCUIT

1. *Former transmission plan*

In the former transmission plan, the overall loss of circuits in terminal service is defined with reference to the two-wire ends of such circuits. In this former transmission plan:

— for all international circuits, the nominal overall loss should be the same for the two directions of transmission;

— for manually operated international circuits, the nominal overall loss (insertion loss between non-reactive resistances of 600 ohms) between the switchboard jacks at the terminal international exchanges, including the line transformers, etc., measured at 800 Hz, should not exceed 7 dB or 8 dNp. This limit also applies to a chain of two circuits interconnected at an international transit centre;

— for automatic international circuits, the value recommended by the C.C.I.T.T. is 7 dB or 8 dNp in each direction of transmission. This value includes the insertion loss of the incoming and outgoing switching equipments and also of pads included in the circuit in terminal service.

2. *New transmission plan*

The new transmission plan considers international circuits to be four-wire circuits interconnected on a four-wire basis at each end, either to another international circuit (at a transit international centre) or to a " national system " in a terminal international centre.

RECOMMENDATION M.57

CONSTITUTION OF THE CIRCUIT; PRELIMINARY EXCHANGE OF INFORMATION

As soon as it is decided to bring a new circuit into operation, the technical services of the terminal countries should agree upon the control I.T.M.C., and the technical service

[1] See Supplement No. 2.2 of Volume IV of the *White Book*.

of each transit country should advise the other technical services concerned of the name of the sub-control I.T.M.C. chosen for its territory. If the circuit is routed in a direct group crossing a transit country without demodulation, no sub-control I.T.M.C. need be provided for the transit country.

Also the technical services of all the countries concerned should send to the technical service responsible for the control I.T.M.C. information which will be required for the preparation of the circuit routing form (Appendices A and B to this Recommendation) using the letter and number code on the form. The information for a circuit without audio sections will consist of the numbers of the groups used and the number of the channel in each group.

The information should preferably be sent by telex and the examples below show typical telex messages concerning the provision of Bucureşti–London 1.

This method using the telex services enables agreement on routing details to be obtained quickly and also enables circuit routing forms to be completed by the technical services responsible for the control I.T.M.C. as soon as a circuit is put into service or rearranged.

Example I—Telex message from the technical services of the United Kingdom Administration to the technical services of the German Federal Republic, Austria, Hungary, and Roumania:

SERVTECH LONDON, E.C.1. TO FTZ DARMSTADT
GENTEL WIEN
GENTEL BUDAPEST
GENTEL BUCUREŞTI

AH 1036/2

PROPOSE PROVISION OF BUCUREŞTI–LONDON 1 USING FRANKFURT–LONDON 1201/9 SIGNALLING 500/20. LOSS 0.8 N. GRATEFUL FOR YOUR AGREEMENT OR COUNTER PROPOSALS. REGARDS.

Example II—Telex message from the technical services of the German Federal Republic in reply to telex in Example I:

FTZ SCHALT DMST TO SERVTECH LONDON E.C.1.
10 APR
FS NR 38
1 = GERMAN FEDERAL REPUBLIC 2 = BUCUREŞTI–LONDON 1
5 = FRANKFURT/MAIN 10 = 10 FEBRUARY 1961
A = FFT – L1201/9 B = 840
A = FFT – WIEN1201/11 B = 740

REGARDS.

COPIES TO WIEN, BUDAPEST, BUCUREŞTI

For a circuit with an audio section or sections, in addition to the carrier channels of the group, information on the terminal stations and the effectively transmitted bandwidth of the audio-frequency section or sections should also be shown.

That part of a telex message giving the routing information should give such information on a single line for each section of the route, as in the following example of routing information as it would be supplied by the French technical services for London–Paris Plage 4:

A = ST. MARGARET'S BAY-CALAIS 1202/4.	B = 36
A = CALAIS-PARIS PLAGE.	B = 80 E = 20 MS, 300-2200 Hz

In planning the routing, the technical services will try to reserve channels 1 and 12 of a group for circuits terminating at the same points as the group concerned. In cases where the group link is not provided with a group reference pilot, channel 6 should also be reserved for a circuit terminating at the same points as the group concerned, in order to take account of the Note to paragraph 2 of Recommendation M.52.

Using the above-mentioned information and the data supplied by sub-control stations, the control I.T.M.C. makes out a " circuit routing form " [1] which is used as a level diagram for voice-frequency sections. This routing form shows the nominal relative levels at:

— control and sub-control I.T.M.C.s;

— frontier stations, if the circuit is reduced to voice-frequency section across a frontier;

— stations where the circuit is reduced to voice frequencies, in those cases where the circuit passes via a series of groups.

The technical service of the control I.T.M.C. sends the routing form to the technical services of the sub-control I.T.M.C.s of the international circuit concerned in the following cases:

a) only at the specific request of one of the administrations concerned when the circuits are routed on one channel of a single international group link;

b) in all cases for circuits otherwise constituted.

The despatches are sent in duplicate, one copy for the technical service and one for the sub-control I.T.M.C.

[1] See Appendix A or B to this Recommendation, which can serve as a routing form or level diagram.

APPENDIX (A)
(to Recommendation M.57)

Routing form for a circuit (category A)

1. Date of issue . . . . 17 March 1963
2. Technical Service of . . . . United Kingdom
3. Circuit designation . . . . București–London 1
4. Length . . . . 2510 km

5a. Control I.T.M.C. . . . . London

5b. i) Sub-control I.T.M.C.s in the direction London to București . . Frankfurt-Main. Wien. Szeged. București

ii) Sub-control I.T.M.C.s in the direction București to London . . București, Szeged, Wien, Frankfurt-Main

6. Date of putting into service . . . . 18 February 1964
7. Echo suppressor at . . . .
8. Compandor at . . . .

Stations and constitution	Length of section (in km)	Nominal relative level at reference measurement point [1] (dBr)		Estimated group delay time at 800 Hz (milliseconds) [2]	Remarks [3]
		Direction ↓	Direction ↑		
(A)	(B)	(C)	(D)	(E)	(F)
London		−0.46	+0.46		N (*t*)
1201/9	840				
Frankfurt		+1.00	+1.00		N (*t*)
1201/11	740				
Wien		+1.00	+1.00		N (*t*)
1 + 1 channel 2	400				
Szeged		+1.40	+0.57		N (*t*)
BTO 303 channel 3	530				
București		−0.80	+2.16		N (*t*)

[1] An asterisk after the relative level indicates that the nominal value of the impedance at the measuring point differs from 600 ohms.

[2] When this column is completed for loaded cables the effective bandwidth of the section will be inserted.

[3] Give the appropriate indication in the " Remarks " column for each station:

N = nepers (*t*) = " niveau relatif de tension " or 600-ohms through level when 0.775 volt is applied to the (two-wire) sending end.

dB = decibels *p* = relative power level (dBr).

APPENDIX (B)
(to Recommendation M.57)

Routing form for a circuit (category B)

1. Date of issue	
2. Technical Service of	American Telephone and Telegraph Co.
3. Circuit designation	Stockholm–White Plains M32
4. Length	9038 km
5a. Control I.T.M.C.	White Plains
5b. i) Sub-control I.T.M.C.s in the direction White Plains–Stockholm	London (Eng.), Stockholm
ii) Sub-control I.T.M.C.s in the direction Stockholm–White Plains	Stockholm, London (Eng.)
6. Date of measurements	October 1963
7. Echo suppressors at	White Plains (½), Stockholm (½)
8. Compandors at	None
9. Signalling: Direction White Plains–Stockholm	Type: 500/20 Hz
Direction Stockholm–White Plains	Type: 1000/20 Hz
10. Switching equipment	
11. Special equipment at	None
12. Speech concentrator [1]	None
13. Estimated weighted noise power	–48 dBm0 (36 dBa)
14. Special performance requirements at	None
15. Hangover time of suppressors at	White Plains: 70 ms Stockholm: 70 ms

Stations and constitution	Length of section (in km.)	Nominal relative level at reference measurement point [2] (dBr)		Estimated group delay time at 800 HZ-ms	Remarks [3]
		Direction ↓	Direction ↑		
(A)	(B)	(C)	(D)	(E)	(F)
White Plains		0.0	−6.0		
2LR/1	259				
Tuckerton		+7.0	+7.0		
1608/1	6450			40.5	
Widemouth		+4.0	−4.0		
901/2	439			2.7	
London		+4.0	−4.0		
1204/5	1845			11.4	
Stockholm		−6.0	0.0		

[1] Insert " TASI only ", " THROUGH and TASI ", or " NONE " as appropriate (or equivalent).

[2] An asterisk after the relative level indicates that the nominal value of the impedance at the measuring point differs from 600 ohms.

[3] Give the appropriate indication in the " Remarks " column for each station using the following abbreviations:

N = nepers — (t) = " niveau relatif de tension " of 600-ohms through level when 0.775 volt is applied to the (two-wire) sending end.

dB = decibels — p = relative power level (dBr)

RECOMMENDATION M.58

SETTING UP AND LINING UP AN INTERNATIONAL CIRCUIT FOR PUBLIC TELEPHONY

1. *Introduction*

This Recommendation applies to all circuits operated on a manual, semi-automatic or fully automatic basis.

2. *Organization*

The guiding principles for the general maintenance organization of international circuits are given in Recommendation M.7.

2.1 An international circuit may consist of various national and international circuit sections (audio-carrier, etc.); these circuit sections consist of two telephony channels, one for each direction of transmission, each consisting of a channel of a group or an audio-pair.

2.2 At the terminal stations or I.T.M.C.s of the circuit, access points are provided in accordance with Recommendation M.11 (see also Recommendation M.64). At intermediate stations an access point is provided (see also Recommendation M.11 for transit circuits), its position in the circuit being so chosen that as much as possible of the audio-frequency apparatus in the station is included in any measurement made at that station in the direction of transmission concerned.

2.3 Where an intermediate station on the circuit is an I.T.M.C., access points will be provided as given in Recommendation M.11 and meeting the conditions given in paragraph 2.2 above.

2.4 In establishing an international circuit, the circuit, line and circuit section access points define the limits of the circuit, line and circuit section, and these are used as the basic elements involved in setting-up, lining-up, and fault location.

Note. — The line access point at the terminal station or I.T.M.C. will also be used as a circuit section access point at that station or I.T.M.C.

3. *Limits for the overall loss of a circuit and circuit sections*

3.1 *Limits for overall loss at 800 Hz*

The objective is to make the value of overall loss at 800 Hz as near as possible to its nominal value. When adjustment is provided in steps, these should enable the loss to be adjusted to within ± 0.3 dB or ± 0.4 dNp of the nominal value.

3.2 *Limits for the overall loss/frequency characteristic*

National telephone networks are planned and provided by administrations to give satisfactory telephone transmission on national calls in the most economical way and will, in consequence, have but little margin against additional transmission impairment in calls on the longest connections.

International telephone calls require the two corresponding parts of the national networks in the terminal countries to be interconnected by a switched chain of international circuits. The new C.C.I.T.T. plan for world-wide telephone connections contemplates the use of more circuits than in the past (for example, a maximum of six international circuits) and in some circumstances the nominal reference equivalent of the connection could be 3 dB (3.5 dNp) higher than in the past. This additional loss, in combination with increased line noise, makes it very desirable to minimize the transmission impairments introduced by the international circuits.

The C.C.I.T.T. is studying what limits of overall loss/frequency distortion shall apply in future to a circuit.

Meanwhile, in order to have an objective for a circuit for maintenance purposes, the following principles should be provisionally applied.

3.3 The overall loss/frequency distortion of a circuit depends on whether it is set up entirely on 4-kHz spaced channels, or entirely on 3-kHz spaced channels or on combinations of such channels, even including small sections of audio cable. Three sets of limits are given in Tables A, B and C.

The principles on which the tables are based are as follows:

i) The maximum loss in the relevant frequency range should not be greater than 9.0 dB (10.0 dNp) relative to the loss at 800 Hz in order to avoid disturbing the noise power distribution in the circuit to any extent;

ii) the use of equalizers at intermediate stations should be avoided as far as possible;

iii) where a mixed type of composition is used the arrangement of 3-kHz plus 4-kHz spaced channels in a circuit would cater for most of the cases of composition likely to be encountered in practice[1];

iv) to permit some flexibility to administrations to use a measure of pre-equalization if necessary in order to avoid low level signals entering a long section.

3.4 Table A is based on the limits recommended for a pair of 4-kHz channel equipments (Recommendation G.232), a small addition having been made to the recommended limits to allow for the additional distortions likely to be introduced by the group link and by the circuit and exchange apparatus. The equalization limits are three times the circuit limits.

Table B is similarly based on the limits recommended for a pair of 3-kHz channel equipments (Recommendation G.235) with an allowance for the group link and for circuit and exchange apparatus.

For international circuits composed of 4-kHz and 3-kHz sections, the limits given in Table C are a combination of the limits given in Tables A and B, taking into account the factors given in paragraph 3.3 i) to 3.3 iii).

[1] For example, one 3-kHz channel in series with two 4-kHz channels.

The limits to be imposed on the loss/frequency characteristic at intermediate stations are also shown in Tables A, B and C.

4. *Setting up and lining up the circuit sections*

4.1 a) The circuit sub-control I.T.M.C.s responsible for the various national and international circuit sections should arrange to set up these sections.

b) The circuit sections are lined-up and the overall loss/frequency characteristic of each is recorded from terminated-level measurements.

This is done by sending at a level of 0 dBm0 (0 dNm0)[1] at the reference test frequency at the access point at the intermediate sub-control I.T.M.C. or at the line access point at the control I.T.M.C. or terminal sub-control I.T.M.C. and adjusting the received level at the access point at the adjacent intermediate sub-control I.T.M.C. to as near as possible to its nominal level in the direction of transmission concerned.

4.2 The loss/frequency characteristic should then be measured at frequencies chosen from the following list, according to the characteristics of the circuit section to be set up.

200, 250, 300, 400, 600, 800, 1000, 1400, 2000, 2400, 2700, 2900, 3000, 3050 and 3400 Hz.

Technical services may agree to make measurements at other frequencies if it is considered useful to do so.

For circuit sections effectively transmitting up to only 3000 Hz (for example, circuits using 3-kHz spaced channels) the measurement at 3400 Hz is, of course, not applicable.

The overall loss at 800 Hz[2] should be as near as possible to the nominal value.

The overall loss at other frequencies should lie within the limits given in Tables A, B and C (see paragraph 3.3).

For each circuit section the results for each direction of transmission are forwarded to the control and terminal sub-control I.T.M.C.

At terminal stations, during these measurements, the signalling connections to the automatic equipment should be disconnected if the signalling units are incorporated in the carrier terminal equipment. When the line-signalling relay sets are included in the lines and apparatus being measured, any voice-frequency signalling receiver must be rendered inoperative or its action made ineffective.

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[1] A level of −10 dBm0 can be used by agreement between administrations.

[2] For international circuits, 800 Hz is the recommended frequency for single-frequency maintenance measurements. However, by agreement between the administrations concerned, 1000 Hz may be used for such measurements, since it is a fact that 1000 Hz is widely used for single-frequency measurements on some international circuits.

Multi-frequency measurements made to determine the loss/frequency characteristic will include a measurement at 800 Hz and therefore the reference frequency for such characteristic can still be 800 Hz.

5. *Setting up and lining up an international circuit*

5.1 *Setting up the circuit*

a) The sub-control I.T.M.C.s responsible for the various national sections crossing a frontier having set up and lined up the sections should arrange to connect these sections together and advise the control I.T.M.C. In addition, the control and terminal sub-control I.T.M.C.s, in conjunction with their I.S.M.C.s, should ensure that all associated signalling, switching and other terminal equipment has been connected, is free from faults, and is operating satisfactorily.

b) When the control I.T.M.C. has been advised by all the sub-control I.T.M.C.s that the sections constituting the circuit have been connected together, the control I.T.M.C. should agree with the sub-control I.T.M.C.s upon a time when the whole circuit may be lined-up.

5.2 *Lining up the circuit*

5.2.1 *Preliminary work*

i) The receiving terminal sub-control I.T.M.C. studies the test results of the individual circuit sections, particularly observing the way in which the variations within the permissible tolerances will accumulate when the sections are interconnected. The receiving terminal sub-control I.T.M.C. for each direction of transmission determines from these studies and observations the amount of gain and equalization adjustment which will be required at intermediate and terminal stations to obtain a satisfactory overall characteristic.

ii) From the test results the cumulative overall loss over the frequency band at intermediate sub-control I.T.M.C.s is calculated with respect to the overall loss at 800 Hz. An equalizer should be fitted at the request of the receive terminal sub-control I.T.M.C. at those stations at which the sum of the measured overall loss/frequency characteristics of the individual sections exceeds the provisional limits (see paragraph 3.4). In determining the limits, due account must be taken of the presence of 3-kHz-spaced channel translating equipment.

The number of intermediate equalizers should be kept to a minimum. When the receiving terminal sub-control I.T.M.C. has been advised by all the other sub-control I.T.M.C.s that the circuit sections and any prescribed equalizers have been connected together, a time when the circuit can be lined-up should be agreed upon.

5.2.2 *Adjustment of the overall loss at the reference test frequency*

a) At the appropriate time of line-up, the control I.T.M.C., in co-operation with the various sub-control I.T.M.C.s, proceeds with the overall line-up of the circuit, first at a frequency of 800 Hz [1].

For this, the control I.T.M.C. arranges to send an 800-Hz test signal at a level of 0 dBm0 (0 dNm0),[2] for example at the circuit access point of the circuit. In addition, the

[1] For international circuits, 800 Hz is the recommended frequency for single-frequency maintenance measurements. However, by agreement between the administrations concerned, 1000 Hz may be used for such measurements, since it is a fact that 1000 Hz is widely used for single-frequency measurements on some international circuits.

Multi-frequency measurements made to determine the loss/frequency characteristic will include a measurement at 800 Hz and therefore the reference frequency for such characteristic can still be 800 Hz.

[2] A level of −10 dBm0 can be used by agreement between administrations.

level at the line access point at the terminal stations should be adjusted to as close to the nominal value as possible.

b) The intermediate sub-control I.T.M.C.s will then arrange to measure the level of the 800-Hz test signal and to adjust it to the nominal value at the access points of the circuit (as defined in paragraph 2.2) in that direction of transmission. Measurements and adjustments should also be made at frontier stations where the circuit includes an audio-frequency section crossing a frontier.

c) At the distant terminal sub-control I.T.M.C. the received level of the test signal should be adjusted until the required overall loss is obtained at the circuit access point.

The procedure is then repeated for the other direction of transmission of the circuit.

In order to minimize cumulative gain or loss at 800 Hz the receive terminal sub-control I.T.M.C. may request intermediate sub-control I.T.M.C.s to alter the gain setting for the receive direction of their sections by not more than one gain control step. In this way it should be possible to arrange that the departures from the nominal value at successive stations are of opposite sign and yet still lie within the permissible limits. Theoretically, this adjustment will be needed in not more than half the stations.

d) It is not possible to recommend a value for the nominal transmission loss between the circuit access points of a switched public telephony circuit because of the freedom accorded to administrations in arranging the relative levels at these points. However, bearing in mind that at each end of the circuit the attenuation between the circuit access point and the virtual switching points will have a fixed and known value and that it is possible to " build out " the wiring to circuit access points to a known loss, the send level at the circuit access point should be so chosen that, on the circuit, the circuit hypsogram is respected, i.e. 0 dBm at a point of zero relative level. (See also Recommendation M.64, paragraph B, 1 d.)

5.2.3 *Measurement of the overall loss/frequency response*

i) When the circuit has been lined-up at 800 Hz measurements should then be made between circuit access points at the terminal stations and also at intermediate sub-control I.T.M.C.s and frontier stations when an audio-section crosses a frontier. The loss/frequency characteristic should then be measured at frequencies chosen from the following list, according to the characteristics of the circuit to be set up:

200, 250, 300, 400, 600, 800, 1000, 1400, 2000, 2400, 2700, 2900, 3000, 3050 and 3400 Hz.

Technical services may agree to make measurements at other frequencies if it is considered useful to do so.

ii) If necessary, the receiving terminal sub-control I.T.M.C. may equalize the circuit at this stage by means of an equalizer in that station, so that the overall loss/frequency characteristic lies within the required limits. Minor adjustments to compensate for accumulated manufacturing tolerances in pad and equalizer values can now also be made at intermediate stations. Those stations at which receive equalizers were necessary should remeasure the section including the equalizer, making terminated-level measurements. The results of those measurements should be passed to the receive terminal I.T.M.C.

These results now replace those previously submitted under operation 5.2.1 ii) above for these sections, and are the results with which comparison is to be made in subsequent maintenance. (The overall loss/frequency characteristic of a " section+equalizer " may not now lie within the limits appropriate to a circuit section. It should be noted that one consequence of this is that such a combination cannot be used as a replacement for a faulty circuit section; for such replacement purposes the circuit section should be transferred without the equalizer.)

5.2.4 When the above measurements and necessary adjustments have been carried out, the control and terminal sub-control I.T.M.C.s ensure that the limits are achieved. The circuit can be regarded as being lined-up.

Limits for the overall loss/frequency characteristic between circuit access points and the access points of circuit sections

TABLE A (M.58)

Circuits and circuit sections using 4-kHz spacing

Frequency Hz	Between circuit access points		At the access point at intermediate stations	
	dB	dNp	dB	dNp
Below 300	not less than 0.0 otherwise unspecified	not less than 0.0 otherwise unspecified	not less than −3.0 otherwise unspecified	not less than −3.6 otherwise unspecified
300 to 400	+3.5 to −1.0	+4.0 to −1.2	+9.0 to −3.0	+10.0 to −3.6
400 to 600	+2.0 to −1.0	+2.3 to −1.2	+6.0 to −3.0	+7.0 to −3.6
600 to 2400	+1.0 to −1.0	+1.2 to −1.2	+6.0 to −3.0	+7.0 to −3.6
2400 to 3000	+2.0 to −1.0	+2.3 to −1.2	+6.0 to −3.0	+7.0 to −3.6
3000 to 3400	+3.5 to −1.0	+4.0 to −1.2	+9.0 to −3.0	+10.0 to −3.6
Above 3400	not less than 0.0 otherwise unspecified	not less than 0.0 otherwise unspecified	not less than −3.0 otherwise unspecified	not less than −3.6 otherwise unspecified

TABLE B (M.58)

Circuits and circuit sections using 3-kHz spacing

Frequency Hz	Between circuit access points		At the access point at intermediate stations	
	dB	dNp	dB	dNp
Below 200	not less than 0.0 otherwise unspecified	not less than 0.0 otherwise unspecified	not less than −1.5 otherwise unspecified	not less than −1.8 otherwise unspecified
200 to 250	+10.5 to −0.5	+12.1 to −0.6	not less than −1.5 otherwise unspecified	not less than −1.8 otherwise unspecified
250 to 300	+6.5 to −0.5	+7.6 to −0.6	+9.0 to −1.5	+10.0 to −1.8
300 to 2700	+1.0 to −0.5	+1.2 to −0.6	+7.0 to −1.5	+8.0 to −1.8
2700 to 2900	+2.5 to −0.5	+2.9 to −0.6	+7.0 to −1.5	+8.0 to −1.8
2900 to 3050	+6.5 to −0.5	+7.6 to −0.6	+9.0 to −1.5	+10.0 to −1.8
Above 3050	not less than 0.0 otherwise unspecified	not less than 0.0 otherwise unspecified	not less than −1.5 otherwise unspecified	not less than −1.8 otherwise unspecified

TABLE C (M.58)

Circuits and circuit sections using 3-kHz and 4-kHz spacing

Frequency Hz	Between circuit access points		At the access point at intermediate stations	
	dB	dNp	dB	dNp
Below 300	not less than 0.0 otherwise unspecified	not less than 0.0 otherwise unspecified	not less than −3.0 otherwise unspecified	not less than −3.6 otherwise unspecified
300 to 400	+3.5 to −1.0	+4.0 to −1.2	+9.0 to −3.0	+10.0 to −3.6
400 to 600	+2.0 to −1.0	+2.3 to −1.2	+6.0 to −3.0	+7.0 to −3.6
600 to 2400	+1.0 to −1.0	+1.2 to −1.2	+6.0 to −3.0	+7.0 to −3.6
2400 to 2700	+2.0 to −1.0	+2.3 to −1.2	+6.0 to −3.0	+7.0 to −3.6
2700 to 2900	+2.5 to −1.0	+2.9 to −1.2	+9.0 to −3.0	+10.0 to −3.6
2900 to 3050	+6.5 to −1.0	+7.6 to −1.2	+9.0 to −3.0	+10.0 to −3.6
Above 3050	not less than 0.0 otherwise unspecified	not less than 0.0 otherwise unspecified	not less than −3.0 otherwise unspecified	not less than −3.6 otherwise unspecified

6. *Measurement of circuit noise*

6.1 The measurement of circuit noise should be made for both directions of transmission.

For the measurements of noise in one direction of transmission, the far end of the circuit should be terminated at the circuit access point, with an appropriate value of pure resistance.

At the circuit access point at the other end of the circuit (near end) a measurement of the psophometric voltage should be made, using a psophometer[1] having the characteristics recommended by the C.C.I.T.T.

Note.—For telephone circuits used as reserves for data-transmission circuits, other means of measuring noise may prove necessary.

6.2 The following values (average over any one hour) have been taken for design purposes:

i) For circuits of 2500 km in length the uniform random noise should not exceed 10 000 pW or 2.45 mV[2] at a zero relative level point: this is equivalent to —50 dBm0p (—57 dNm0p)[3].

ii) For circuits having a length of 25 000 km the uniform random noise should not exceed 40 000 pW or 4.9 mV at a zero relative level point equivalent to —44 dBm0p (—51 dNm0p).

6.3 For practical circuits whose length is less than the lengths given above, the noise level will normally be less than the values indicated, but it will not be possible to specify actual values since these depend upon the constitution of the circuit. The theoretical value of the noise level at the end of a particular circuit could be estimated (based on Recommendation G.143) when the constitution of the circuit is known.

6.4 The noise measured at the circuit access point should be recorded (and compared with the estimated value if this is available) for comparison against subsequent measured noise values. In the case of long and complex circuits, if the estimated noise level is worse than 4.9 mV, —44 dBm0p (—51 dNm0p), a compandor should be fitted to the circuit.

6.5 If the relative level at measuring access points is not zero, the appropriate correction should be made. (See Figure 1/M.58.) See in Supplement No. 2.5 of Volume IV of the *White Book* the details of corrections to be made to measured values when the impedance differs from 600 ohms.

The procedure should be repeated for the other direction of transmission.

7. *Measurement and equalization of phase-frequency characteristic*

Circuits used for certain applications, for example, data and facsimile transmission, have particular requirements in respect of phase-frequency distortion. Reference should be made to Recommendation T.12 of Volume VII of the *White Book* for facsimile circuits, and to Recommendation M.102 for special quality private circuits.

[1] See the weighting curve for this psophometer in Supplement No. 3.2, Volume IV of the *White Book*.

[2] The limit for the psophometric voltage is raised from 2.45 to 3.7 millivolts in the case of an open-wire carrier circuit.

[3] For the conversion to dBmp of noise values expressed in dBrnC, see the table in Supplement No. 1.2 or the curves in Supplement No. 3.2 of Volume IV of the *White Book*.

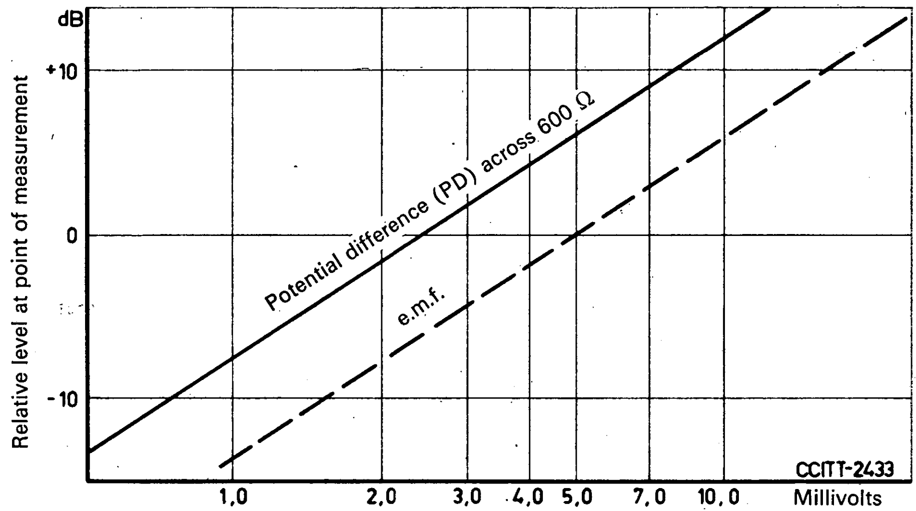


FIGURE 1/M.58. — **Graph showing noise in millivolts at points of different relative level when the noise power at a zero relative level point is 10 000 pW (at 600 Ω points)**

8. *Measurement of crosstalk between the "go and return" directions of transmission of a circuit*

Measurement of the go-to-return crosstalk should be made after disconnecting the circuit at suitable four-wire test points at each end, and terminating both directions of transmission at the far end with a pure resistance equivalent to the nominal impedance. The measurements should be made at each end of the circuit. The measured signal-to-crosstalk ratio should not be worse than 43 dB or 50 dNp.

9. *Check of signalling level*

9.1 Measurements should also be made to check that the absolute power level of the signalling current at the transmitting end of the circuit in each direction of transmission has a nominal value in accordance with Table D, or as agreed between administrations for signalling systems not covered by C.C.I.T.T. Recommendations.

9.2 *Absolute power level of signalling currents*

10. *Functional tests*

When the line-up procedure as described in the above paragraphs has been completed, a check should be made of the functioning of the compandors where appropriate in accordance with Recommendation M.59. This should be followed by a speaking test including a check of the satisfactory operation of echo suppressors and a check that signalling transmission over the circuit is satisfactory. For an automatically operated circuit the signal-transmission testing facilities available at the control I.T.M.C. should at least enable a

TABLE D (M.58)

Type of signalling	Signalling frequency		Absolute power	
	Nominal value	Tolerance	Nominal value in dNm0 (tolerance ± 1 dNp)	Nominal value in dBm0 (tolerance ± 1 dB)
Manual signalling (System No. 1)	500 Hz interrupted at 20 Hz	± 2%	uninterrupted (500 Hz) 0	uninterrupted (500 Hz) 0
		± 2%	interrupted (500/20 Hz) −3.5	interrupted (500/20 Hz) −3
One-frequency signalling (System No. 3)	2280 Hz	± 6 Hz	−7	−6
Two-frequency signalling (System No. 4)	2040 Hz	± 6 Hz	−10	−9
	2400 Hz	± 6 Hz	−10	−9
Multifrequency systems (Systems No. 5 and 5*bis*)				
Line signals [1] (two-frequency)	2400 Hz	± 6 Hz	−10	−9
	2600 Hz	± 6 Hz	−10	−9
Register signals [2] (multifrequency)	700 Hz	± 6 Hz	−8	−7
	900 Hz	± 6 Hz	−8	−7
	1100 Hz	± 6 Hz	−8	−7
	1300 Hz	± 6 Hz	−8	−7
	1500 Hz	± 6 Hz	−8	−7
	1700 Hz	± 6 Hz	−8	−7

[1] For compound signals, the difference between the sent levels of f_1 and f_2 should not exceed 1 dB (1 dNp).

[2] The difference between the sent levels of two frequencies of which a signal is composed should not exceed 1 dB (1 dNp).

check to be made of the line-signals transmitted between circuit access points, for example, to verify that the forward signals are followed by the return of the appropriate backward signals.

For manually operated circuits a check should be made to confirm that line-signalling to the distant end is satisfactory.

Where possible, both for manually and automatically operated circuits, test calls should be made to the distant-end operators or technical staff, as the case may be, to check the circuit both for signalling and transmission performance.

11. *Records of results*

Each station should keep a careful record of the measurement results for the receiving direction of transmission of the sections terminating in the station. A record should be kept of the overall loss at 800 Hz and also of the overall loss/frequency characteristic relative to the overall loss at 800 Hz.

The measurements made must include the characteristics of any equalizers which have been fitted and the final choice of gain setting must be stated.

The receiving terminal stations will also maintain a careful record of all the section measurements in the receiving direction of transmission. In addition the terminal sub-control I.T.M.C. should send a copy of the overall records to the control I.T.M.C., which thus will hold records for both directions of transmission. (Stations should prepare local records of in-station tests of equalizers and records of equalizer and gain settings.)

Careful records of the results of tests given in paragraphs 4 to 10 above should be made by both terminal stations. The control I.T.M.C. should hold a copy of the records for both directions of transmission.

RECOMMENDATION M.59

SETTING UP A CIRCUIT FITTED WITH A COMPANDOR

a) The compandor should first be tested in accordance with the appropriate design information which should be made available in a suitable form to the repeater station staff.

b) The compandor should be fitted to the circuit only after the circuit without its compandor is satisfactory in respect of loss and loss/frequency response (see Recommendation M.58). The loss/frequency characteristic of a circuit fitted with a compandor is likely to be misleading and need not be measured.

c) The loss (or gain) at the reference frequency between circuit access points [1] should be measured in both directions of transmission with an input level of U dBm0 both with and without the compandor in circuit, where U dBm0 is the unaffected level of the circuit (see Recommendation G.162, *White Book*, Volume III). The difference caused by inserting the compandor should not exceed 0.3 dB (0.35 dNp).

d) The noise power level, psophometrically weighted and unweighted, should be measured with and without the compandor in circuit and the values noted. The inputs to the channels should be terminated with 600-ohm resistors during this test. No limit is specified as the apparent noise advantage gained depends on the level of uncompandored noise, the unaffected level, the compression ratio and the dynamic range of the compandor.

e) A speaking test should be made on the circuit to verify that there are no gross tracking errors.

Note.—Repeater station staff should be well instructed as to the subjective effect of errors and the location of faults affecting compandors.

[1] See the footnote to Recommendation M.64, part B a), concerning the equipment included between line access points of the circuit.

3.2 — Routine maintenance of international telephone circuits

RECOMMENDATION M.60

ORGANIZATION OF ROUTINE MAINTENANCE MEASUREMENTS

The object of routine maintenance measurements is to detect changes in transmission conditions before such changes cause a reduction in the quality of service provided. These changes are those which occur relative to the values recorded for maintenance purposes for the circuit or link concerned. In the various sections of this volume limits are laid down within which:

— no readjustment is necessary,

— readjustment may be made at the terminal stations,

— readjustment must be made on the whole circuit or link.

Routine maintenance measurements have to be made at intervals as defined in Sections 2 and 3 of this volume, and, under the procedure described in Recommendation M.15, a routine maintenance programme is drawn up annually so that it can be agreed beforehand between administrations on which days the circuits and links between their respective countries shall be tested. The time of day at which the tests will be made is agreed between the repeater stations concerned.

Routine maintenance measurements must normally be made at times of light traffic, where staffing arrangements permit. If such measurements have to be made on a large group of circuits, it may nevertheless be necessary to do the measurements on some of the circuits during the busy period, if the operating services are not adversely affected thereby.

Circuits on a given route are generally measured in batches based on the way in which the maintenance programme has been arranged (see Recommendation M.15). The advantages are:

— once co-operation has been arranged for routine testing with a distant station, time is saved if test co-operation can be maintained for as long as necessary;

— testing a large number of circuits on one route within a fairly short period enables a more accurate overall notion of the route to be obtained than could be gained from measurements on only a few circuits;

— some simplification of the routine maintenance programme results, since only the first and last circuits need to be named to define a “ batch ”.

RECOMMENDATION M.61

PERIODICITY OF MAINTENANCE MEASUREMENTS

Routine maintenance measurements should be made on a complete circuit and should comprise measurements of:

a) overall loss and levels at one frequency;

b) overall loss and levels at several frequencies;

c) stability (for two-wire audio circuits or sections of circuit only);

d) signalling current and operation of signalling units;

e) noise.

The periodicity for measurements of loss, stability and signalling is given in Tables A and B below.

Table A shows the periodicity for measurements on the types of circuit normally used in the international telephone network of Europe (except for frontier circuits).

These circuits are:

— four-wire audio-frequency circuits. Included also in this category are circuits on carrier systems providing a small number of telephone channels. No distinction is made between circuits in underground cables and circuits on open-wire lines unless the open-wire section is equipped with repeater;

— or four-wire carrier circuits on telephone channels of systems providing at least one group;

— or four-wire circuits of mixed constitution, i.e. consisting of a mixture of audio and carrier sections. To determine the periodicity of maintenance measurements a distinction is made between circuits routed mainly on carrier systems and circuits routed mainly on audio-frequency sections.

Table B shows the periodicity of measurements to be made on short-distance international circuits that are generally used for terminal traffic, but which can, when necessary, be used to extend more important international circuits. It is desirable that the same recommendations be applied to national circuits that are frequently used for international communications.

TABLE A (M.61)

Periodicity of measurements to be made on international telephone circuits
(Circuits normally used in the international network)

Column 1	Column 2	Column 3	Column 4	Column 5	
				Signalling tests	
Type of circuit	Number of repeaters or group links	Measurements of overall loss and levels at one frequency [1]	Measurements of overall loss and levels at several frequencies	Manual circuits	Automatic circuits
Audio-frequency four-wire circuits [2]	Four-wire circuits with 1 to 14 repeaters	Monthly	Half-yearly	At the same time as the measurement of overall loss and levels at several frequencies (see column 4)	See the Recommendations of Volume VI for tests of automatic circuits
	Four-wire circuits with 15 or more repeaters	Weekly	Half-yearly		
	Four-wire circuits including an open-wire section with at least one repeater	At least monthly as agreed between administrations	Half-yearly		
Circuits wholly carrier	Circuits set up on channels on a single-group link and terminating at the same points as the group				
	Category A	Every 2 months	Yearly		
	Category B	Weekly	Yearly		
	Circuits routed over several groups				
	Category A	Monthly	Yearly		
	Category B	Weekly	Yearly		
Four-wire circuits of mixed constitution	*Category A*				
	Circuits routed mainly on carrier systems	Monthly	Yearly		
	Circuits routed mainly on audio sections	Weekly or monthly as agreed between administrations	Yearly		

[1] Measurements of overall loss and levels at one frequency shown in column 3 are included in the measurements made at several frequencies shown in column 4.

[2] Included also in the category " audio-frequency circuits " are circuits on carrier systems which provide a few telephone channels.

TABLE B (M.61)

Periodicity of measurements to be made on international telephone circuits
(Types of circuit not normally used in the international network)

<table>
<tr><th>Column 1</th><th>Column 2</th><th>Column 3</th><th>Column 4</th><th>Column 5</th><th colspan="2">Column 6</th></tr>
<tr><th rowspan="2">Category of circuit</th><th rowspan="2">Type of circuit</th><th rowspan="2">Measurements of overall loss and levels at one frequency [1]</th><th rowspan="2">Measurements of overall loss and levels at several frequencies</th><th rowspan="2">Measurements of stability</th><th colspan="2">Signalling tests</th></tr>
<tr><th>Manual circuits</th><th>Automatic circuits</th></tr>
<tr><td rowspan="5">Audio-frequency</td><td>Two-wire circuits with one repeater</td><td>Yearly</td><td>Yearly</td><td>Yearly</td><td rowspan="5">At the same time as measurements of overall loss and levels at several frequencies (see column 4)</td><td rowspan="5">As agreed between administrations</td></tr>
<tr><td>Two-wire circuits with two or three repeaters</td><td>Half-yearly</td><td>Yearly</td><td>Half-yearly</td></tr>
<tr><td>Two-wire circuits with at least four repeaters</td><td>Quarterly</td><td>Half-yearly</td><td>Quarterly</td></tr>
<tr><td>Two-wire circuits including an open-wire section with at least one repeater</td><td>Monthly</td><td>Half-yearly</td><td>Monthly</td></tr>
<tr><td>Four-wire circuits with a two-wire section having at least one repeater</td><td colspan="3">As agreed between administrations</td></tr>
</table>

[1] Measurements of overall loss and levels at one frequency shown in column 3 are included in the measurements at several frequencies shown in column 4.

RECOMMENDATION M.62

METHODS FOR CARRYING OUT ROUTINE MEASUREMENTS ON CIRCUITS

1. *Measurements of overall loss and levels*

On each circuit, measurements are made of the overall loss and, when necessary, the levels.

The measurements should be made:

— at the frequency of 800 Hz [1] when measurements are confined to one frequency;

[1] For international circuits 800 Hz is the recommended frequency for single-frequency maintenance measurements. However, by agreement between the administrations concerned, 1000 Hz may be used for such measurements, since it is a fact that 1000 Hz is widely used for single-frequency measurements on international and intercontinental circuits.

Multifrequency measurements made to determine the loss/frequency characteristic will include a measurement at 800 Hz, and therefore the reference frequency for such characteristics can still be 800 Hz.

— at frequencies of 300, 400, 600, 800, 1000, 1400, 2000, 2400, 3000 and 3400 Hz, when measurements are made at more than one frequency [1]. Whenever automatic level recorders or display sets are available at the ends of the circuit, the measurements should be made with this equipment at all frequencies over the range 300 to 3400 Hz at least;

— at frequencies of 400, 800 and 3000 Hz on circuits carried by single 12-channel groups (4-kHz spacing) ending at the same points as the circuits themselves.

The levels are also measured at intermediate sub-control stations and at frontier stations when the circuit includes an audio-frequency section crossing a frontier, and at stations where the circuit is reduced to voice frequency in those cases where the circuit passes via a series of groups.

The sub-control stations responsible for the circuits in the different national sections should be called in by the control station to take part in all the measurements. All the results of the measurements should be recorded by the control station and by the sub-control station concerned.

2. *Readjustment*

When, during a routine measurement, the overall loss at 800 Hz is not equal to its nominal value, the procedure below should be followed:

a) *Circuits working entirely at audio-frequency*

These circuits should be readjusted to their nominal overall loss after each measurement.

Adjustment at the terminal station only may be permissible if this does not involve deviations greater than 2 dB or 2 dNp from the initial setting of the gain adjustment in this station. Otherwise, the necessary correction should be distributed as well as possible among the various repeater stations, after ensuring that no fault exists.

b) *Circuits set up throughout on a channel of one group link*

For these circuits, before making any adjustments, it should be ensured that the group link carrying them is correctly adjusted in accordance with Recommendation M.53, paragraph 2. It should also be ensured that no fault exists in the channel-translating equipment at either end of the group link. After the above has been confirmed, the circuit should be readjusted if there is a variation of more than ± 1 dB or ± 1 dNp in the received level with respect to the level that would be received if the group pilot level were at its nominal value. The adjustment made should be such that if the level of the group reference pilot were at its nominal value, the received level for the circuit would be as near as possible to its nominal value.

c) *Circuits of more complex constitution*

Deviation of 2 dB or 2 dNp or less may be left. If measurements reveal a variation of overall loss of more than 2 dNp or 2 dB the cause of the variations should be located and readjustment should be made in those repeater stations where it is most necessary.

[1] With 16-channel carrier channels and old-type circuits which do not transmit frequencies above 2400 Hz, measurements should be made at 300, 400, 600, 800, 1000, 1400, 2000 and 2400 Hz.

For category B international circuits, deviations of 0.2 dB or 0.2 dNp may be left. If measurements reveal a variation of between 0.2 dB or 0.2 dNp and 2.5 dB or 3 dNp, adjustment to as near the nominal value as possible should be made at the terminal station. If the variation exceeds 2.5 dB or 3 dNp, a fault should be suspected which should be sought and cleared. If no fault is found, readjustment should be carried out at the intermediate and terminal stations as necessary.

3. *Measurements at more than one frequency*

When measurements are made at more than one frequency, a check should be made to ensure that the values obtained are within the limits permitted (see Tables A, B and C of Recommendation M.58). If they are not, appropriate steps should be taken.

4. *Noise measurements*

On international circuits (category A), it would be useful to make a check of the noise existing on the circuit at least at the same time as the measurements of overall loss and level at several frequencies.

On more complex international circuits (category B), the psophometric noise power as indicated by a C.C.I.T.T. psophometer should be measured monthly in both directions of transmission, any compandors on the circuit being rendered inoperative during the test.

For circuits used for voice-frequency telegraph links (Recommendation M.81) and data transmission (Recommendation M.102), the value of unweighted noise should also be measured.

5. *Signalling tests*

a) *Manually operated circuits*

The power of the voice-frequency signalling current, in its normal operating condition, should be measured at the same time as the overall loss at several frequencies is measured.

If n is the relative power level at the point of measurement, the measured absolute power level of the signalling current transmitted at 500/20 Hz (interrupted signalling current) should fall within the following limits:

$$(n-3.5)\,{}^{+1}_{-2}\ \text{dNp or}\ (n-3)\,{}^{+1}_{-2}\ \text{dB}$$

assuming that the signalling units used conform to the specifications of the C.C.I.T.T. (*White Book*, Volume VI).

The operation of the voice-frequency signalling receivers is tested as an in-station test.

For information, the operating limits of the signalling receiver are as follows:

If n is the relative power level at the point of connection in the circuit where the receiver is connected, it will operate reliably when the absolute power level N of the signalling current at the input of the receiver falls within the following limits:

$$-9.5 + n \leqq N \leqq +2.5 + n \text{ dNp}$$

or

$$-8.5 + n \leqq N \leqq +2.5 + n \text{ dB}.$$

b) *Semi-automatic or automatic circuits*

(See the " Guiding principles for the maintenance of the international automatic service ".)

6. *Routine measurements for category B circuits only*

i) *Measurement of crosstalk between go and return channels*

This measurement should be made annually. The measured signal to crosstalk ratio should not be worse than 43 dB or 5 Np.

ii) *Delay distortion*

This measurement should be made annually.

iii) *Frequency errors arising from frequency translation*

This measurement should be made weekly. The difference between the sent and received audio-frequency should not exceed 2 Hz.

Administrations must agree between themselves on the method to be used to check this value. A suitable pair of equipments for such a check is described in Supplement No. 2.10 (Volume IV of the *White Book*).

RECOMMENDATION M.63

MAINTENANCE OF CIRCUITS USING CONTROL CHART METHODS

Administrations which so wish may replace the periodical measurements specified in Recommendations M.61 and M.62 by measurements using sampling methods. They will need to arrange their own programme for these on a bilateral basis. Administrations which wish to use such methods are requested to report their conclusions to the C.C.I.T.T. giving their comments on:

— the method used (for information, some methods are described in Supplement No. 1.4 of Volume IV of the *White Book*);

— the saving in manpower in repeater stations;

— the transference of work from repeater stations to administrative offices;

— any observed change in the quality of groups of circuits maintained by sampling methods.

RECOMMENDATION M.64

FOUR-WIRE SWITCHED CONNECTIONS AND FOUR-WIRE MEASUREMENTS ON CIRCUITS

PART A [1]

1. *Principles*

A new transmission plan has been drawn up with the object of making use, in the international service, of the advantages offered by four-wire switching. However, the recommendations in the plan are considered to be met if the use of technical media other than those described gives an equivalent performance at the international centre.

Note 1.—From the point of view of the transmission plan no distinction is made between category A circuits and category B circuits.

Note 2.—Short trans-frontier circuits are not covered by the new transmission plan; they should be the subject of agreement between the administrations concerned.

2. *Definitions relating to a complete international telephone connection*

2.1 *The international chain and the national systems*

A complete international telephone connection has three parts, as shown in Figure 1/M.64, namely:

— *An international chain* made up of one or more four-wire international circuits. These are connected on a four-wire basis to other international circuits (in transit international centres) or to national systems (in international centres).

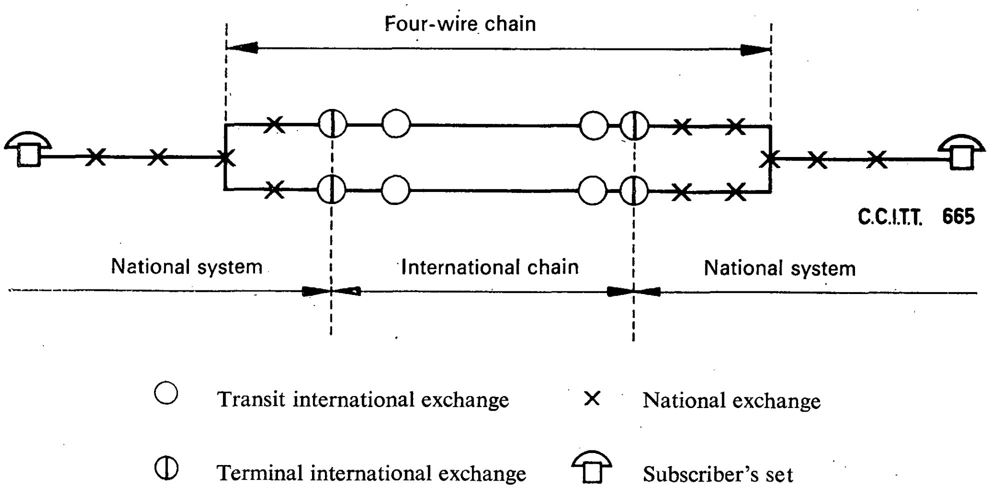


FIGURE 1/M.64. — **Constituent parts of an international telephone connection**

[1] This part A includes extracts from the relevant Recommendations in Volume III, Section 1, of the *White Book*, to which reference should be made for the complete text of these Recommendations.

— *Two national systems,* one at each end. These may comprise one or more four-wire amplified national circuits with four-wire interconnection, and circuits with two-wire connection to terminal exchanges and subscribers.

2.2 *Four-wire circuit ; virtual switching points ; circuit terminals (Figures 2 and 3/M.64)*

A four-wire circuit is defined by its *virtual switching points* in the international centres. These are theoretical points with specified relative levels.

The virtual switching points may not be the same as the points at which the circuit terminates physically in a switching equipment. These latter points are known as the *circuit terminals*; the exact position of the terminals is decided in each case by the administration concerned (see Figure 2/M.64) [1].

In an international centre, the boundary between the international chain and the national system is determined by the virtual switching points of the international circuit.

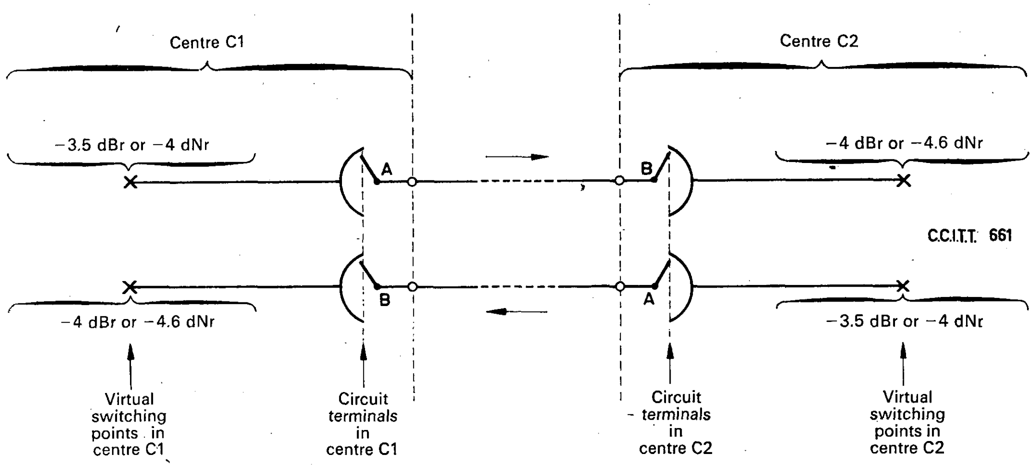
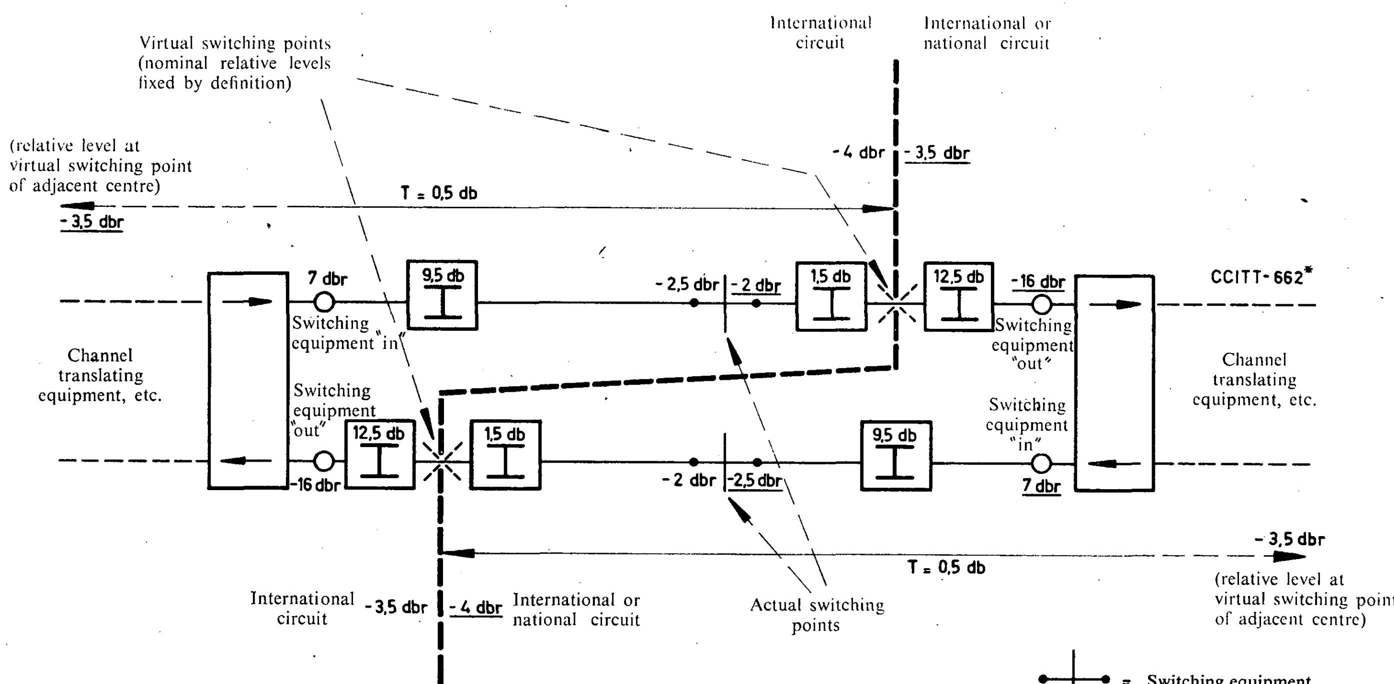


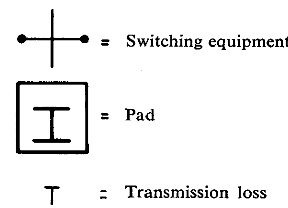
FIGURE 2/M.64. — **Definitions for an international circuit**

2.3 *Nominal transmission loss*

The difference between the nominal values at the virtual switching points of the sending and receiving relative levels at the reference frequency is, by definition, *the nominal transmission loss* of the four-wire circuit *between virtual switching points.*

[1] It should not be assumed that the " actual switching points " are the same as the " circuit terminals ".





Note. — Underlined values of relative level refer to the circuit on the right of the point concerned. Values of relative level not underlined refer to the circuit on the left of the point concerned. In an actual switching centre the virtual switching points would not physically exist and the loss of 14 dB between the switch and the channel equipment would not necessarily comprise a 1.5 and a 12.5 dB pad.

FIGURE 3/M.64. — **Example showing, on a simplified representation of a transit connection, the possible location of virtual switching points in an international transit centre**

3. *Relative levels specified at the virtual switching points of international circuits*

The virtual switching points of an international four-wire telephone circuit are fixed by convention at points of the circuit where the nominal relative levels at the reference frequency are:

−3.5 dBr or −4.0 dNr, sending

−4.0 dBr or−4.6 dNr, receiving

The nominal transmission loss of this circuit at the reference frequency between virtual switching points is therefore 0.5 dB or 0.6 dNp.

The relationship between the actual switching points and the virtual switching points in a practical international exchange is illustrated in Figure 3/M.64.

4. *Interconnection of international circuits*

Two international circuits interconnected in an international centre are considered to be connected together directly at their virtual switching points without any pad or amplifier between those virtual switching points (see Figure 2/M.64).

Therefore a chain of *n* international circuits has a nominal transmission loss in transit of *n* time 0.5 dB or 0.6 dNp in each direction of transmission; this contributes to the stability of the connection.

PART B

1. *Access points*

An international four-wire telephone circuit is defined by its *virtual switching points* in the transit or terminal international centre. Virtual switching points are theoretical points having specified relative levels and between which nominal transmission losses are calculated. For maintenance purposes, access points are required and these should be provided and used in accordance with the following principles:

a) The international circuit for public telephony includes the international line. Points serving to distinguish the ends of the international line should be provided in the form of four-wire test-access points called " *line access points* "[1]. The precise location of these points will depend on the administration concerned. In addition, test-access points should be provided at the audio input and output of the channel-translating equipment;

b) At the international four-wire switching centres at the terminals of a circuit there should also be four-wire test-access points so located that as much as possible of the international circuit is included between corresponding pairs of these access

[1] *points d'accès de la ligne*

Points utilisés par le C.C.I.T.T. pour définir les limites d'une ligne internationale à partir desquelles des mesures seront effectuées. Il n'existe qu'un « seul point d'accès de la ligne » pour chaque extrémité d'une ligne internationale. L'emplacement précis de chacun de ces points est du ressort de l'administration intéressée.

line access points

Points used by the C.C.I.T.T. to define the limits of an international line, and from which measurements are made. Only one such " line access point " exists at each end of an international line. The precise location of each such point depends on the administration concerned.

points at the two centres concerned. These points are called " *circuit access points* "[1];

c) Both the line test-access points and the circuit test-access points will be used in tests made by the repeater stations staff[2];

d) It is not possible to recommend a value for the nominal transmission loss between the circuit test-access points of a switched public telephony circuit, because of the freedom accorded to administrations in choosing the transmission levels at these points. However, bearing in mind that the attenuation between the circuit test-access points and the virtual switching points will have a fixed and known value and that it is possible to " build-out " the wiring to circuit test-access points to a known loss, the send level at the circuit test-access point should be so chosen that the circuit hypsogram is respected, i.e. 0 dBm or 0 dNm at a point of zero test level;

e) The impedance at the access points should have a return loss against the nominal impedance of the measuring apparatus of the station (for example 600 ohms, non-reactive) of not less than 20 dB (23 dNp) over the range 600-3400 Hz and not less than 15 dB (17 dNp) over the range 300-600 Hz.

2. *Choice of levels at access points for line measurements*

a) It is advantageous to adopt the same value of relative level at the send line test-access points for every circuit connected to the exchange. Similarly, all the receive line test-access points could also be at a particular common nominal value of relative level. When relative levels are made uniform in this way, lines can be readily cross-connected at the line access points, which is useful in the immediate replacement of faulty lines in an emergency.

b) If the nominal relative level at the receive line test-access point is chosen to be higher than that at the send line access point of the same exchange this level difference can

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[1] *See beginning of the note on the preceding page*

points d'accès du circuit

Points d'accès pour les mesures en quatre fils situés de telle manière qu'une partie aussi importante que possible du circuit international soit comprise entre paires correspondantes de ces points d'accès aux deux centres intéressés. Ces points et leur niveau relatif (par rapport au point de référence pour la transmission) sont déterminés dans chaque cas par l'administration intéressée. On les prend en pratique comme points dont les niveaux sont connus et auxquels les mesures de transmission seront rapportées. En d'autres termes, pour les mesures et réglages, le niveau en un point d'accès pour les mesures du circuit convenablement choisi est le niveau par rapport auquel on règle les autres niveaux.

circuit access points

Four-wire test-access points so located that as much as possible of the international circuit is included between corresponding pairs of these access points at the two centres concerned. These points, and their relative level (with reference to the transmission reference point) are determined in each case by the administration concerned. They are taken as the basic practical reference points of known level to which other transmission measurements will be related. In other words, for measurement and lining-up purposes, the level at the appropriate circuit test-access point is the level with respect to which other levels are adjusted.

[2] A compandor, if fitted, should be connected on the line side of the line test access points and not between the line test-access point and the circuit test-access point. In this way the relationship between the nominal transmission levels at these two points on a circuit with a compandor is the same as for other circuits.

be used to offset the inherent transmission loss in the signalling and switching equipment, and the requirements of the new switching plan can be met without being obliged to install supplementary audio-frequency amplifiers.

Note. — It is preferred to make transmission measurements between four-wire access points but, as a permissible alternative, a terminating unit may be provided together with an associated two-wire test-access point for measurement purposes. The transmission levels and losses must be chosen so that the nominal loss between virtual switching points is 0.5 dB (0.6 dNp) and the circuit hypsogram is respected.

RECOMMENDATION M.65

ROUTINE LINE MEASUREMENTS TO BE MADE ON THE LINE REPEATERS OF AUDIO-FREQUENCY SECTIONS OR CIRCUITS

Besides the routine tests made from end to end on the complete circuit, routine maintenance measurements of the equipment of audio-frequency circuits should be made throughout the line for purposes of repeater maintenance.

These routine measurements comprise:

— measurements of repeater gain (where there is little or no feedback);

— measurements for *testing and rejecting electronic valves* (measurements of slope or measurements of anode current, variation with heater current variation);

— measurements of *relative level* at the output of the repeaters (when measuring overall loss on the complete circuit, in the frontier stations and wherever else such measurements are considered necessary);

— measurements of circuit *stability* and test for determining singing points (with two-wire repeaters).

The measurement of stability is obtained from the definition of stability σ of the circuit considered:

$$\sigma = q - \frac{q_1 + q_2}{2}$$

q being the mean of the nominal overall loss of the circuit in each of the two directions of transmission under normal working conditions and q_1 and q_2 being the singing points measured for the two directions of transmission respectively.

In order to measure these singing points in the case of a two-wire circuit, singing is started by increasing, step-by-step and simultaneously for the two directions of transmission, the gains of one or of several repeaters (preferably those in the middle of the circuits because they are usually in the most critical position from the point of view of singing).

Having done this, without touching the adjustment which has been obtained, the transmission in the reverse direction is suppressed and the overall loss of the circuit at 800 Hz is measured for the forward direction of transmission; this is the singing point q_1 above. Next the transmission in the first direction is suppressed and the overall loss of the circuit at 800 Hz is measured for the reverse direction of transmission: this is the singing point q_2 above.

When the circuit is composed of two-wire and four-wire sections, or carrier sections, the method of measurement given for two-wire circuits is valid.

This stability should be determined with the ends of the circuit open-circuited; when there are high-impedance relays permanently connected across the line during a call, these relays may remain during stability tests.

RECOMMENDATION M.66

PERIODICAL IN-STATION TESTS OF ECHO SUPPRESSORS COMPLYING WITH RECOMMENDATION G.161 OF THE *BLUE BOOK*, VOLUME III[1]

1. The following tests should be made monthly:

a) Check of operate level[2]. If not within $\pm$ 2 dB of the initial value, readjust to be as close to the initial value as possible.

b) Check of disabling facilities:

i) Some echo suppressors can be disabled by the associated signalling and switching equipment. When this facility is provided it should be checked that it functions correctly;

ii) Some echo suppressors can be disabled by special audio-frequency signals on the circuit. When this facility is provided it should be checked that it functions correctly;

c) Check of differential action[2];

d) Check of blocking attenuation[2];

Check that the blocking attenuation is removed in the presence of a signal on the transmit path of sufficient magnitude as compared with a signal on the receive path. This check should be made with magnitudes of the signal on the receive path, ranging from the operate level to the expected maximum speech level.

Check also that the blocking attenuation is not removed by the echo produced under condition of the expected corresponding to the worst expected return loss. Use of an interrupted signal at the operate frequency or a test speech signal is likely to be effective for this check.

The blocking attenuation should not be less than 30 dB (34.5 dNp) in the frequency range 200-3500 Hz and not less than 40 dB (46 dNp) in the range 1000-1500 Hz.

[1] For the prescriptions concerning modern-type echo suppressors, see Recommendation G.161 of Volume III of the *White Book*.

[2] See definitions in Volume III of the *White Book*.

2. The following characteristic times should be measured every six months and if they are not within 20% of the initial values they should be readjusted to be as close to the initial values as possible:

a) Operate time [1]

Relay type echo suppressor. The operate time should not exceed 4 ms. Alternatively, the operate time should not be greater than 12 ms with a test signal at the operating frequency and 3 dB or 3.5 dNp above the operate level.

Valve or rectifier type echo suppressor. The operate time should not exceed 4 ms. The period subsequent to the operate time, during which the specified blocking attenuation is achieved, should not exceed 0.5 ms. Thereafter, as long as the test signal is applied, the loss should not fall below the specified blocking attenuation.

b) Hangover time [1]

The hangover time of the echo suppressor should be 50 ms. Exceptionally, where there is a long chain of national or international circuits beyond the point where the half echo suppressor is fitted, the hangover time should be 70 ms.

Note. — Recommendation G.131, B, gives rules for the use of echo suppressors on the switched international telephone circuits in the new world-wide switching and transmission plan. It is to be expected that intercontinental circuits will be of such a length that any connection made over them would need an echo suppressor; the half echo suppressors [1] are normally fitted at the international centres at the ends of the circuits.

It should be noted that there may be arrangements for deactivating (disabling) echo suppressors, when a connection is used for certain types of data transmission, and an echo suppressor deactivation (disabling) signal is being considered for this purpose.

RECOMMENDATION M.67

MAINTENANCE OF A CIRCUIT FITTED WITH A COMPANDOR

In-station tests

The compandor should be tested at intervals determined by the administration or private operating agency. The tests should be in accordance with the appropriate design information which should be made available in a suitable form to the repeater station staff.

Circuit tests

No special objective test of the circuit to check the operation of the compandor is recommended, but when the circuit is routine tested a speaking test should also be made.

The unaffected level of the circuit and the noise advantage should be checked in accordance with paragraphs c) and d) of Recommendation M.59 (Setting-up a circuit fitted with a compandor) at intervals determined by the administration or private operating agency.

[1] See definitions in Volume III of the *White Book*.

Volume IV SERIES M RECOMMENDATIONS | Volume VI PART V

3.3 — Guiding principles for the maintenance of the international automatic service [1]

The guiding principles for the maintenance of automatic telephone circuits deal with the division of responsibility for the maintenance of international automatic or semi-automatic telephone circuits between those concerned (operating services, switching services, transmission services, etc.). These principles are found in Recommendations M.70 to M.74 and Q.70 to Q.74.

RECOMMENDATION M.70 AND Q.70

DEFINITIONS FOR THE MAINTENANCE ORGANIZATION

international line

Transmission system contained between the " line access points " of the two international transmission maintenance centres (I.T.M.C.).

Each international line has only one " line access point " at each terminal I.T.M.C. This access point is defined in Recommendations M.64 and Q.75.

international automatic circuit

The whole of the international line and the outgoing and incoming equipment (or both-way equipments) proper to the automatic circuit considered. The ends of this circuit are defined by the " circuit access points ". These points are defined in Recommendations M.64 and Q.75.

automatic switching equipment

That part of an international exchange concerned with switching operations for routing the call in the desired direction.

maintenance

The whole of the operations required for setting up and maintaining, within prescribed limits, any element entering into the setting-up of a connection.

In international automatic service, maintenance is particularly concerned with circuits and automatic switching equipment.

Circuit and automatic equipment maintenance includes:

a) the carrying out of setting-up measurements and adjustments [2];

[1] As is mentioned in Volumes IV and VI, the expression " automatic circuit ", except where otherwise indicated, means circuits which may be used either for semi-automatic or automatic operation.

[2] It is considered that maintenance commences from the start of measurements and adjustments that precede entry into service. The results of these measurements provide reference values for subsequent maintenance, in the strict sense of the word.

b) the planning and programming of a maintenance scheme;

c) carrying out the prescribed routine preventive maintenance measurements and all other tests and measurements deemed necessary;

d) locating and clearing faults.

routine or preventive maintenance

Method involving the use of systematic operations intended to discover and clear faults before they affect service.

corrective maintenance

Method based solely on locating and clearing faults after they have affected the service.

qualitative maintenance[1]

Method based on an analysis of faults.

international connection

Whole of the means joining temporarily two subscribers and enabling them to exchange information. (See Recommendation G.101.)

measurement

The numerical assessment in suitable units of the value of a simple or complex quantity or magnitude.

test

A direct practical trial in whatever manner it may be made.

" *yes or no* " *test*

A test made to indicate whether a quantity or magnitude would fall above or below a specified limit or boundary defined to distinguish pass and fail conditions.

functional test

A " yes or no " test made to indicate whether a circuit, equipment or part of an equipment will function or not function under actual working conditions.

limit test[2]

A test made to indicate whether a quantity would fall within or outside a pair of limits or boundaries.

The required degree of precision of expression is to be achieved by extending the term to state:

— *on what the limit test is made,* for example " circuit limit test ";

— *the function or characteristic that is tested,* for example, " limit test of signalling "; and

[1] See the *Manual on National Automatic Telephone Networks,* Chapter IX, page 10.

[2] Such a test might be made to ascertain the margin of security in actual operating conditions.

— *for what purpose the limit test is intended*, for example, " limit test for readjustment purposes ".

localization of faults

The *broad localization* of a fault consists of finding the general part of the equipment in which it exists.

Fault finding consists of determining the faulty item of the equipment.

RECOMMENDATION M.71 AND Q.71

GENERAL MAINTENANCE ORGANIZATION FOR THE INTERNATIONAL AUTOMATIC SERVICE

1. *General*

To ensure satisfactory service quality in the international automatic telephone service, it is necessary to have an organization which can use the techniques recommended for achieving this. This organization is described in paragraphs 2.1 to 2.5 below and relates to the maintenance of the different component parts of an international connection.

Administrations are requested to apply these recommendations in order to obtain satisfactory service quality.

2. *Maintenance organization for the automatic service*

2.1 Co-operation in the maintenance of the international automatic service should be based on an organization comprising three types of centre in each country, which will be responsible for:

— transmission maintenance

— switching maintenance

— analysis of international service quality

as in the organizational chart shown in Figure 1/M.71 et Q.71.

The size and complexity of the maintenance organization will depend on the particular case and the particular country concerned. In some instances it may be possible to carry out all functions from a single centre; in others each function may be carried out from separate locations or, alternatively, only some of the functions might be combined and carried out from one location. The C.C.I.T.T. limits itself to defining the functions of the separate elements, and it is left to the administration concerned to decide whether to keep these functions separate or to combine them in a manner to suit the administration.

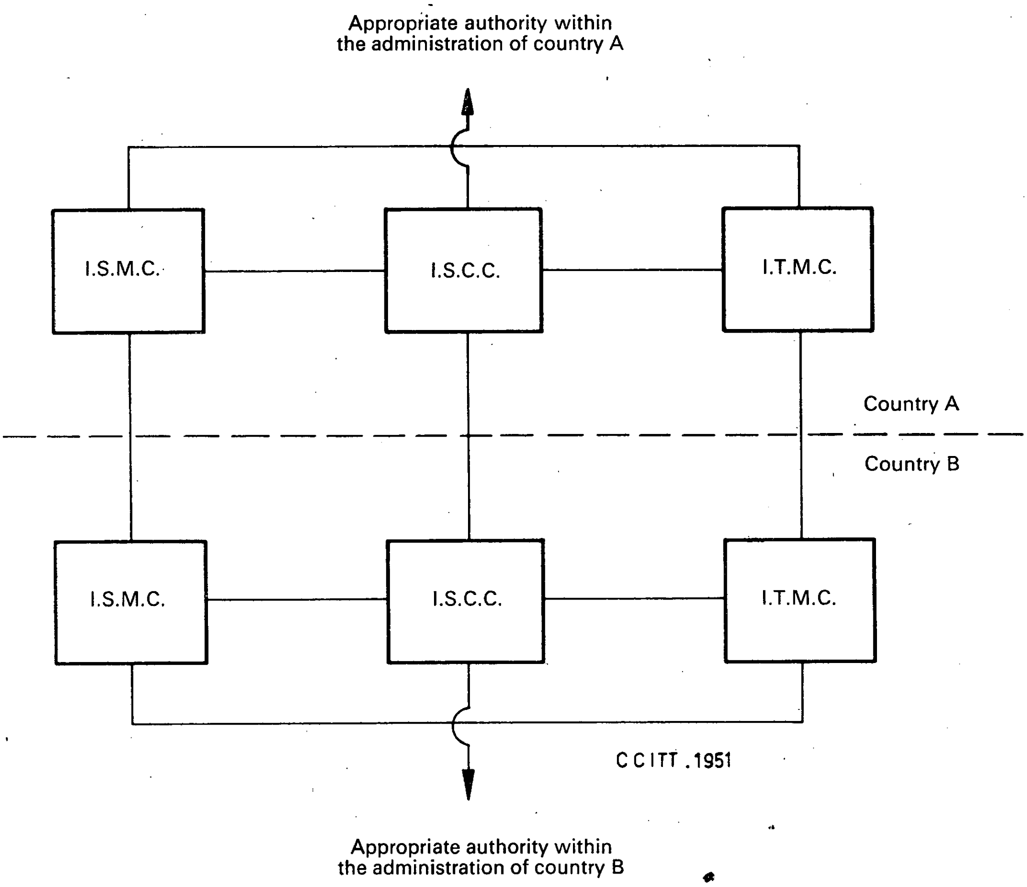
2.2 The maintenance centres for transmission and switching are those attached to the international repeater station and the international switching centre respectively. Their duties are described in the *White Book*, Volume IV (for transmission) and in Volume VI (for switching).

The international service co-ordination centre is to be responsible for supervising the quality of the service. Its duties are defined in Recommendation M.72 (Q.72). This centre should be in direct contact with the appropriate superior authority.

2.3 The three types of centre in each country should not be subordinated to one another on the international level.

The three types of centre may communicate directly with one another and with their corresponding centres in other countries.

Communication between centres of the same type in different countries may be carried out by means of telephone or telegraph service circuits (order wires) or through the switching networks, as arranged between the administrations concerned.



I.T.M.C. = International transmission maintenance centre
I.S.M.C. = International switching maintenance centre
I.S.C.C. = International service co-ordination centre

FIGURE 1/M.71 and Q.71

2.4 The attention of administrations is drawn to the benefit that may be derived from enabling staff in the international service who work in corresponding centres in different countries to meet and discuss their work.

2.5 These three centres are known in C.C.I.T.T. Recommendations as:

— International transmission maintenance centre (I.T.M.C.)

— International switching maintenance centre (I.S.M.C.)

— International service co-ordination centre (I.S.C.C.)

(see Figure 1/M.71 and Q.71).

RECOMMENDATION M.72 AND Q.72

INTERNATIONAL SERVICE CO-ORDINATION CENTRE (I.S.C.C.)

1. The appropriate service, which will analyse information from various sources in regards to international network performance at each international centre or in complex arrangements for more than one international centre, is the international service co-ordination centre (I.S.C.C.).

2. The I.S.C.C. has the authority to request assistance from:

— the international switching maintenance centres in its own country.

— the international transmission maintenance centres in its own country,

— the I.S.C.C.s in other countries.

The I.S.C.C. that refers a fault condition to any other organization must be informed of the essential action taken to clear the referred fault.

3. All events likely to affect the international service must be reported to the appropriate I.S.C.C.

4. The functions of the I.S.C.C. are as follows:

4.1 To collect and analyse information from various sources on the quality of the international service;

4.2 To initiate action, as indicated by the analysis, in conjunction either with maintenance forces within its own country or with I.S.C.C.s in other countries;

4.3 To keep a continuous watch on out-of-service times and to co-operate with the maintenance units in their efforts to reduce such times to a minimum;

4.4 To make optimum use of statistical methods [1] for determining the probable location of failure points;

4.5 To co-operate with the I.S.C.C.s of other countries in order to co-ordinate action in case of service defects and congestion existing in the part of the network depending on those I.S.C.C.s.

5. Besides having the required knowledge and experience to cater for the functions listed under 4, the I.S.C.C. staff should also possess, collectively, an adequate knowledge of switching equipment and of transmission equipment. In addition, the staff should be selected with a view to avoiding language difficulties.

6. The I.S.C.C. must also have the following information:

— routing information, diagrams or plans of the arteries relevant to the international network and the national network of the country concerned;

— general information about signalling, switching and transmission systems employed by other administrations.

7. The I.S.C.C. should also be kept up to date with:

— all relevant service observation data;

— all relevant information relating to the current state of service.

8. If considerable alterations are made to the numbering plan in a given country all the I.S.C.C.s concerned will be given prior notice. They will, moreover, be informed of the action taken to deal with calls to the old numbers.

RECOMMENDATION M.73 AND Q.73

PREVENTIVE MAINTENANCE

1. *Functional tests*

1.1 In carrying out functional tests, ordinary working conditions apply and the equipment and circuits are taken as found.

They are carried out on a systematic basis to discover faults that would influence the quality of service. The response to each signal may be tested by equipment provided for this purpose. Such tests may be applied to any part of the signalling path.

1.2 Functional tests are carried out locally, or from either end of an international circuit to the other.

1.3 The organization of the programme for carrying out functional tests locally is left to the discretion of the administration responsible for the international exchange.

[1] These methods are intended to include what are known, in some countries, as " trouble pattern techniques " (for example, graphical analysis of series of service defects) but this term has not yet been defined by the C.C.I.T.T.

1.4 Overall functional tests on an international circuit are such that they can be made from one end of the circuit without co-operation of technical personnel at the other end of the circuit. These tests may utilize the switching equipment at each end of the circuit, but such equipment is not being tested directly, only the circuit.

The verification of satisfactory signalling operation may be done by using various types of tests:

a) Certain types of tests not requiring any special equipment, for example checking that a seizing-signal is followed by the return of a proceed-to-send signal and that a clear-forward signal is followed by the return of a release-guard signal;

b) Other types combining several tests, using special equipment at both ends. Any type which is in general use by administrations may be used if suitable and agreed between the administrations concerned.

2. *Circuit limit tests*

2.1 A circuit limit test is made to verify that the international circuit meets specified operating margins. These tests enable the performance of the whole international circuit to be checked. They will be made as required but normally at the following times:

— before putting the circuit into service;

— according to a systematic test programme which may be based on measurement results or fault (trouble) statistics or quality of service observations.

They may also be made if functional tests indicate a fault, in order to locate such a fault.

Circuit limit tests may be made with respect either to transmission or to signalling conditions.

2.2 The frequency of such tests will be determined by the administrations concerned and the test conditions to be applied will be in conformity with C.C.I.T.T. Recommendations.

2.3 The test equipment, the specifications and methods of gaining access to this equipment are described in the specifications of international signalling, switching and transmission equipment.

3. *Limit tests on the constituent parts of a circuit*

3.1 These limit tests are made to verify that the constituent parts of a circuit meet specified operating margins. They will be made as required but normally at the following times:

— at installation;

— if functional or limit tests on the circuit indicate a fault, if such tests will help in fault-location;

— systematic test programmes which may be based on measurement results or trouble statistics or quality of service observations.

3.2 The frequency of such tests will be determined by the administrations concerned and the test conditions to be applied will be in conformity with C.C.I.T.T. Recommendations.

3.3 Limit tests on constituent parts may indicate that the latter need to be readjusted; in such a case, measurements are made on those constituent parts and they are then re-adjusted in accordance with the relevant C.C.I.T.T. Recommendations.

3.4 The test equipment, its specification and the provision of access points will be determined by the administration concerned taking into account the relevant C.C.I.T.T. Recommendations.

4. *Maintenance measurements*

4.1 *General*

Maintenance measurements are made periodically on complete circuits as well as on their constituent parts. Their object is to indicate whether the circuits and equipments are maintained to their specified values when first put into service and, if not, to allow the necessary readjustment to be carried out.

Some maintenance measurements are made to check signalling; others are made to check transmission. They are carried out by the respective technical services responsible for signalling and transmission.

4.2 *Measurements concerning signalling*

The conditions for carrying out such measurements, the apparatus used and the periodicity of operations are determined by the relevant Recommendations of the Q series. Interventions following such measurements are determined by:

a) C.C.I.T.T. Recommendations;

b) equipment specifications when these are not given in detail by the C.C.I.T.T.

For example, for carrying out local measurements concerning signalling on circuits using C.C.I.T.T. signalling system No. 4, the C.C.I.T.T., in Recommendation Q.138, has specified a calibrated signal generator and a signal measuring set.

In Recommendation Q.164 analogous specifications are given for signalling system No. 5.

4.3 *Measurements concerning transmission*

These measurements include:

a) local measurements, for which the administrations concerned decide the conditions and periodicity;

b) circuit and line measurements for which the conditions are generally defined in the Series M Recommendations of the C.C.I.T.T. *White Book*, Volume IV.

These Series M Recommendations give, in particular, the periodicity of the measurements and the conditions for readjustment of transmission equipment.

The C.C.I.T.T. has already specified certain transmission measuring apparatus, and other apparatus specifications are being studied.

RECOMMENDATION M.74 AND Q.74

FAULT REPORTING PROCEDURE IN INTERNATIONAL MAINTENANCE

1. *General*

Within the framework of the organization indicated in Recommendation M.71 and Q.71 three categories of personnel are concerned in fault reporting procedure in international maintenance:

a) International transmission maintenance centre staff;

b) International switching maintenance centre staff;

c) International service co-ordination centre staff.

2. *Reporting service defects to the international service co-ordination centre*

As a general rule, the international service co-ordination centre should receive fault reports from the following sources:

a) operators,

b) customers,

c) service observation staff,

d) other international service co-ordination centres,

e) international transmission maintenance centres of its own country,

f) international switching maintenance centres of its own country,

g) accounting (charging) analysis service,

h) various maintenance centres regarding the quantities of equipment or circuits available following a major breakdown,

i) any other source.

The transmission and switching maintenance centres will deal directly with faults detected as a result of alarms, tests, or measurements. Details of faults found will be forwarded to the international service co-ordination centre for analysis to detect long-term trends. Reports of faults for which no cause has been found will also be forwarded to the international service co-ordination centre of their own country.

3. *Action to be taken by the international service co-ordination centre*

If, as a result of analysis, the general location of a fault is clear, the international service co-ordination centre will refer details of its findings to the appropriate service which will endeavour to locate the fault and advise the international service co-ordination centre of the results achieved.

If the analysis does not give a clear indication of the location of a fault, the international service co-ordination centre may request the service that it deems most appropriate to undertake an investigation without delay to locate the fault.

SECTION 4

INTERNATIONAL CIRCUITS FOR VOICE-FREQUENCY TELEGRAPHY AND FACSIMILE TRANSMISSION

4.1 Setting-up and lining-up international voice-frequency telegraphy links

RECOMMENDATION M.80[1]

USE OF CIRCUITS FOR VOICE-FREQUENCY TELEGRAPHY

A. Composition and nomenclature

Figure 1/M.80 illustrates the composition of an international voice-frequency telegraph system and the nomenclature used.

1. *The international voice-frequency telegraph system*

This is the whole of the assembly of apparatus and lines including the terminal voice-frequency telegraph equipment. In Figure 1/M.80 the system illustrated provides 24 duplex telegraph circuits, but other numbers of telegraph circuits can be provided.

2. *The international voice-frequency telegraph link* (sometimes referred to as the bearer circuit, but in English this expression is imprecise and is deprecated).

2.1 Four-wire telephone type circuits are used for international voice-frequency telegraph links. The link comprises two unidirectional transmission paths, one for each direction of transmission, between the terminal voice-frequency telegraph equipments.

2.2 The voice-frequency telegraph link consists of an international telegraph line together with any terminal national sections connecting the international telegraph line to the voice-frequency telegraph terminal equipment and may be constituted entirely on carrier channels (on symmetric pairs, coaxial pairs, radio-relay systems, etc.) or on audio-frequency lines or combinations of such lines.

2.3 The normal links for voice-frequency telegraphy have no terminating units, signalling equipment or echo suppressors.

3. *The international telegraph line*

3.1 The international telegraph line may be constituted by using a channel in a carrier group or channels in tandem on a number of groups. National and international sections can be interconnected to set up an international telegraph line. See Figure 1/M.80, but note that subparagraph 3.2 details a preferred method.

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[1] This Recommendation appears also as Recommendation R.77 of Volume VII. Part A appears also as Recommendation H.21 of Volume III, of the *White Book*.

The international telegraph line could equally well be set up between, for example, only A and C or between C and D, in which case A and C or C and D would be the terminal international centres.

3.2 Wherever possible, an international telegraph line for a voice-frequency telegraph link should be provided on channels of a single carrier group, thereby avoiding intermediate audio-frequency points. In some cases, such a direct group may not exist or, for special routing reasons, it may not be possible to set up the international telegraph line in the preferred way. In such cases, the international telegraph line will consist of channels in tandem on two or more groups with or without audio sections, depending on the line available and the routine requirements.

4. *Terminal national sections connected to the international telegraph line*

In many cases the voice-frequency telegraph terminal equipment is remote from the terminal international centre of the international telegraph line (Figure 1/M.80), and such cases necessitate the provision of terminal national sections in order to establish international voice-frequency telegraph links. These sections may be in short-distance local audio cables, amplified or unamplified, or may be routed in long-distance carrier groups or on amplified audio plant.

B. Reserve arrangements for international voice-frequency telegraph links

All necessary action should be taken to enable the duration of interruption of international voice-frequency telegraph links to be reduced to a minimum and, for this purpose, it is expedient to standardize some of the methods to be adopted for replacing defective portions in the link.

Although it does not appear necessary for these methods to be the same in detail in every country, it would be advisable to reach agreement regarding the general directives to be followed.

The make-up of the reserve voice-frequency telegraph link will in general be similar to that of the normal voice-frequency telegraph link. However, if the voice-frequency telegraph terminal equipment is not located at the terminal international centres, the line portion of an international telephone circuit can be used to replace only the international telegraph line of the voice-frequency telegraph link.

1. *Reserve international lines*

1.1 Wherever possible, a reserve international telegraph line should be provided between the two terminal international centres by means of the line portion of an international telephone circuit (between A and B in Figure 1/M.80).

1.2 The telephone circuit used as a reserve should be chosen wherever possible so as to follow a different route from that of the normal international telegraph line. Where this cannot be done, as much as possible of the circuit or its sections should be alternatively routed.

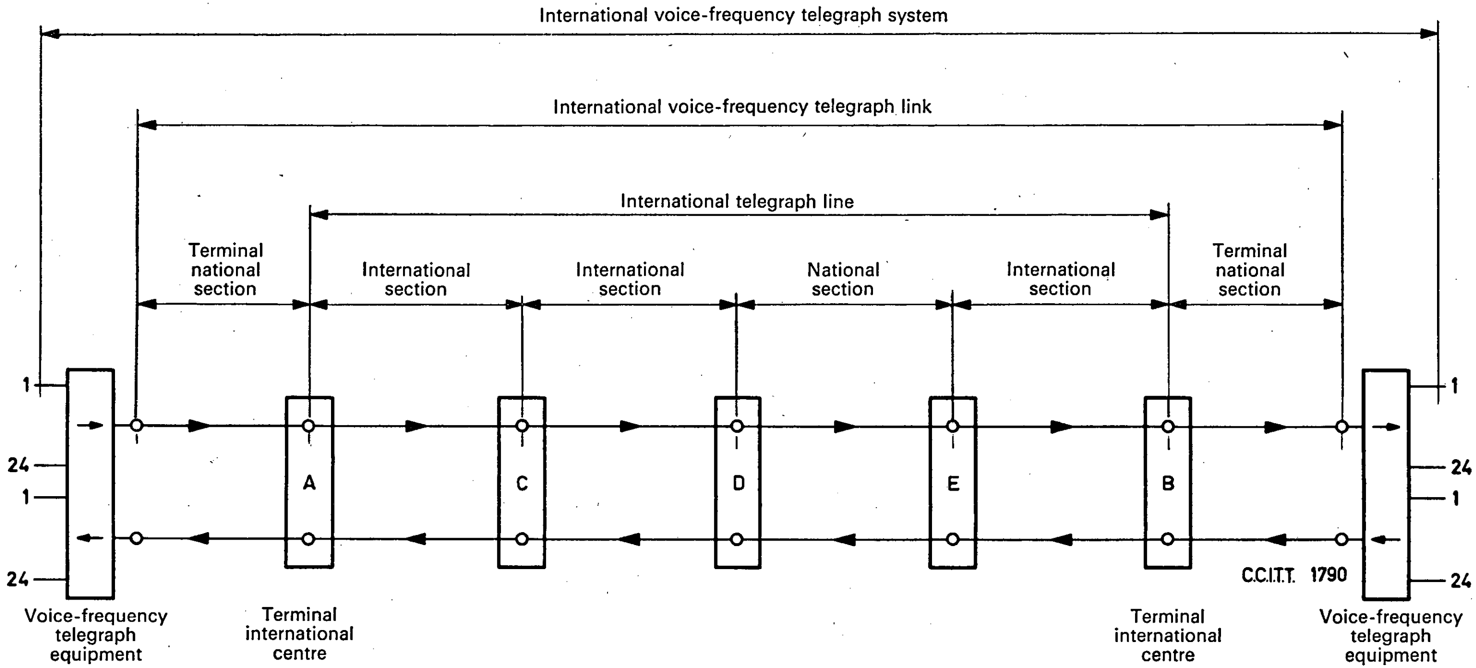


FIGURE 1/M.80. — **The components of an international voice-frequency telegraph system**

(at the intermediate centres C, D and E and at the terminal international centres A and B, the signals transmitted are at audio-frequencies. At these points it is possible to make measurements.)

1.3 If there is a choice, the use of manually-operated circuits as reserve lines for voice-frequency telegraphy is technically and operationally preferable to the use of automatic circuits.

It should be possible, after prior agreement between the controlling officers at the international terminal exchanges concerned, for an operator to break into a call in progress to advise the correspondents that the circuit is required elsewhere and that the call will have to be transferred to another circuit if it lasts longer than six minutes.

1.4 If the telephone circuit used as a reserve is automatic or semi-automatic a direct indication should be given at the changeover point. If it is not available when needed the reserve circuit should be blocked against any further call.

2. *Reserve sections for the sections of the international voice-frequency telegraph link*

Where it is not possible to provide a reserve international telegraph line or a reserve international voice-frequency telegraph link either because there are not suitable telephone circuits or because the number of telephone circuits does not permit the release of a circuit for reserve purposes, a reserve section should be provided wherever possible for each of the component sections. For these sections, national or international telephone lines or, where they exist, spare channels, circuits, etc. should be used.

3. *Reserve arrangements for the terminal national sections connecting the voice-frequency telegraph terminal equipment to the international telegraph line*

Reserve sections should be provided by means of national telephone circuits or by the use of spare channels, lines, etc., particularly in the case of long sections and of sections forming part of a category B voice-frequency telegraph link (see the Preface to Volume IV for an explanation of what is meant by " category B ").

4. *Changeover arrangements from normal to reserve lines*

4.1 When an international telephone line (i.e. part of an international telephone circuit) is used to provide a reserve for the international telegraph line (or for one of its sections as mentioned in B.2 above), there should be changeover arrangements to enable the changeover from the normal line to the reserve line to be made as rapidly as possible. The changeover arrangements (Figure 2/M.80) should be such that on changeover, all signalling equipment, echo suppressors, etc., associated with the telephone circuit that is used as a reserve for the international telegraph line are disconnected on the line side. When the fault is cleared on the normal line, it should be possible to join it to the signalling equipment, echo suppressors, etc., of the telephone circuit used, until the agreed time for restoration to the normal routing.

It is desirable to introduce as little disturbance as possible when changing back from reserve to normal. Arrangements of cords and parallel jacks can be devised to achieve this.

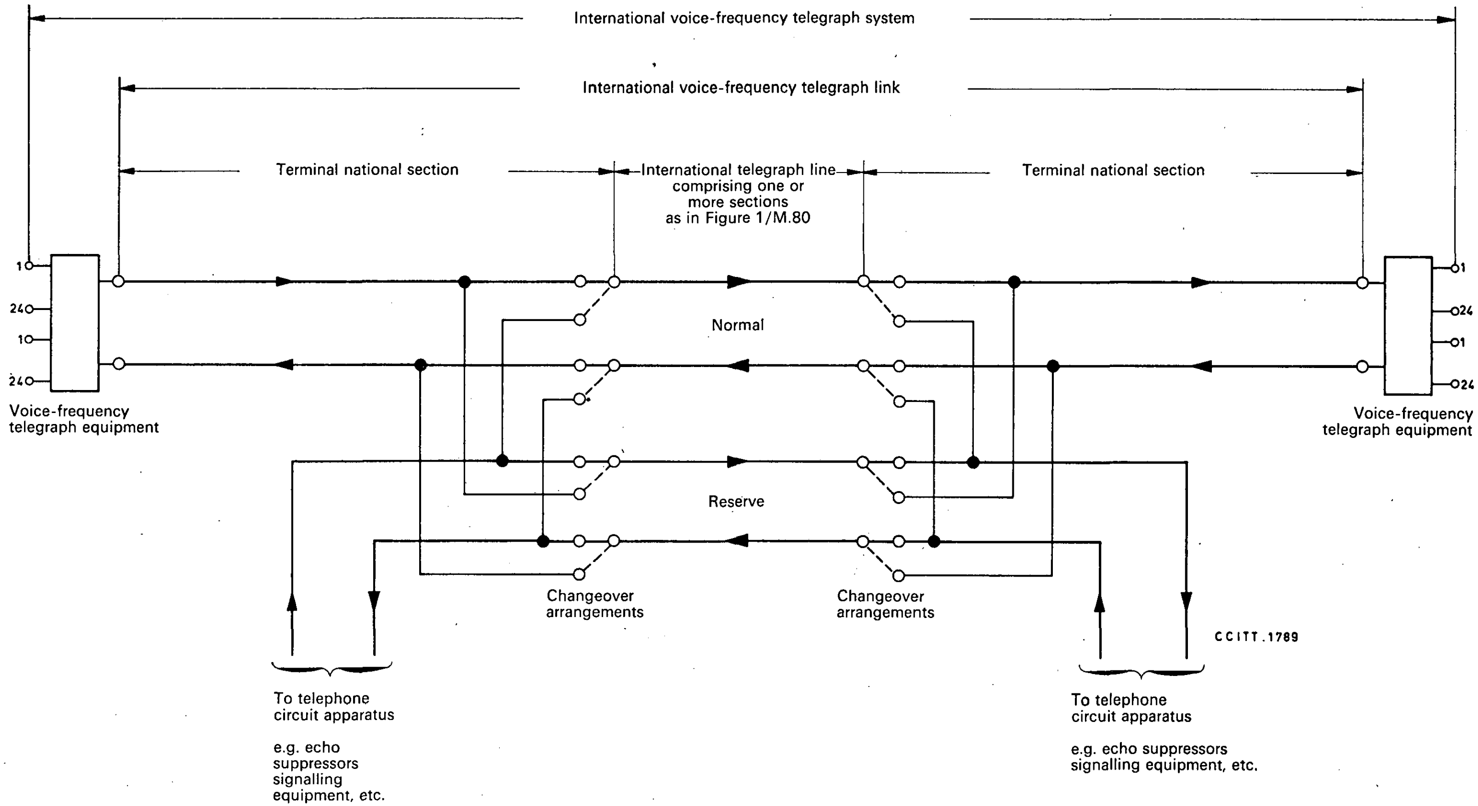


FIGURE 2/M.80 — **An example of how an international telephone line can be used as the reserve for the international telegraph line of an international voice-frequency telegraph system**

4.2 The changeover arrangements shown in Figure 2/M.80 could be applied to sections of the international telegraph line mentioned under paragraph B.2 above when it is not possible to obtain an overall reserve for the international telegraph line. Normal sections and the corresponding reserve sections should be routed via suitable changeover arrangements at the stations concerned.

4.3 Making manual, automatic or semi-automatic international telephone circuits available for reserve purposes for voice-frequency telegraphy should be in accordance with the instructions issued and the arrangements made by the respective administrations. Should the normal and reserve lines both be faulty, the technical services of the administration concerned should take immediate joint action to find a temporary remedy.

5. *Designation and identifying marks*

Normal and reserve links, etc., should be clearly distinguishable from other circuits both from the point of view of designation (see Recommendation M.14) and identifying marks (see Recommendation M.81).

RECOMMENDATION M.81

SETTING-UP AND LINING-UP AN INTERNATIONAL VOICE-FREQUENCY TELEGRAPH LINK FOR PUBLIC TELEGRAPH CIRCUITS (FOR 50-, 100- AND 200-BAUD MODULATION RATES)

1. *Designation of control stations*

1.1 The designations of the control and sub-control stations should follow the principles given in Recommendations M.8 and M.9.

1.2 By agreement between administrations, one of the terminal international repeater stations or I.T.M.C.s will be designated as the " voice-frequency telegraph link control station ": the other terminal repeater station or I.T.M.C. being the terminal sub-control station for the link.

1.3 In making the choice, the location of the control station or I.T.M.C. for any international circuit designated as a reserve for the international voice-frequency line should also be taken into account, as it is very desirable that the voice-frequency telegraph link control station or I.T.M.C. should be at the same terminal station as the control station or I.T.M.C. for the nominated reserve circuit.

2. *Organization*

2.1 The maintenance organization arrangements for voice-frequency telegraph links should conform to the general principles given in Recommendations M.7 and M.60 concerning public telephone circuits.

3. *Setting up and lining up a voice-frequency telegraph link*

3.1 In setting up and lining up voice-frequency telegraph links, three types of link are concerned, differing mainly in their constitution and they are referred to as type I, type II and type III links:

Type I are those links which contain 4-kHz sections;

Type II are those links which contain one or more 3-kHz sections, or contain a mixture of 3-kHz and 4-kHz sections;

Type III are those links which are routed over audio-frequency line plant.

3.2 The method to be used and the procedure to be followed in setting up and lining up a voice-frequency telegraph link is the same as that given in Recommendation M.58 for public telephone circuits as far as it applies.

The test signals to be used for these three types of link and the limits of the loss/frequency characteristics at intermediate sub-control stations are the same as those given in Recommendation M.58 for public telephone circuits.

3.3 The overall loss/frequency characteristics of types I, II and III voice-frequency telegraph links are given in Tables A, B and C respectively.

3.4 The nominal relative power level of the test signals at the input and output of the link will be those normally used by the administration concerned.

If the voice-frequency telegraph terminal stations are remote from the terminal international centres, the administration should arrange the nominal transmission loss of the national section so that the levels at the input and output of the voice-frequency telegraph link are respected, and to permit the conventional national levels to be used at terminal international centres.

3.5 For voice-frequency telegraphy the use of the edge-channels of a group should be avoided if at all possible since these may introduce greater distortion than other channels of the group.

4. *Limits for the overall loss of a voice-frequency telegraph link*

4.1 *Nominal overall loss at 800 Hz*

The nominal relative power levels at the extremities of the telegraph link are those levels normally used in the national network of the countries concerned so that it is not possible to recommend a particular nominal value for the overall loss.

The nominal relative power level at the input to the link and the absolute power level of the telegraph signals at this point must be such that the limits concerning the power level per telegraph channel at a zero relative point on carrier systems are respected (see the Annex to this Recommendation).

4.2. *Overall loss/frequency distortion*

The variation with frequency of the overall loss of the link with respect to the loss at 800 Hz must not exceed the following limits:

4.2.1 *Type I—Links with 4-kHz sections throughout*

TABLE A (M.81)

Frequency range, Hz	Overall loss relative to that at 800 Hz	
Below 300	Not less than −2.2 dBp (−2.5 dNp); otherwise unspecified	
300-400	−2.2 to +4.0 dB	−2.5 to +4.5 dNp
400-600	−2.2 to +3.0 dB	−2.5 to +3.5 dNp
600-3000	−2.2 to +2.2 dB	−2.5 to +2.5 dNp
3000-3200	−2.2 to +3.0 dB	−2.5 to +3.5 dNp
3200-3400	−2.2 to +7.0 dB	−2.5 to +8.0 dNp
Above 3400	Not less than −2.2 dB (−2.5 dNp); otherwise unspecified	

4.2.2 *Type II—Links with one or more 3-kHz sections or with a mixture of 3- and 4-kHz sections*

TABLE B (M.81)

Frequency range, Hz	Overall loss relative to that at 800 Hz	
Below 300	Not less than −2.2 dB (−2.5 dNp); otherwise unspecified	
300-400	−2.2 to +4.0 dB	−2.5 to +4.5 dNp
400-600	−2.2 to +3.0 dB	−2.5 to +3.5 dNp
600-2700	−2.2 to +2.2 dB	−2.5 to +2.5 dNp
2700-2900	−2.2 to +3.0 dB	−2.5 to +3.5 dNp
2900-3050	−2.2 to +6.5dB	−2.5 to +7.6 dNp
Above 3050	Not less than −2.2 dB (−2.5 dNp); otherwise unspecified	

4.2.3 *Type III—Links on audio-frequency line plant*

TABLE C (M.81)

Frequency range, Hz	Overall loss relative to that at 800 Hz	
Below 300	Not less than −1.7 dB (2 dNp); otherwise unspecified	
300-400	−1.7 to +4.3 dB	−2 to +5 dNp
400-600	−1.7 to +2.6 dB	−2 to +3 dNp
600-1600	−1.7 to +1.7 dB	−2 to +2 dNp
1600-2400	−1.7 to +4.3 dB	−2 to +5 dNp
2400-2450	−1.7 to +5.2 dB	−2 to +6 dNp
2450-2520	−1.7 to +7.0 dB	−2 to +8 dNp
Above 2520	Not less than −1.7 dB (−2 dNp); otherwise unspecified	

4.3 *Change of overall loss due to a changeover to the reserve line or section*

4.3.1 The nominal relative power level at 800 Hz of the normal and reserve lines or sections at the changeover points for a particular direction of transmission should be the same. This level will be that normally used in the national network of the country concerned.

4.3.2 *Change in overall loss at 800 Hz*

Bearing in mind that the overall loss of the normal line (or section) and the reserve line (or section) are both subject to variations with time, these variations being, in general, uncorrelated, it is not possible to assign a limit to the change of insertion loss at 800 Hz introduced by the changeover procedure.

4.3.3 *Values of overall loss over the frequency band, relative to the value at 800 Hz*

The overall-loss/frequency distortion characteristic of the link when established over the normal route should be within 2 dB or 2 dNp of that of the link when established over the reserve route. This limit applies over the frequency bands 300-3400 Hz, 300-3050 Hz or 300-2600 Hz as appropriate.

There should ordinarily be no difficulty in achieving the limit when only one portion of the link, for example, the international telegraph line, or one section, has a reserve section. However, when two or more portions of the link are separately associated with reserve portions it becomes administratively difficult to ensure that all combinations of normal and reserve portions comply with the limit. In these circumstances the best that can be done is to ensure that the overall-loss/frequency characteristics of corresponding normal and reserve portions are as much alike as possible. Careful attention should be paid to the impedance of normal and reserve sections at the point where they are connected to the changeover apparatus so that errors due to changing mismatch losses are minimized. A suitable target would be for all impedances concerned to have a return loss against 600 ohms, non-reactive, if not less than 20 dB (23 dNp) over the appropriate band of frequencies.

5. *Measurement of noise voltage on a voice-frequency telegraph link*

The psophometrically weighted noise voltage should be measured at the ends of the voice-frequency telegraph link in both directions of transmission. The unweighted noise voltage should also be measured using a C.C.I.T.T. psophometer without the weighting network.

5.1 *Uniform-spectrum random noise*

The mean psophometric noise power referred to a point zero relative level should not exceed 80 pW (—41 dBm0p or —47 dNm0p).

Notes.—

a) If recourse is made to synchronous operation, a higher noise level might be tolerated (such as −30 dBm0p or −35 dNm0p for a particular telegraph system).

b) In principle it would be desirable to specify a value of unweighted noise power level. However, such a value cannot be specified in unqualified terms. If the noise power is uniformly distributed over the band 300-3400 Hz and if there is no significant noise power outside this band then the level of the unweighted noise power will be approximately 2.5 dB (2.9 dNp) higher than the weight value (using the weightings specified in the table in Part A of Recommendation P.53, *Red Book*, Volume V, from which Supplement No. 3.2 gives some essential values). However, on a practical telegraph link neither of these conditions is likely to be met. The overall-loss/frequency distortion will affect the within-band noise distribution and, in a telegraph installation, there is likely to be significant noise power outside the band, particularly at low frequencies.

As a consequence it is not possible to recommend a limit for the unweighted noise power level and the C.C.I.T.T. psophometer with the telephone weighting network should continue to be the instrument used for specifying and measuring random noise power levels on international voice-frequency telegraph links.

5.2 *Impulsive noise*

Impulsive noise should be measured with an instrument complying with Recommendation H.13 of Volume III of the *White Book* [1].

The number of counts of impulsive noise which exceeds —18 dBm0 (—21 dNm0) should not exceed 18 in 15 minutes [2].

6. *Crosstalk*

6.1 The near-end crosstalk ratio (between the go and return telephone channels) of the link should be at least 43 dB (5 Np).

6.2 The crosstalk ratio between the link and other carrier circuits is restricted by Recommendation G.151, D a), *White Book*, Volume III, to not worse than 58 dB (67 dNp).

[1] See also Recommendation V.55, Volume VIII, *White Book*.

[2] These values are still under study.

Crosstalk in any audio cables forming part of the terminal national sections should not normally significantly worsen the crosstalk ratio.

7. *Group-delay/frequency distortion*

Practical experience obtained up to the present shows that it is not necessary to recommend limits for group-delay/frequency distortion for 50-baud voice-frequency telegraph links even when they are composed of several sections each provided on telephone channels of carrier systems. There is little practical experience with higher-speed telegraph systems.

It may happen that under adverse conditions some telephone channels of the link are of insufficient quality to provide twenty-four telegraph channels. In such a case a better combination of telephone channels must be chosen for the telegraph service.

Annex 44 (*Blue Book*, Volume III, page 530) gives the result of a calculation made by the French Administration regarding the effect of group-delay/frequency distortion on amplitude-modulated telegraph signals.

8. *Frequency error*

The frequency error introduced by the link must not be greater than $\pm$ 2 Hz.

9. *Interference caused by power supply sources*

When a sinusoidal test signal is transmitted over the link at a level of 0 dBm0 (0 dNm0) the level of the strongest unwanted side component should not exceed —45 dBm0 (—52 dNm0).

Note by the United Kingdom Administration

Interference arising from the presence of harmonics of the mains supply frequency [1]

It has been found in practice that unwanted sidebands generated by mains frequency components on a voice-frequency telegraph link can adversely affect the performance of a frequency-modulated voice-frequency telegraph system. We have found it necessary to check the level of the unwanted sidebands by connecting a test signal at nominal level at one end of the link and measuring the levels of the unwanted sidebands at the far end with a selective frequency level-measuring set (wave analyser). The limit to be proposed for the level of the spurious sidebands is being studied. Provisionally a limit of −40 dBm0 or −46 dNm0 for the the strongest unwanted sideband component is being used in the United Kingdom.

10. *Variation of overall loss with time*

10.1 *Level stability with time*

Before a voice-frequency telegraph link is placed into service it is desirable that a test signal in each direction of transmission should be monitored at the distant end with a level-recording instrument for a minimum of 24 hours. Where possible the instrument should be capable of detecting level variations of duration as short as 5 ms.

[1] A question in this connection is still under study by the C.C.I.T.T. (37/XV).

10.1.1 The mean value of the departure from nominal of the overall loss with time should not exceed 1 dB (1.2 dNp).

10.1.2 The standard deviation of the variation of overall loss should not exceed 1.7 dB (2 dNp).

It is reasonable to assume a normal distribution of variations and therefore, with the above values, the probability of the received level falling outside the working range of the telegraph terminal equipment is very slight (see Recommendation R.31, *White Book*, Volume VII).

11. *Sudden variations of overall loss and short interruptions*

Such defects of the transmission path spoil the quality of the telegraph transmission and should be reduced to the minimum possible.

12. *Record of results*

All measurements made during the lining-up of the link are reference measurements and should be carefully recorded and a copy sent by the sub-control stations to the control station in accordance with Recommendation M.57.

13. *Information concerning voice-frequency telegraph terminal equipment*

Information concerning international voice-frequency telegraphy is given in the Annex to this Recommendation.

14. *Marking of circuits used for voice-frequency telegraphy*

Any interruption of a voice-frequency telegraph link, even of very short duration, spoils the quality of the telegraph transmission. It is therefore desirable to take great care when making measurements on circuits used for voice-frequency telegraphy. To draw the attention of staff to this, all equipments used for voice telegraphy links should bear a special identification mark in the terminal exchanges and, where necessary, in repeater stations where the circuits are accessible.

ANNEX

(to Recommendation M.81)

Basic characteristics of telegraph equipments used in international voice-frequency telegraph systems

A. *Limiting power per channel*

Amplitude-modulated voice-frequency telegraph systems at 50 bauds

Administrations will be able to provide the telegraph services with carrier telephone channels permitting the use of 24 voice-frequency telegraph channels (each capable of 50 bauds) on condition that the power of the telegraph channel signal on each channel, when a continuous marking signal is transmitted, does not exceed 9 microwatts at zero relative level points.

For 18 telegraph channels only, the power so defined may be increased to 15 microwatts per telegraph channel, so that even telephone channels with a relatively high noise level can then be used.

The power per telegraph channel should never exceed 35 microwatts, however few channels there may be.

These limits are summarized in Table 1.

TABLE 1

Limiting power per telegraph channel when sending a continuous marking signal in amplitude-modulated voice-frequency telegraph systems at 50 bauds

System	Limiting power per telegraph channel when sending a continuous marking signal		
	μW0	dBm0	dNm0
12 telegraph channels or less	35	−14.5	−16.7
18 telegraph channels	15	−18.3	−21
24 (or 22) telegraph channels	9	−20.5	−23.5

Frequency-shift voice-frequency telegraph system at 50 bauds

The mean power transmitted to line by all the channels of a frequency-shift voice-frequency 50-baud telegraph system is limited to 135 microwatts (at a zero relative level point), which gives the limits shown in Table 2 for the mean permissible power per telegraph channel at a zero relative level point.

TABLE 2

Normal limiting power per telegraph channel in frequency-shift, voice-frequency, 50-baud telegraph systems

System	Permissible mean power per telegraph channel		
	μW0	dBm0	dNm0
12 telegraph channels or less	11.25	−19.5	−22.5
18 telegraph channels	7.5	−21.3	−24.5
24 (or 22) telegraph channels	5.6	−22.5	−26

B. *Telegraph channel carrier frequencies*

For international voice-frequency 24-channel, 50-baud, non-synchronous telegraph systems the frequency series consisting of odd multiples of 60 Hz has been adopted, the lowest frequency being 420 Hz as shown in Table 3 below. In the case of frequency-shift systems, these frequencies are the mean frequencies of the telegraph channels, the frequency of the signal sent to line being 30 Hz (or 35 Hz) above or below the mean frequency according to whether A or Z space is being sent.

TABLE 3

Telegraph channel position n	Frequency (Hz) fn	Telegraph channel position n	Frequency (Hz) fn
1	420	13	1860
2	540	14	1980
3	660	15	2100
4	780	16	2220
5	900	17	2340
6	1020	18	2460
7	1140	19	2580
8	1260	20	2700
9	1380	21	2880
10	1500	22	2940
11	1620	23	3060
12	1740	24	3180

The carrier frequency fn of the channel is given by the expression:

$$fn = 60\ (2n+5),$$

where n is the number of the channel.

In addition, a pilot channel using a frequency of 300 Hz or 3300 Hz can be used. For details of the normal frequencies used in other types of voice-telegraph systems, see the "Table of numbering of frequencies and multiplication" in Recommendation R.38, B, of Volume VII of the *White Book.*

RECOMMENDATION M.82

PERIODICITY OF ROUTINE TESTS

1. *International voice-frequency telegraph links* (category A)

1.1 The recommendations concerning the periodicity of routine tests on international telephone circuits given in Recommendation M.61 are applicable to international voice-frequency telegraph links and the dates of these measurements are given in the " Routine maintenance programme ", issued by C.C.I.T.T. Study Group IV.

In certain cases and by agreement between the administrations concerned, routine maintenance measurements may be omitted if those administrations so wish.

Such cases are to be indicated in the routine maintenance programme.

Routine measurements of level at one frequency (800 Hz) should be made at the intervals recommended for international telephone circuits (Recommendation M.61, Table A).

Measurements at different frequencies should be made once every six months.

1.2 It is desirable that the maintenance measurements on the voice-frequency telegraph reserve circuit should be made just before the maintenance measurements on the normal circuit, so that the reserve circuit can replace the normal circuit while the latter is being tested.

For reserve circuits for sections of an international voice-frequency telegraph link, the periodicity of routine tests will be agreed between the administrations concerned.

1.3 When several voice-frequency telegraph systems are in use between two repeater stations and if the maintenance measurements on the telephone circuits between these stations are spread over several days, the measurements on the circuits carrying the voice-frequency telegraph systems should also be spread over these days; this makes it easier to carry out the measurements on the voice-frequency telegraph circuits.

2. *International voice-frequency telegraph links* (category B)

2.1 At the present time no periodicity for routine tests is specified for category B international voice-frequency telegraph links[1]. If administrations agree between themselves to do such tests the periodicity should also be so agreed.

2.2 The periodicity of measurements on telephone circuits used as reserve circuits is fixed at weekly intervals.

For circuits providing reserve sections for a category B voice-frequency telegraph link the periodicity of routine measurements will be agreed upon between the administrations concerned.

2.3 A check should be made when suitable opportunities occur, to see that the limits shown in Tables 1 and 2 of the Annex to Recommendation M.81 for the permissible power per telegraph channel are not exceeded.

[1] Some administrations make an annual re-line of the voice-frequency telegraph link instead of routine measurements. (Routine measurements are not normally made on category B circuits—see Recommendation M.83.)

RECOMMENDATION M.83

ROUTINE MEASUREMENTS TO BE MADE ON INTERNATIONAL VOICE-FREQUENCY TELEGRAPH LINKS

1. The routine maintenance measurements to be made in the two directions of transmission are measurements of level and loss/frequency distortion (using a measurement signal of 0 dBm0 or 0 Nm0) and noise.

The measuring frequencies are as follows:

circuits providing an 18-channel telegraph system: 300, 400, 600, 800, 1400, 2000, 2400, 2600 Hz;

circuits providing a 24-channel telegraph system: 300, 400, 600, 800, 1400, 2000, 2400, 3000, 3200, 3400 Hz.

2. If the level and overall loss/frequency distortion exceed the limits given in Recommendation M.81, any faults existing should first be removed, and the link should then be readjusted to within the limits given in Recommendation M.81.

3. Weighted and unweighted noise measurements should be made on the voice-frequency telegraph link at the time of the routine measurements of level as given in Recommendation M.81.

4. Routine measurements are not normally made on category B links (see paragraph 2 of Recommendation M.82).

4.2 — Setting-up and lining-up international facsimile links

RECOMMENDATION M.88

INTERNATIONAL FACSIMILE TRANSMISSION

(This Recommendation applies to category A circuits. The provisions for category B circuits are under study.)

1. *Types of circuits*

a) Permanent circuits used between phototelegraph stations should be set up and lined up as four-wire circuits between these stations.

b) Circuits used normally (and preferentially) will be nominated international telephone circuits, the international line of which is normally extended to the phototelegraph station on a four-wire basis, it being ensured that the terminal equipment (line relay sets, terminating sets, echo suppressors, etc.) is disconnected.

2. *Line-up*

a) The same conditions apply to the overall transmission loss of four-wire circuits used for phototelegraphy as apply in general for telephony.

b) If an international telephone circuit is used to provide a phototelegraph circuit and if the international line is extended to the phototelegraph station the levels of the circuit so established should be such as to maintain the levels found on the level diagram of the telephone circuit.

3. *Relative levels*

If phototelegraph transmissions take place simultaneously from a transmitting station to several receiving stations, arrangements shall be made at the junction point so that, on the circuits following the junction point, the same power levels are maintained as those prescribed for individual transmissions.

4. *Loss/frequency distortion*

a) When amplitude modulation is used, the loss/frequency distortion between phototelegraph stations should not exceed the values given in Recommendation M.58. Since the band of frequencies to be transmitted for the phototelegraph transmission is less than the full bandwidth of the telephone circuit, and since the distortion admitted for the telephone circuit itself should not exceed 6.6 dB (7.5 dNp), it will not in general be necessary to compensate for the distortion of the lines joining the phototelegraph stations to the repeater stations.

b) For a phototelegraph transmission using frequency modulation, it is sufficient to use telephone circuits conforming to C.C.I.T.T. recommendations regarding loss/frequency distortion given in Recommendation M.58. Frequency modulation is always used for facsimile in the general switched telephone network.

5. *Variation of overall loss with time*

The overall loss should remain as constant as possible during picture transmissions. In the case of amplitude modulation, abrupt variations of even 1 dB or 1 dNp may have an effect. It is moreover necessary to avoid any interruption of the circuit, however brief. For this reason, the greatest attention should be paid to the measurements made on amplifiers and lines and to the changing of batteries. To reduce the likelihood of disturbance, it is desirable that the long-distance terminal exchange equipment should be excluded from the circuit when it is extended to the facsimile stations.

Special precautions should be taken to make sure that no modulation of the carrier is caused by the line or the amplifiers, even if the modulation is inaudible. Such modulation may be due, in particular, to variations in the voltage of the supply batteries, or to sub-audio telegraphy equipment.

In the case of frequency modulation, sudden changes of even 10 dB (11.5 dNp) can be tolerated and telephone circuits, even when set up without special precautions, have sufficient stability.

Nevertheless, sudden variations of level are equally to be avoided in the case of circuits carrying frequency-modulated phototelegraphy.

6. *Phase/frequency distortion*

Phase/frequency distortion limits the range of satisfactory phototelegraph transmission. The differences in group-delay time of the telephone circuit, over the phototelegraph transmission range, should not exceed:

$$\Delta t \leq \frac{1}{2f_p}$$

where f_p is the maximum modulating frequency for the definition and scanning speed concerned.

(See Recommendation T.12 of Volume VII of the *White Book.*)

7. *Sent signal power*

The conditions applying to the transmitted power in phototelegraph transmission are as follows:

The sent voltage of the phototelegraph signal at maximum amplitude should be so adjusted that the absolute power of the signal, at a zero relative level point found from the level diagram of the telephone circuit, is for a double sideband amplitude-modulated phototelegraph transmission 0 dB referred to 1 mW (0 neper) and for a frequency-modulated transmission −10 dB referred to 1 mW or −11.5 dNp. With amplitude modulation, the black level is usually 30 dB or 34.5 dNp below the white level.

Notwithstanding the observations in paragraph 5 above concerning frequency modulation, in order to avoid the risk that facsimile signals be disturbed, for example by dial pulses transmitted over adjacent channels or by noise, it is important that the sending level should be as high as permissible; however, it shall not exceed −10 dBm0 on the multichannel system and the power at the output of the sending apparatus shall not exceed 1 mW.

This value of −10 dBm0 is in accordance with Recommendation V.2, since in all cases the facsimile transmissions are operated in simplex. This value may have to be revised if the percentage of circuits used for applications other than telephony should go beyond the assumptions indicated in Recommendation V.2 of Volume VIII of the *White Book.*

8. *Marking of equipment*

When a telephone circuit is specially allocated for phototelegraph transmission (circuit identified by the letter F), the associated equipment should be specially marked to attract the attention of staff. All interruptions in a phototelegraph transmission, no matter how short, and all sudden variations of more than 0.2 dB or 0.2 dNp must be avoided.

9. *Routine tests*

The recommendations for four-wire telephone circuits concerning the periodicity of measurements are also applicable to phototelegraph circuits.

Routine measurements of level at one frequency (800 Hz) should be made at the intervals recommended for international telephone circuits (see Table A, Recommendation M.61 and in the Routine maintenance programme).

Measurements at different frequencies should be made once every six months.

10. *Information concerning frequencies transmitted by phototelegraph equipment*

a) *Amplitude modulation*

For audio circuits the recommended carrier frequency is about 1300 Hz.

For circuits routed on carrier systems and effectively transmitting the band of frequencies 300-3400 Hz the recommended carrier frequency is about 1900 Hz.

b) *Frequency modulation*

Mean frequency	1900 Hz
White frequency	1500 Hz
Black frequency	2300 Hz
Phasing signal frequency	1500 Hz

11. Information about the characteristics to be taken into account when choosing the circuit used for telegraph transmissions is given in Recommendation T.12 of Volume VII of the *White Book*.

SECTION 5

INTERNATIONAL PRIVATE CIRCUITS

5.1 — Characteristics of international private circuits

Preface

International private circuits will in most cases be provided over the same sort of transmission lines, cables, systems, etc., as figure in an international telephone connection established over the public switched telephone network. Hence the overall characteristics of international private circuits from renter to renter can be expected to be similar to those of international telephone connections from subscriber to subscriber (except in so far as there are no intermediate telephone exchanges). The C.C.I.T.T. has not been able to recommend in detail the transmission performance of international telephone connections because such performance is very largely determined by the characteristics, nature and extent of national transmission lines, etc. It follows that in principle this must necessarily be the case for international private circuits and the recommendations in this section have been worded in terms that recognize that administrations and private operating agencies arrange matters in their networks according to their own practices. Accordingly, in some respects some of the recommendations in this section lack the precision to be found in other sections of Volume IV.

The guiding principle in lining-up an international private circuit and which is the same that has been adopted for public switched telephony uses the notion in the Series G Recommendation of the *White Book*, Volume III, specifying an interface between the national and the international portions of the circuit. Limits are given concerning the signals passing the interface and also for the transmission performance of the international portion between interfaces. However, the detailed transmission characteristics of the national portion up to and from the interface are not defined.

In the case of private circuits, every administration or private operating agency has established rules to which a renter's installation must comply before it may be connected to the circuit (for example, the maximum value of the absolute power level of the sent signal is defined). Furthermore, the administration normally gives some indication of the minimum level it will deliver to the renter in the receive direction of transmission.

The following Recommendations have been drawn up in a way that ensures that in principle the nominal characteristics of an international private circuit, from the point of view of the renter, are similar to those of any analogous national private circuit he may operate. In particular, the international private circuit accepts and delivers nominally the same signal level as that accepted and delivered by an analogous national private circuit. Hence in principle the renter can use the same type of apparatus for both sorts of private circuits and the need for special arrangements is minimized.

A necessary consequence of adopting this principle is that the nominal transmission loss between renters' premises cannot now be specified by the C.C.I.T.T. (It can, however, in principle, be specified by the pair of terminal administrations concerned.)

Note. — Supplement No. 4.3 of this Volume gives information about the characteristics likely to be exhibited by an international point-to-point private circuit having the least favourable values for all the permissible limits. The special requirements for particular uses are given in the following Recommendations.

RECOMMENDATION M.101

CONSTITUTION AND NOMENCLATURE OF INTERNATIONAL PRIVATE CIRCUITS

1. *Some features of the constitution of international private circuits are:*

a) the number of locations connected may be two or more;

b) the circuit may be available either two-wire or four-wire at a renter's installation;

c) the transmission paths may be provided with a combination of unloaded (or loaded) subscribers line plant (in the local network), unloaded or loaded cable pairs (in the junction network) channels in frequency division multiplex carrier systems (in the national long-distance network and in the international network). There may also be pulse code modulation systems in some national networks.

Figure 1/M.101 illustrates two types of circuits: those which connect two points and those connecting more than two points. These are referred to as point-to-point circuits and multi-terminal circuits respectively.

2. *Access-points*

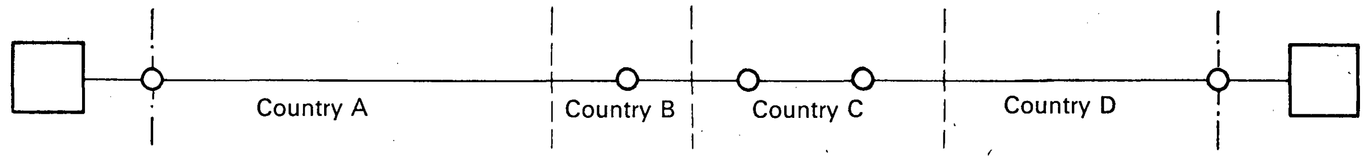
a) It is recommended that administrations establish access-points on the various circuit-sections analogous to the access-points recommended for international telephony circuits in the public service at which the nominal relative levels are fixed and determined by the administration. At the international centre it would be advantageous if the same relative level as that adopted for public circuits is used for private circuits. Within the national networks there are very often access-points of defined relative level and impedance provided in accordance with national practices and these points, together with the international access-points, serve to divide the circuit into circuit sections.

b) In principle, an access-point is also available at the renter's premises but it is not always convenient to test from there. Accordingly, many of the procedures recommended in this chapter involve only the access-points in the installations of administrations and private operating agencies. In particular the access-points in repeater stations or telephone exchanges which are both:

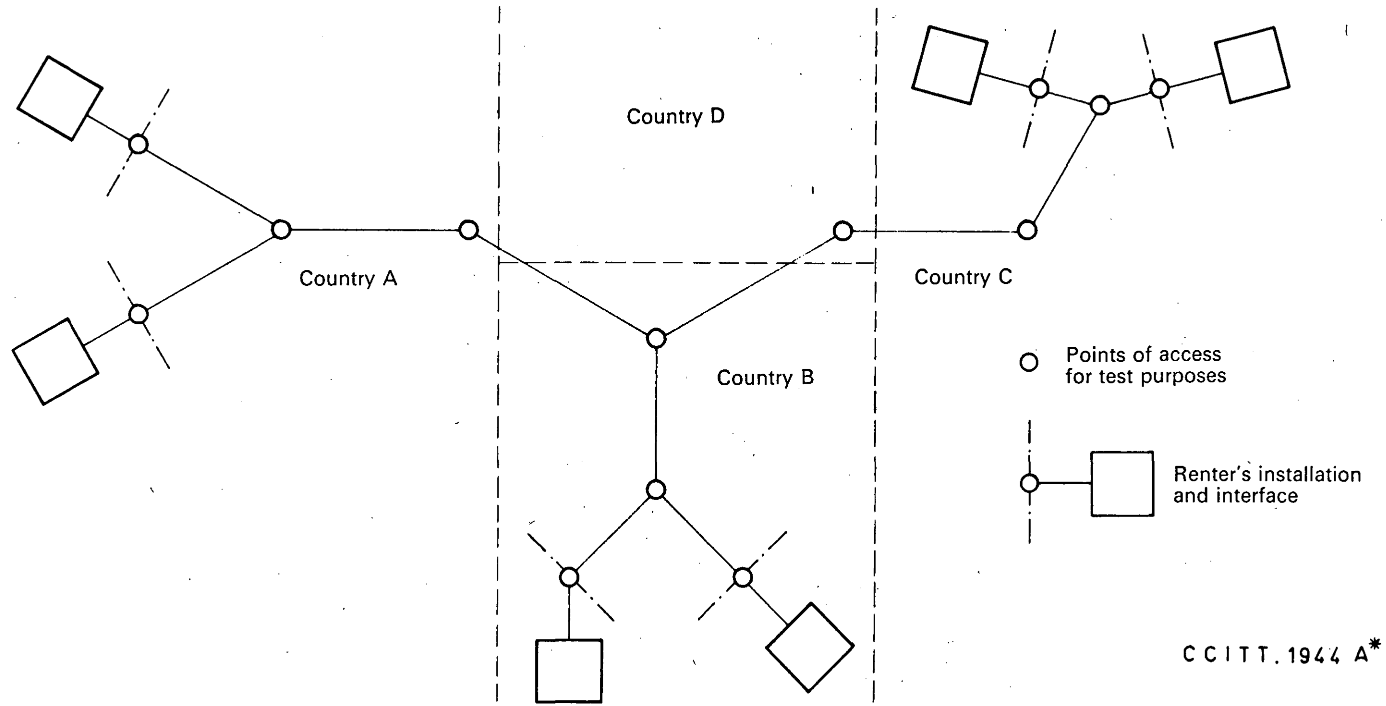
— the nearest to the renter's installation,

— staffed and equipped to make transmission measurements

are points between which it might be expected that measurements could be made, though not always because the staff at such stations concerned do not always have experience of international maintenance procedures. Measurements made by administrations between



a) Point-to-point circuit



b) Multi-terminal private circuit

FIGURE 1/M.101

renters' installations could encounter particular problems and may have to be the subject of special agreement.

3. *Definitions and nomenclature*

These definitions are illustrated in Figure 2/M.101.

international private circuit

The whole of the assembly of lines and apparatus from renter's installation to renter's installation, between the interfaces as defined by the respective administrations.

international link

The whole of the assembly of international and national circuit-sections between terminal national centres.

international line

The whole of the assembly of international and national circuit-sections between terminal international centres.

national line

The whole of the assembly of national circuit-sections connecting the renter's installation to the terminal international centre. When a distinction is needed to indicate the transmission direction in one country the expressions " national sending line ", that is, sending from the renter, and " national receiving line ", that is, receiving from the renter, may be used.

terminal international centre

The international centre serving the renter in the country in which the renter's installation is situated. There will be two terminal international centres in a point-to-point international circuit. There may be more in a multi-terminal circuit.

terminal national centre

The national installation (e.g. repeater station, telephone exchange) which is:

— nearest to the renter's installation,

— equipped and staffed to make transmission measurements,

— provided with a circuit test-point.

terminal national section

The lines and apparatus connecting the renter's installation with the terminal national centre concerned. There may be intermediate installations (e.g. telephone exchanges) in the terminal national section but they are assumed to have no testing facilities normally available.

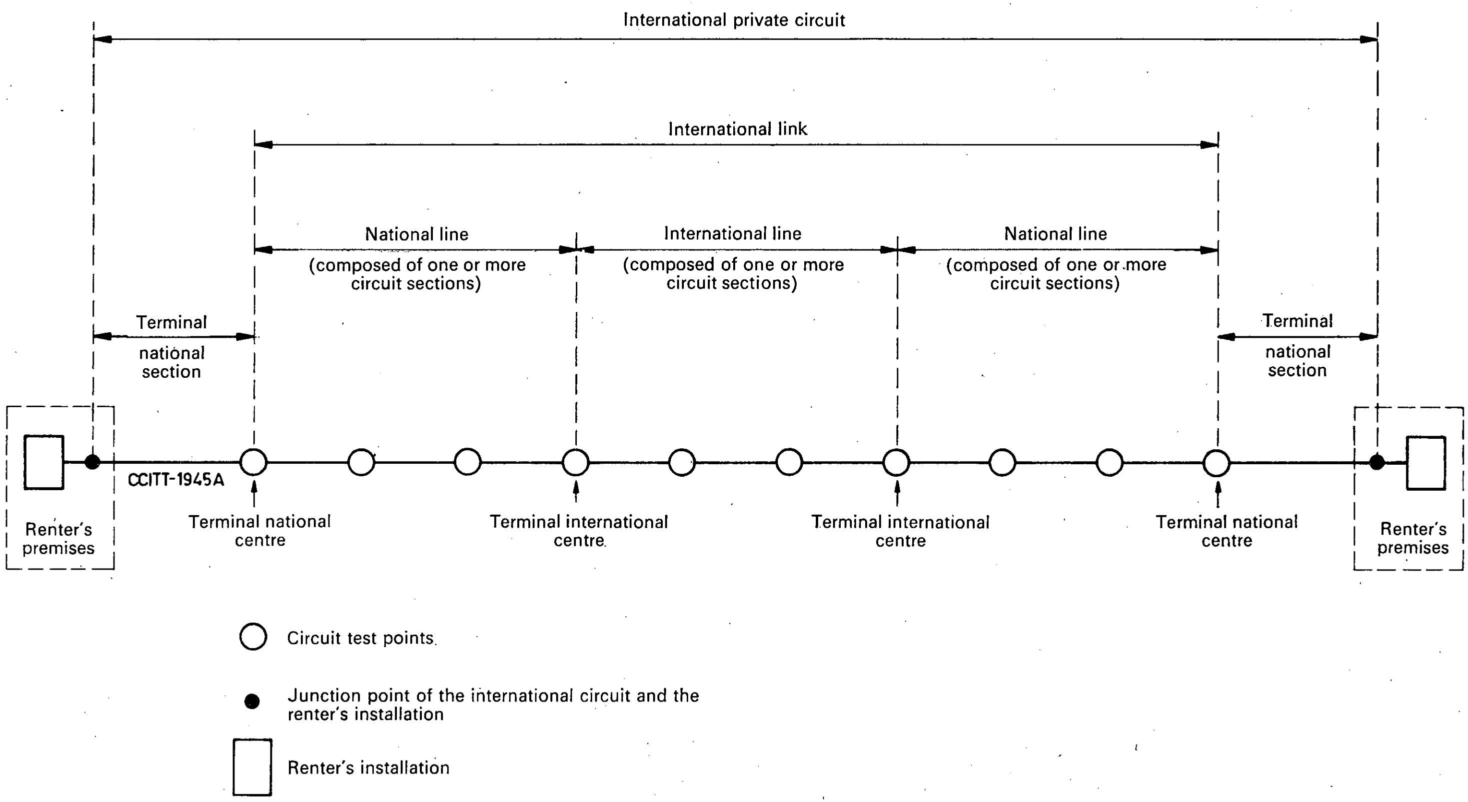


FIGURE 2/M.101

RECOMMENDATION M.102

CHARACTERISTICS OF SPECIAL QUALITY PRIVATE CIRCUITS[1] (FOR EXAMPLE, FOR DATA TRANSMISSION)

1. *Scope*

This Recommendation deals with private circuits for uses other than telephony—for example, data transmission.

2. *Constitution*

The constitution of this type of private circuit can be either:

a) point-to-point or multi-terminal,

b) two-wire or four-wire at each of the renters' premises according to the description given in Recommendation M.101.

3. *Characteristics*

3.1 *Nominal operating levels*

(See Recommendation M.111.)

Only exceptionally can a predetermined specified nominal overall loss at the reference frequency between renters' installations be offered to renters and then only after prior consultation among the administrations and private operating agencies concerned.

3.2 *Attenuation-distortion*

The limits for the overall loss[2] relative to that at 800 Hz for the circuit between renters' installations are given in Table A below.

TABLE A (M.102)

Frequency range	Overall loss relative to that at 800 Hz	
Below 300 Hz	Unspecified	
300-500 Hz	+6 to −2 dB	+7 to −2.3 dNp
500-2800 Hz	+3 to −1 dB	+3.5 to −1.2 dNp
2800-3000 Hz	+6 to −2 dB	+7 to −2.3 dNp
Above 3000 Hz	Unspecified	

[1] See Supplement No. 4.3 for the characteristics of telephone-type private circuits.

[2] The fact that national measuring instruments normally used may not be of the same nominal impedance is of negligible consequence. Impedances known to exist at present are 600, 800 and 900 ohms and using any pair of these introduces negligible error.

Attenuation distortion equalizers (perhaps with routing restrictions) may be needed to meet these limits.

3.3 *Group-delay distortion*

Only some of the types of non-speech transmission require limits to be placed on group-delay distortion. It should therefore always be verified whether limits concerning group-delay distortion are necessary. When it is necessary to equalize the group-delay distortion, the limits that should apply are those given in the following Table B, in which the limiting values over the frequency band are expressed as values relative to the minimum measured group delay.

TABLE B (M.102)

Frequency range	Group delay relative to the minimum group delay
Below 500 Hz	Unspecified
500-600 Hz	Not exceeding 3 ms
600-1000 Hz	Not exceeding 1.5 ms
1000-2600 Hz	Not exceeding 0.5 ms
2600-2800 Hz	Not exceeding 3 ms
Above 2800 Hz	Unspecified

3.4 *Variation with time of the overall loss at 800 Hz*

The variation with time of the overall loss at 800 Hz should be as small as possible but should not exceed the following limits:

3.5 *Circuit noise*

a) *Uniformly distributed random noise*

The nominal level of the psophometric noise power at a renter's premises depends upon the actual constitution of the circuit, in particular upon the length of frequency division multiplex carrier systems in the circuit. A typical mean noise power rate is 4 pW/km which for 2500 km can be expected to give rise to a psophometric noise power level of —50 dBm0p (—57 dNm0p). From such information an estimate of the signal/noise ratio can be made. (The absolute noise-power level measured at a renter's premises will depend also on the transmission loss of the lines and apparatus connecting the renter to the carrier circuit-section.)

b) *Quantizing noise (quantizing distortion)*

If any circuit-section is routed over a pulse code modulation system the signal will be accompanied by quantizing noise giving rise to signal/quantizing noise ratios of, for example, 30 dB (35 dNp).

c) *Impulsive noise*

Impulsive noise should be measured with an instrument complying with Recommendation V.55 of Volume VIII of the *White Book.*

The impulsive noise requirements for non-speech transmission and the method of measurement are under study.

3.6 *Frequency error*

See Supplement No. 2.10 for a way of measuring this error.

4. *Lining-up*

The method of lining-up and equalizing the circuit is given in Recommendations M.111, M.112 and M.113. It may be of interest to make reference measurements at intermediate points by high-impedance bridging methods. However, it must be borne in mind that high-impedance bridging measurements made on a working circuit are likely to disturb transmission on that circuit. Before making such measurements, authority must be obtained from the terminal station, and in the case of a private circuit, such measurements must only be made by arrangement with the renter.

5. *Routine maintenance measurements*

In principle, the recommendations concerning routine tests for international telephone circuits and voice-frequency telegraph links apply, as far as they can, to international private circuits used for non-speech transmission.

It will be necessary for administrations to agree with the renters concerned upon the times at which the circuit may be released for test purposes. The dates agreed will be shown in the periodical maintenance programme for circuits designated in accordance with Recommendation M.14.

Type of test	*Periodicity*
Overall loss at 800 Hz	as given in M.61
Overall loss frequency distortion	annually
Noise power level	as 800 Hz test

In addition, if the circuit has been fitted with group-delay distortion equalizers and if suitable measuring instruments are available

Group-delay distortion	annually

All the measurements above would normally be made only between the installations of administrations (or private operating agencies) closest to the renters' installations, that is, between terminal national centres, and normally equipped with the necessary test equipment.

If measurements are required to be made at renters' installations then special arrangements must be made among the parties concerned.

6. *Fault reporting procedures*

As far as possible the provisions of Recommendation M.12 apply. Any additional special procedures must be devised by the parties concerned.

7. *Marking of equipment associated with special quality circuits*

In order to reduce to a minimum interruptions on the circuits it is necessary that all equipment associated with such circuits (e.g. amplifiers, channel-translating equipment, distribution frames, etc.) be positively marked so as to make them readily identifiable to the maintenance staff and so that they do not inadvertently cause interruptions to the circuit when carrying out maintenance work in repeater stations and exchanges.

RECOMMENDATION M.103

TYPES OF TRANSMISSION ON PRIVATE CIRCUITS

1. A point-to-point or multi-terminal circuit can be provided in some instances for one type of service only, such as:

— telephony (that is, speech transmission),

— voice-frequency telegraphy,

— data transmission,

— facsimile.

(The list is not complete but it includes the most common types of service.)

2. In other instances private circuits are used for different transmission purposes at different times, in which case the circuit characteristics should in principle be determined by the requirements of the more exacting form of transmission (when there is a difference in requirements).

Note. — The North American expression for this type of operation is " alternate-use ".

3. In some instances the bandwidth provided by the circuit is divided into two or more bands thus providing two or more circuits which may be used for different types of transmission.

If the band is divided among two or more classes of transmission by means of equipment under the control of the administration then band-dividing filters should wherever possible be used in preference to hybrid transformers because it affords the possibility in some circumstances of being able to do maintenance operations on one circuit (obtained by frequency division) without affecting another.

In those cases in which the frequency division is effected by the renter's apparatus in the renter's premises the administrations should make it clear that even though the renter's apparatus must be approved by the administration, this latter is not responsible for faults or misoperation of equipment attributable to the arrangement adopted by the renter.

Figures 1/M.103 to 3/M.103 illustrate some typical arrangements.

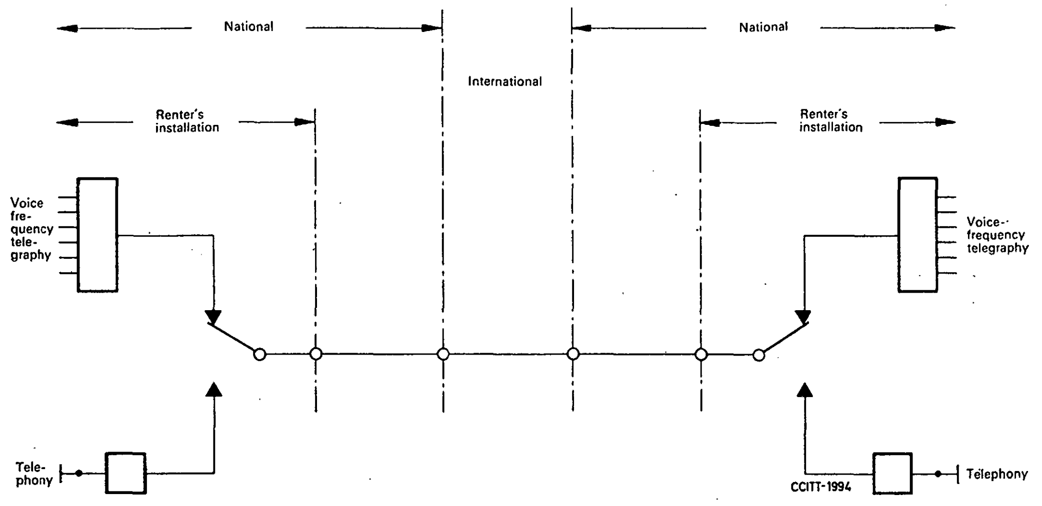


FIGURE 1/M.103. — **Point-to-point private circuit alternatively used for telegraphy or telephony**

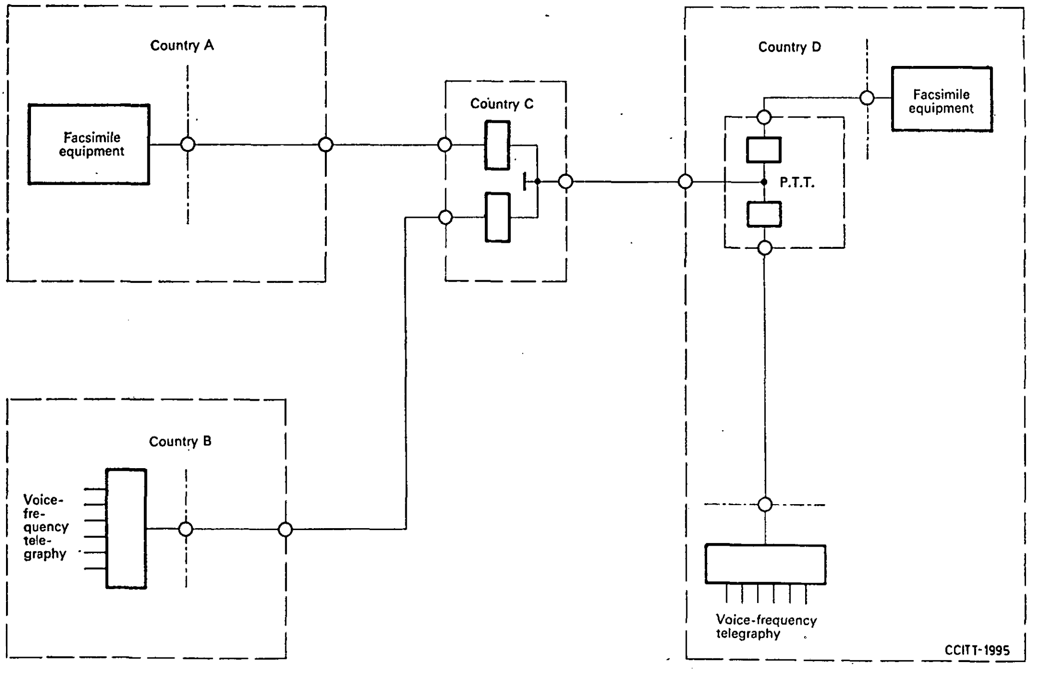


FIGURE 2/M.103. — **Simultaneous voice-frequency telegraphy and facsimile**

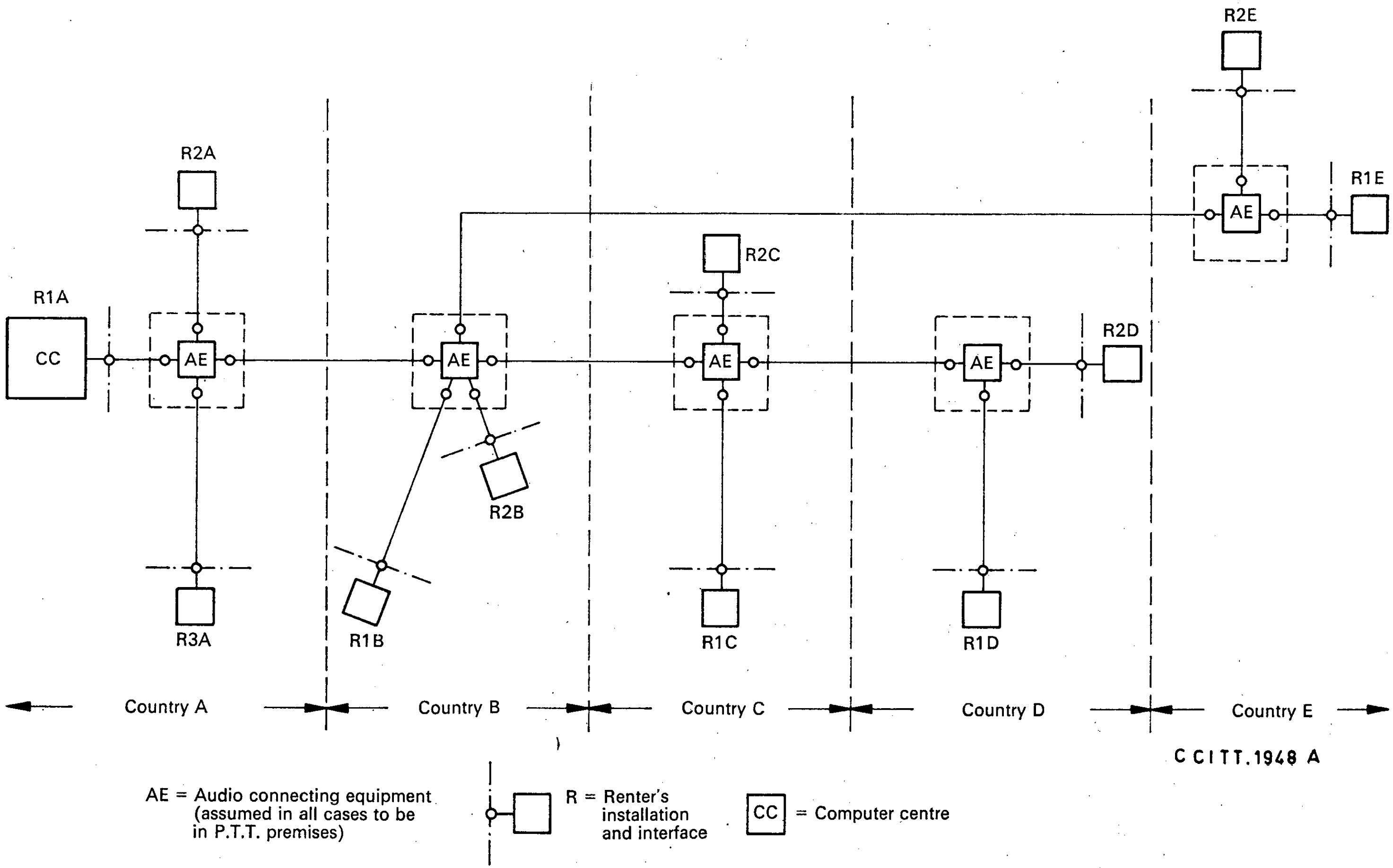


FIGURE 3/M.103. — **International private multi-terminal data circuit**

5.2 — Lining-up of international private circuits

RECOMMENDATION M.111

LINING-UP AN INTERNATIONAL POINT-TO-POINT PRIVATE CIRCUIT

1. *Telephony only*

1.1 After the circuit has been set up the following lining-up procedure should be followed in each direction of transmission:

a) *National sending line*

The national sections should be lined-up at the reference frequency according to national practices from the terminal national centre to the terminal international centre. A record should be kept of the levels received at the terminal international centre (and at any intermediate national test points). National sections beyond the terminal national centre must also be lined-up.

b) *International line*

The sections comprising the international line should be lined-up so that when, at the sending terminal international centre, a test signal at a level of 0 dBm0 is connected to the input of the international line, the level received at the other terminal international centre is as close as possible to 0 dBm0. The level at intermediate test points should also be as close as possible to 0 dBm0.

c) *National receiving line*

The national sections should be lined-up from the receiving terminal international centre to the terminal national centre according to national practices. This will in principle ensure that when correct levels are received from the international line appropriate levels according to national practices will be received at the renter's premises. A record should be kept of the levels obtained at the terminal national centre and at any intermediate test points. National sections beyond the terminal national centre must also be lined-up.

d) *International link*

If it is possible, after the terminal international centres have connected the circuit through, the international link should be measured. The staff at the terminal international centre may give linguistic and technical assistance. If this measurement can be made, a record should be kept by the circuit control station.

1.2 The complete circuit should now be connected together by adding on the terminal circuit sections and handed over to the renter for functional tests.

Note. — In the case of circuits two-wire at both ends some limitation may be necessary on the nominal overall transmission loss to avoid echo and stability problems. The overall loss can be estimated from the circuit routing information and from the line-up measurements made in a), b), c) and d) above. The mean value of estimated overall losses for the two directions of transmission should be calculated.

1.3 *Echo*—The curve given in Recommendation G.131, B, of Volume III of the *White Book* may be used to determine whether an echo suppressor is necessary.

1.4 *Stability*—The mean value of the nominal transmission losses should not be less than 3 dB (3.5 dNp) though such factors as complexity of routing, long two-wire extensions from the terminating set to the renter's installation, and unregulated groups may make a somewhat higher minimum nominal mean loss necessary.

The requirements of Recommendation G.122 should be met. Inasmuch as the same sort of plant is used for private circuits as is used to provide the " national system " of Recommendation G.101, this should ordinarily present no problem. References to virtual switching points (*extrémités virtuelles* in French) in the G Recommendations should be interpreted as " points in the two directions of transmission on the international line at equal relative level ".

In addition to the above requirements the provisions of Recommendation M.58 must be met, so far as they apply.

2. *Transmissions other than speech* (Ordinary circuit standards)

Similar procedures to those recommended for private telephony circuits should be followed. In addition it should be verified by direct measurement if possible (otherwise by calculation) that when the renters' apparatus is transmitting signals at the level permitted by national regulations the following limits are not exceeded at the input to international line:

Telephone signalling (see Recommendation Q.1)	
(for example, interrupted 500/20 signalling) . . .	−3 dBm0 (−3.5 dNm0)[1]
Data transmission (Recommendation V.2, Volume VIII, *White Book*)	
Continuous tone systems	−10 dBm0 (−12 dNm0)
(when idle)	−20 dBm0 (−23 dNm0) or lower
Non-continuous systems	−6 dBm0 (−7 dNm0)
(long-term mean)	−15 dBm0 (−17 dNm0)
Voice-frequency telegraphy	Recommendation M.81, paragraph 3
Phototelegraphy (see Recommendation T.10 in Volume VII of the *White Book*)	
Amplitude modulation (white level)	0 dBm0 (0 dNm0)
Frequency modulation	−10 dBm0 (−12 dNm0)

Note 1. — The above recommendations apply when the whole of the bandwidth is devoted to one particular transmission at any one time. When the band is divided among two or more types of transmission the power levels permitted by the various recommendations mentioned above should be reduced by the quantity 10 log (3100/x) dB or 5 ln (3100/x) dNp, where x is the nominal bandwidth in hertz occupied by the transmission concerned.

Note 2. — In addition to the above specification discrete frequency signals must comply with the requirements of Recommendation G.224, *White Book*, Volume III.

[1] There is a limit of 2 seconds for the duration of such signals. Even with this limit, Study Group IV considers this level to be too high.

RECOMMENDATION M.112

LINING-UP AN INTERNATIONAL MULTI-TERMINAL PRIVATE CIRCUIT

(Provisional text)

These circuits are usually arranged in one of the following ways:

Unidirectional

One station may transmit to every other and receive from every other, but the other stations have no communication among themselves. That is, the circuit is in effect a combination of a distribution network and a contribution network. This arrangement is used to interconnect, for example, a computer centre with outlying user stations.

Conference

Any station may have two-way transmission with any other. This usually implies that any station may in principle have two-way transmission with every other station simultaneously, and for telephony, some sort of selective signalling is employed. An example of this arrangement is the multi-terminal speaker facilities provided for stations on important submarine cable schemes.

A systematic procedure is needed to line up this class of circuit if needless readjustment of interdependent apparatus is to be avoided.

Multi-terminal unidirectional circuits

1. *Distribution network*

The explanation of the principle is given in terms of Figure 1/M.112 which illustrates part of the distribution network (i.e. the sending direction of transmission) emanating from station A. (There may be similar networks also emanating from station A, but these can be treated as this one, thus there is no loss of generality in assuming that station A is at one end of the network.)

The sections a to z are point-to-point circuits or circuit sections, each of which may be composed of national or international sections.

The order in which the distribution network is lined up and connected together is as follows:

a) Identify the path with the greatest number of sections: in the example, this is a-b-c-d-e-f-g-h;

(*Note.* — A-M may be longer geographically, but has only 5 sections, whereas A-R has 8 sections.)

b) Identify the next longest path remaining (i.e., imagine the path A-R to be removed with its branching points). This is taken to be j-k-1 (the distance 2-E is assumed to be greater than the distance 2-F though both of them have three sections);

c) Identify the remaining paths in order of length. In the example, these are all the single sections i, m, b, ... y, z.

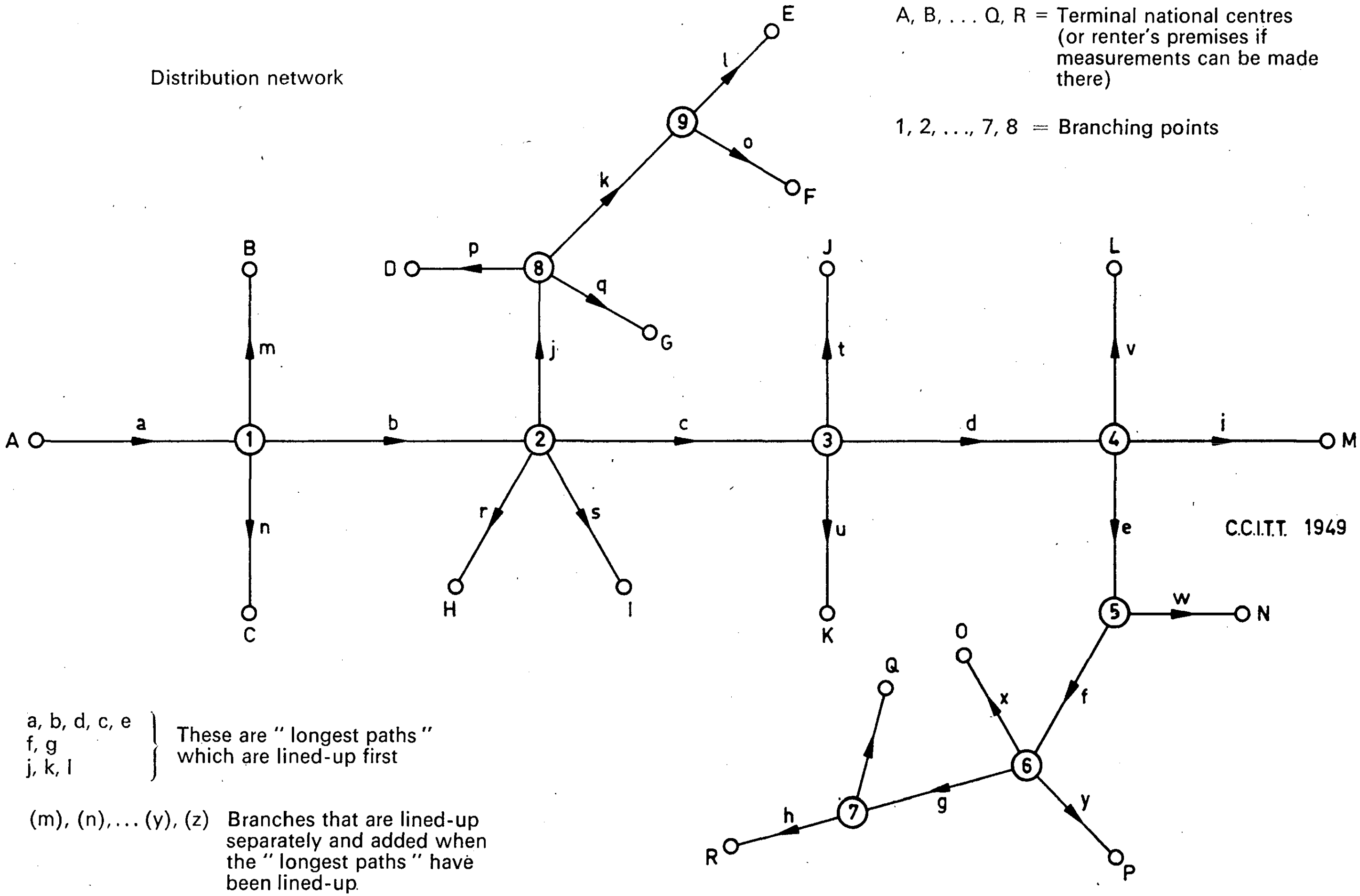


FIGURE 1/M.112. — **To illustrate the lining-up of a multi-terminal unidirectional circuit**

d) When the network is separated in this fashion, the paths

a-b-c-d-e-f-g-h,
j-k-l,
i,
m,
n,
.
.
.
y,
z

may all be lined up concurrently according to the principle of Recommendation M.111;

e) With a measurement-tone at a suitable level connected to A, add on the following branches (concurrently, if possible):

— at 1 the branches m and n;

— at 2 the branches j-k-l, r and s;

— at 3 the branches t and u;

— at 4 the branches v and i

making any necessary adjustments.

f) Stations 8 and 9 now add on branches p, q, and o, adjustments being made if necessary.

2. *Contribution network*

This is much more difficult to organize because the outstations may only send one at a time. The problem is eased if the network is divided into more manageable portions. A possible scheme related to Figure 1/M.112 (with all the arrows assumed to be reversed) would be as follows:

a) The longest paths h-g-f-e-d-c-b-a and o-k-j are lined up concurrently as before.

b) Keeping e disconnected at 4, stations N, O, P and Q send to 4 in turn, stations 5, 6 and 7 making any necessary adjustments to branches w, x, y and z.

c) Concurrently with b) above, stations D, G and E send to 2 in turn (j disconnected) with 8 and 9 making any necessary adjustments to sections p, q and 1.

d) Concurrently with b) and c) above, stations M, L, J and K send to station 3 (c disconnected) with stations 3 and 4 making any necessary adjustments to sections i, v, t and u.

e) Concurrently with b), c) and d), stations B, C, H and I send in turn to station A with stations 1 and 2 making any necessary adjustment to sections m, n, r and s.

3. It is recommended that the administration in the country of which the focal station is situated should be responsible for drawing up the schedule showing the order in which the various circuit sections should be lined up.

4. If the circuit requires to be equalized then a very precise order in which the sections are to be equalized and connected together will be necessary if needless readjustment is to be avoided.

5. In order to apply the principles of equalizing outlined in Recommendation M.113 it will be necessary to identify paths in the circuit connecting the focal station to each of the outstations and to treat each path as a point-to-point circuit bearing in mind section 4 above.

Multi-terminal conference circuits

1. These are usually provided by means of bi-directional branching units which are inserted into the two directions of transmission of a four-wire circuit and derive a send and receive pair.

2. It is recommended that the branching units are designed to enable a branch to be added without affecting the levels of the main circuit.

3. The line-up should be organized so as to avoid needless readjustment of circuit sections. This principle outlined for multi-terminal unidirectional circuits gives guidance in this matter.

4. Four-wire telephones should be used whenever possible to avoid instability problems.

There should be some limit to the number of locations joined together (for example: twelve).

RECOMMENDATION M.113

EQUALIZING AN INTERNATIONAL PRIVATE CIRCUIT

(Provisional text)

In Recommendation M.102 (Characteristics of special quality private circuits) there are given the limits to be met by the circuit (i.e. from renter-to-renter) in respect of attenuation-distortion and (if required) group-delay distortion.

This Recommendation outlines the principles provisionally to be followed to achieve these limits and recognizes that whereas loss/frequency distortion can be measured on international circuits, no test equipment is generally available to enable the group-delay distortion of international circuits to be measured (except by special arrangement). In most cases group-delay distortion, if it can be measured at all by field staff, can only be measured on national circuit sections.

This Recommendation has been devised to minimize the amount of international co-operative procedures and also to permit administrations to re-route their national sections without obliging the other administration to extensively re-equalize, if at all.

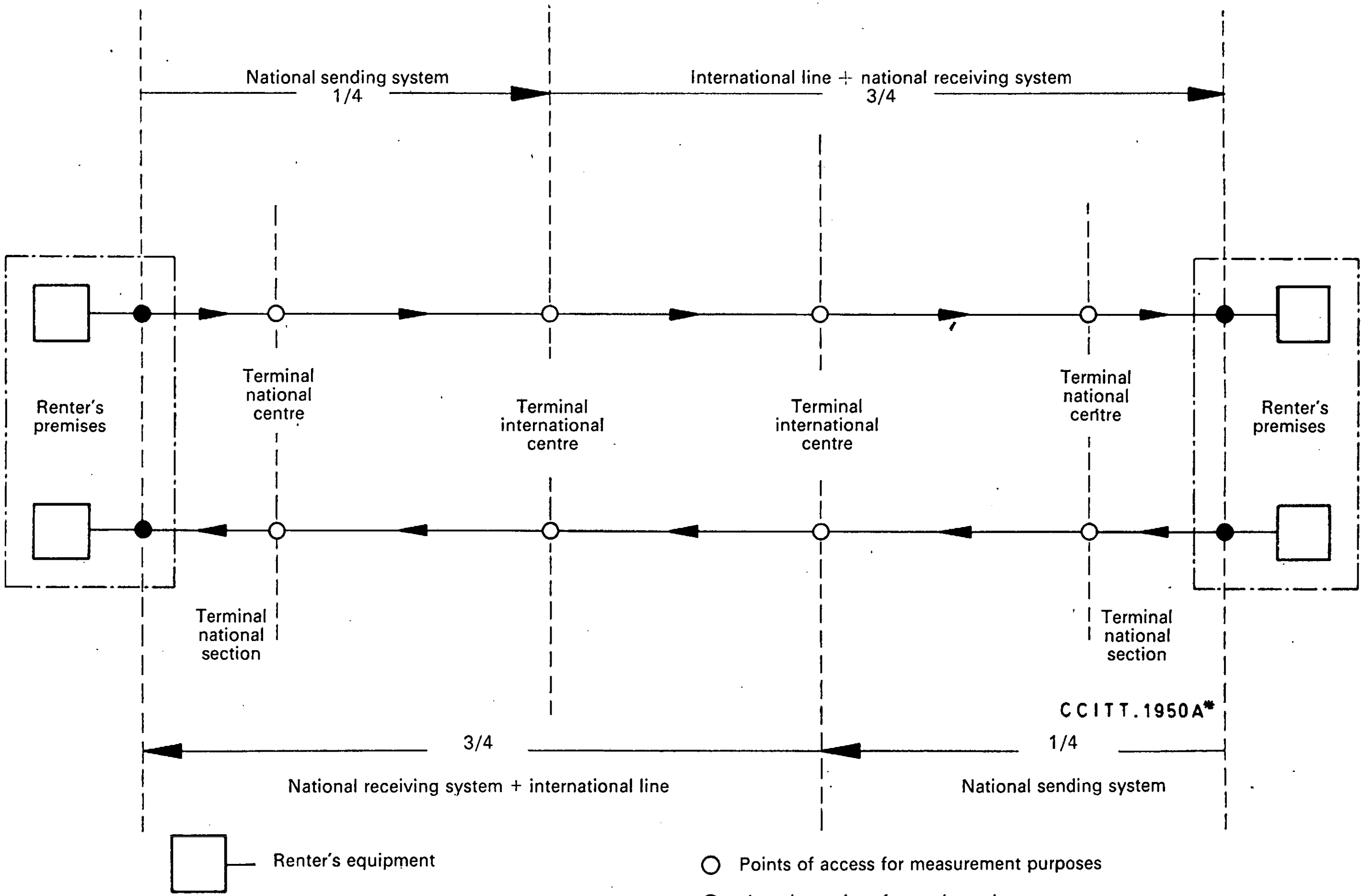


FIGURE 1/M.113. — **Apportionment of overall limits between national and international portions of a private circuit**

TABLE A (M.113)

Loss frequency distortion

Frequency range	Overall loss relative to that at 800 Hz			
	Send allowance		Receive allowance	
	dB	dNp	dB	dNp
Below 300 Hz	Unspecified			
300-500 Hz	+1.5 to −0.5	+1.8 to −0.6	+4.5 to −1.5	+5.2 to −1.7
500-2800 Hz	+0.8 to −0.3	+0.9 to −0.3	+2.2 to −0.7	+2.7 to −0.9
2800-3000 Hz	+1.5 to −0.5	+1.8 to −0.6	+4.5 to −1.5	+5.2 to −1.7
Above 3000 Hz	Unspecified			

TABLE B (M.113)

Group-delay distortion

Frequence range.	Group delay relative to the minimum group delay	
	Send allowance ms	Receive allowance ms
Below 500 Hz	Unspecified	
500-600 Hz	0.75	2.25
600-1000 Hz	0.38	1.12
1000-2600 Hz	0.13	0.37
2600-2800 Hz	0.75	2.25
Above 2800 Hz	Unspecified	

1. The distortion limits given in Recommendation M.102 are apportioned in the following manner (see Figure 1/M.113):

National sending system	One-quarter
International line plus national receiving system	Three-quarters

(The administrations may apportion the limits differently, by agreement among themselves.)

2. The precise location of any necessary equalizers is left to administrations to decide according to national practices. The receive allowance may be apportioned in any way desired.

3. The provisional division is according to the Tables A and B above. (The allowances are rounded up to the nearest tenth for loss/frequency distortion and the nearest hundredth for group-delay distortion so they are only approximately in the ratio 1 : 3.)

4. If required, an overall check of the loss/frequency distortion and of the overall group-delay distortion could be arranged by the administrations and renters concerned.

5. Some administrations have found prescriptive equalizers to be a promising answer to the problem of equalizing group-delay distortion when suitable test equipment is not generally available. One disadvantage is that occasionally on complicated circuits corrected distortions can add up adversely and " mop-up " equalization is necessary which can usually be done only by headquarters staff.

SECTION 6

INTERNATIONAL SYSTEMS ON COMMUNICATION SATELLITES

RECOMMENDATION M.121

LINING-UP AND MAINTAINING GROUPS, SUPERGROUPS, ETC., ROUTED ON COMMUNICATION-SATELLITE SYSTEMS

1. *Some features of a multiple destination unidirectional transmission link as might be provided by a communication-satellite system*

This section refers to Figure 1/M.121, which is drawn in terms of a supergroup. An analogous arrangement can occur for groups or, in principle, for higher-order assemblies. There is no loss of generality in describing the arrangement of a supergroup.

a) In the example the supergroup is assembled in London and portions of it appear in three other places. Hence the designatory letter M standing for MULTIPLE DESTINATION.

b) In the return directions of transmission for any or all of the groups in this supergroup, the transmission path may be quite different and will not necessarily bear any relationship to the direction illustrated. Hence the designatory letter U standing for UNIDIRECTIONAL.

c) The supergroup may be set up initially with only some of the destinations, for example, Ottawa may be connected some time, say a year or so, after Bogotá and Lusaka.

Furthermore, a destination may alter the amount of bandwidth it exploits, e.g. Bogotá may initially derive Groups 1 and 2, Group 5 being derived some time later.

d) The portions of the supergroup defined by the stations 1-2-3, 4-5-6, and 8-9 are supergroup sections which are to be treated in the way described in Recommendation M.46, paragraph 4 (*et seq.*). In particular, they may be combined into major or main sections, have control stations assigned and be lined-up according to the principles for Category B supergroups.

e) The routings connecting stations 3, 4, 7 and 8 to their corresponding earth stations A, B, C and D can be markedly dissimilar. For example, the routing to control station 4 from earth station B need not resemble in any way the analogous routing from earth station D to control station 8. Control station 4 may be at the earth station, that is, the " distance " between B and 4 is zero whereas the " distance " between D and 8 may be several hundreds of miles perhaps and may be routed over a variety of coaxial line or radio-relay systems.

f) The portion 1-2-3 is referred to as a common path. Operations on the common path can affect all destinations whereas operations on the other paths (4-5-6 and 8-9) can affect only one destination.

g) Station 3 is likely to have a community of interest with each of stations 4, 7 and 8. This is not necessarily so likely among 4, 7 and 8 themselves.

h) The stations 4, 7 and 8 each receive the whole of the basic supergroup band from station 3 though none of them exploits the whole of it.

The above-mentioned distinctive features of a multiple destination unidirectional group, supergroup, etc. (such as might be provided by a communication-satellite system) make special procedures for lining-up and maintenance a necessity. Recommendation M.46 is not sufficient. The sections which follow go some way to solving the problems.

2. *Allocating the various degrees of control to group, supergroup, etc., through-connection stations*

a) The multiple destination unidirectional section defined by the through-connection stations nearest to the earth stations is to be a main section (following the nomenclature of Recommendation M.46, paragraph 4.1.2). The full designation is:

" Multiple destination unidirectional main group, supergroup, etc., section "

In the example, stations 3, 4, 7 and 8 serve to define this main section.

b) The through-connection stations defining the extent of the MU main section will be assigned the control functions called for in Recommendation M.46.

It follows that if the group, supergroup, etc. appears in the earth station at the basic group, supergroup, etc. frequencies, the earth station must function as a main section control or sub-control station for the multiple destination unidirectional section.

A very clear distinction must be made between:

— satellite control stations that might be concerned with baseband-to-baseband response (for example),

— group, supergroup, etc. control stations concerned with the performance of the group, supergroup, etc. (These are places where the bands 60-108, 312-552 kHz, etc. are normally accessible.) Such control stations are not called " satellite " stations because group, supergroup, etc. control functions are independent of the means of transmission.

c) In addition:

— the sub-control station for the MU main group, supergroup, etc. section is designated the " send reference station " for the MU main group, supergroup, etc. section (in the example station 3 is so designated).

Again the distribution must be maintained between any co-ordination stations nominated for the satellite system (concerned with baseband, etc. matters) and MU main group, supergroup, etc. section reference stations. If stations 3, 4, 7 and 8 are physically in earth stations A, B, C and D respectively then those earth stations would also have to function as the MU main section reference stations in addition to other responsibilities associated with co-ordination functions of the satellite system.

d) The other through-connection stations are designated according to the principles of Recommendation M.46, paragraph 4 (Stations 1, 2, 5, 6 and 9 in the example.)

3. *Responsibilities of the MU main section send reference station*

In addition to the responsibilities laid upon the send reference station by Recommendations M.8, M.9 and M.46, paragraph 4, the following responsibilities also apply:

a) Co-ordinating the lining-up of the MU main section;

b) Co-operating with MU main section control stations during the lining-up of the section;

c) Keeping a record of the measurements made at MU section control stations during the lining-up of the section;

d) Co-ordinating maintenance action for the MU main section when called upon to do so by one of the MU main section control stations.

4. *Lining-up an MU main section for the first time*

a) The MU main section will first be lined-up between the send reference station and the initial MU main section control station using the procedure and limits given in Recommendation M.46. The whole of the band should be brought to within the appropriate limits even if the destination concerned is not exploiting the whole band. This is to ensure that the various pilots and other measuring signals that can be inserted (for example, intersupergroup measuring signals) are received at the correct levels, and can be measured at the receive station to provide valid reference measurement results for use in maintenance. There are other obvious advantages if this could be done. Unforeseen increases in exploitation or rearrangement of the allocated bandwidth (permanent or emergency) would be eased if the whole band were equalized. Such matters the administration concerned must decide.

b) The sections to the other MU main section control stations (associated with the paths to the other destinations) should now be lined-up in accordance with the procedures given in paragraph 4 a) above.

c) The appropriate reference pilot should now be connected by the MU terminal sub-control and after the sections in the common path have been successively adjusted in accordance with Recommendation M.46, paragraph 4, the MU main section controls should make any necessary adjustments to pilot receivers or automatic regulators. (The reference pilot signals now appearing on the remaining section on each of the paths to the various destinations are adjusted in accordance with Recommendation M.46, paragraph 4.)

d) The send reference station should keep a careful record of the measurements made at all the control stations (including the level of reference pilot and any additional measuring signals).

5. *Lining-up (or other maintenance operations) on the common path of an MU group, supergroup, etc. when portions of its bandwidth are already in service*

Operations on the exclusive path to a particular destination, made by an intermediate station, need the consent of only one control station. However, operations on the common path would, in principle, require the consent of several remote control stations.

In consequence, the following recommendations are made:

a) Control and sub-control stations on the common path should be equipped with decoupled testing points (see Supplement No. 2.5). It is recommended that these decoupled testing points be test hybrids because, as explained in Supplement No. 2.5 there is no need to break the transmission path and make terminated-level measurements if test hybrids are used and, furthermore, test signals may be inserted via a test hybrid.

b) The only signals that may be inserted and measured are:

- — pilot signals,
- — additional measuring signals (e.g. intersupergroup measuring signals),
- — test signals at frequencies lying within the portion of the band concerned (for example, referring to Figure 1/M.121 if Group 4 to Ottawa is to be lined up (all others being in service) then stations 1 or 3 may be required to inject signals only at frequencies lying in the band 456-504 kHz).

c) On the MU main section the record of the response of the portion of bandwidth concerned held by the send reference station can be used to see if any significant difference exists between what was originally achieved on the portion between the send and receive stations.

6. *An outline of the maintenance procedure*

The C.C.I.T.T. Recommendations covering the maintenance of groups and supergroups will apply as far as possible but there will be a number of new maintenance problems which are peculiar to multiple destination links. In particular, arrangements will be needed to check the performance of the MU main section of such links. In order to simplify the procedures and minimize interference to other users of the common path, it is recommended that the send reference station for the MU main section should act as a focal point for reports and inquiries concerning the MU main section. The group, supergroup, etc. control stations will still be responsible for localizing a fault to a particular section of a link in accordance with Recommendation M.13.

When a fault is found to be in the communication satellite link, the send reference station will report the fault to the satellite control responsible for this link from baseband-in to baseband-out. When the fault is cleared the send reference station will advise the MU main section controls which will in turn advise the group, supergroup, etc. controls concerned.

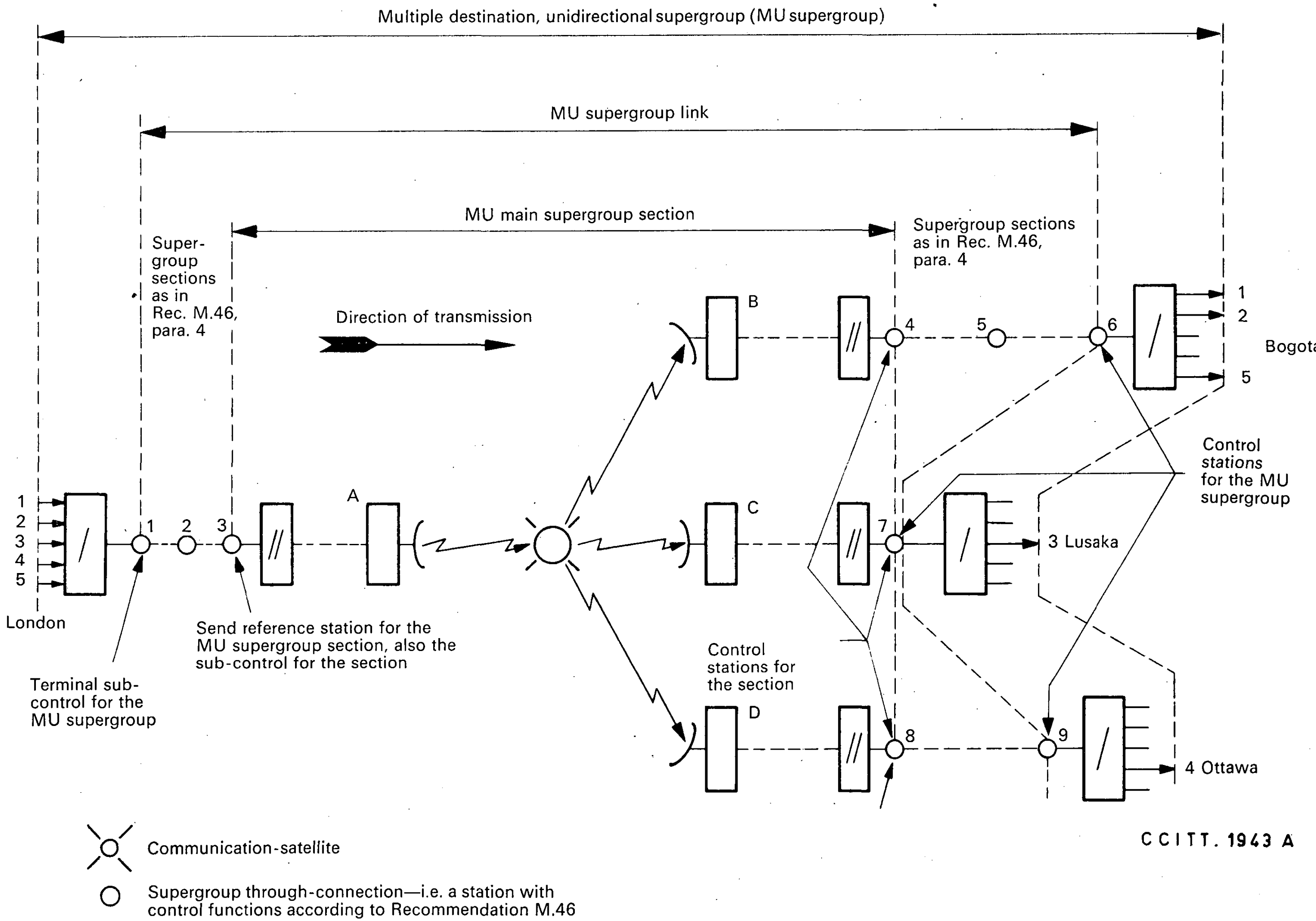


FIGURE 1/M.121. — **Arrangements for a multiple-destination, unidirectional supergroup (MU supergroup)**

PART II

SERIES N RECOMMENDATIONS

MAINTENANCE OF SOUND-PROGRAMME AND TELEVISION TRANSMISSION

SECTION 1

LINING-UP AND MAINTENANCE OF INTERNATIONAL SOUND-PROGRAMME CIRCUITS

1.1 — International sound-programme transmissions—Definitions

RECOMMENDATION N.1

DEFINITIONS FOR APPLICATION TO INTERNATIONAL SOUND-PROGRAMME TRANSMISSIONS

The following definitions apply to international sound-programme transmissions:

a) *international sound-programme transmission*

The transmission of sound over the international telecommunication network for the purpose of interchanging sound-programme material between broadcasting authorities in different countries. Such a transmission includes all types of programme material normally transmitted by a sound broadcasting service, for example, speech, music, sound accompanying a television programme, etc.

b) *broadcasting authority (send)*

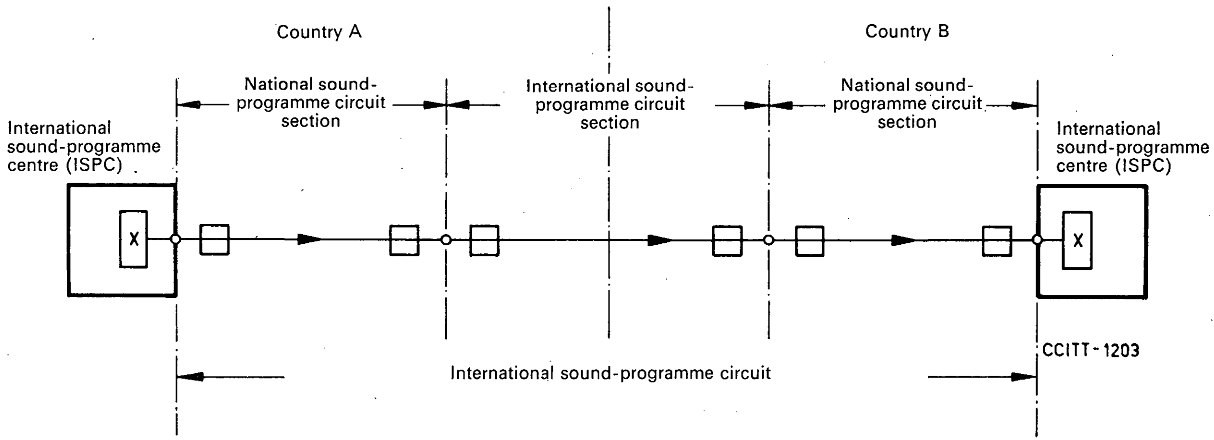
The broadcasting authority at the sending end of the sound programme being transmitted over the international sound-programme connection.

c) *broadcasting authority (receive)*

The broadcasting authority at the receiving end of the sound programme being transmitted over the international sound-programme connection.

d) *international sound-programme centre (I.S.P.C.)*

A centre at which at least one international sound-programme circuit terminates and in which international sound-programme connections can be made by the interconnection of international and national sound-programme circuits.



An international television circuit composed of two national and one international television circuit-sections

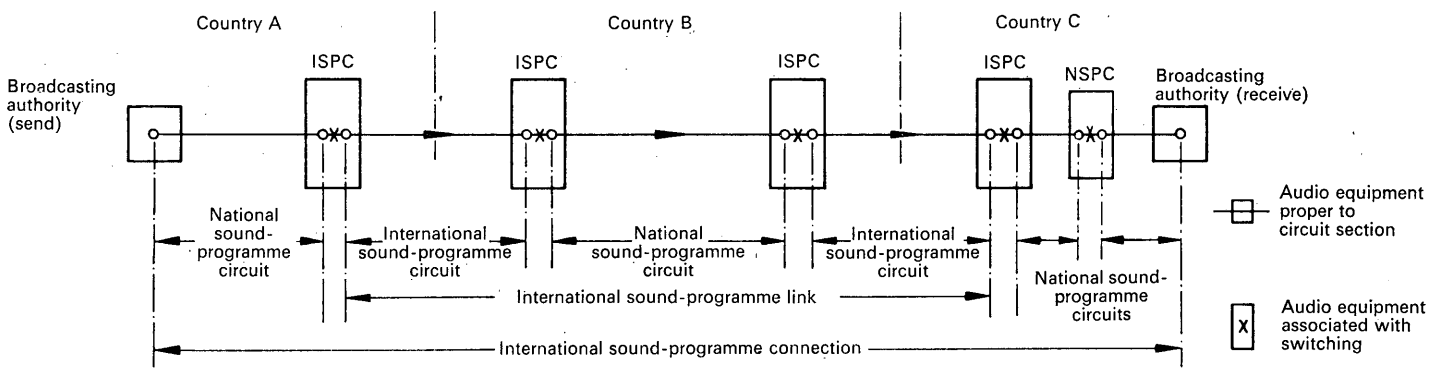


FIGURE 2/N.1. — **An international sound-programme link composed of international and national sound-programme circuits and extended on a national sound-programme circuit at each end to form an international sound-programme connection**

The I.S.P.C. is responsible for setting-up and maintaining international sound-programme links and for the supervision of the transmissions made on them.

e) *international sound-programme connection (Figure 2/N.1)*

The unidirectional path between the broadcasting authority (send) and the broadcasting authority (receive) comprising the international sound-programme link extended at its two ends over national sound-programme circuits to the broadcasting authorities.

f) *international sound-programme link (Figure 2/N.1)*

The unidirectional path for sound-programme transmissions between the I.S.P.C.s of the two terminal countries involved in an international sound-programme transmission. The international sound-programme link comprises one or more international sound-programme circuits interconnected at intermediate I.S.P.C.s. It can also include national sound-programme circuits in transit countries.

g) *international sound-programme circuit (Figure 1/N.1)*

The unidirectional transmission path between two I.S.P.C.s and comprising one or more sound-programme circuit sections (national or international), together with any necessary audio equipment (amplifiers, compandors, etc.).

h) *sound-programme circuit section (Figure 1/N.1)*

Part of an international sound-programme circuit between two stations at which the programme is transmitted at audio frequencies.

The normal method of providing a sound-programme circuit section in the international network will be by the use of carrier sound-programme equipment. Exceptionally sound-programme circuit sections will be provided by other means, for example, by using amplified unloaded or lightly loaded screened pair cables or by using the phantoms of symmetric pair carrier cables.

i) *effectively transmitted signals in sound-programme transmission*

For sound-programme transmission a signal at a particular frequency is said to be effectively transmitted if the nominal overall loss at that frequency does not exceed the nominal overall loss at 800 Hz by more than 4.3 dB or dNp. This should not be confused with the analogous definition concerning telephony circuits given in Recommendation G.151, A, Note 1 (Volume III of the *White Book*).

For sound-programme *circuits* the overall loss (relative to that at 800 Hz) defining effectively transmitted frequency is 1.4 dB (1.6 dNp), i.e. about one-third of the allowance.

RECOMMENDATION N.2

DIFFERENT TYPES OF SOUND-PROGRAMME CIRCUIT

1. *Nominal bandwidth*

In referring to circuits for sound-programme transmission, the nominal bandwidth of the circuit or circuit-section is indicated by including the top nominal frequency in kilohertz that is effectively transmitted.

Example: category A, 10 kHz sound-programme circuit.

2. *Types of sound-programme circuit*

The various types of international sound-programme circuit and circuit-section that can be envisaged are as follows [1]:

— Category A: 10 kHz

— Category A: 6.4 kHz

— Category A: 6.4 kHz old type

— Category B: 10 kHz

— Category B: 6.4 kHz

3. *Use of ordinary telephone circuits* [2]

Although the use of ordinary telephone circuits for a sound-programme transmission ought to be avoided, exceptionally such circuits may be used for the transmission of spoken commentaries. However, it should be noted that the limits of the loss/frequency distortion cannot be guaranteed to be better than the limits shown in Recommendation M.58.

When a telephone circuit is used for a sound-programme transmission the terminating sets and the signalling equipment must be disconnected to avoid echo effects and false operation of the signal receiver.

When a telephone circuit is used for a sound-programme transmission, a point of zero relative level of the telephone circuit must coincide with a point of zero relative level on the sound-programme circuit (but see paragraph 2 of Recommendation N.15 in which it is pointed out that some administrations have found it expedient to introduce a 6-dB (7-dNp) difference in order to reduce the mean power level delivered to the telephone circuit).

RECOMMENDATION N.3

CONTROL CIRCUITS

1. *Definition of a control circuit*

A control circuit, which is a telephone circuit distinct from the special circuit for the sound-programme transmission, is paid for by the broadcasting authorities and provides them with a direct link between the programme source and the point where it is used (recording equipment, switching centre or broadcast transmitter).

[1] The '10 kHz', '6.4 kHz' and '6.4 kHz old type' categories A and B sound-programme circuits referred to above correspond respectively to what are called, in Volume III of the C.C.I.T.T. *White Book*:

— Normal programme circuits, type A

— Normal programme circuits, type B

— Old-type programme circuits.

[2] The C.C.I.T.T. has noted the fact that broadcasting organizations use a tone having a frequency of 1900 Hz$\pm$6 Hz and a level not exceeding -10 dBm0, for their signalling purposes on control circuits. Under the conditions of use specified in the C.C.I.T.T. Recommendations for control circuits, the C.C.I.T.T. has no objections to the use of this tone.

In the case of television transmissions, the control circuits can be associated with sound-programme circuits set up for transmitting the sound of the television programme, or with the television circuits themselves. The broadcasting authorities then distinguish between:

— the " vision " control circuit,

— the " international sound " control circuit (for supervising the programme effects circuit provided for transmitting only the background noises of a programme),

— the " commentary " control circuit (for supervising the sound-programme circuit transmitting a commentary in a given language),

— the " complete programme " control circuit (for supervising the sound-programme circuit transmitting the whole of the sound part of a programme).

2. *Different types of sound-programme transmission*

For setting up control circuits, a distinction is made between:

— " regular transmissions ", transmissions ordered once for all, because they are to take place at regular intervals, at fixed times, on established links and always between the same points; and

— " occasional transmissions ", transmissions not covered by the above definition.

These transmissions may each be direct sound-programme transmissions or multiple sound-programme transmissions.

The conditions governing the provisions and lease of control circuits for sound-programme transmissions are given in Recommendations E.330 and E.331 in Volume II of the C.C.I.T.T. *White Book*.

RECOMMENDATION N.4

DEFINITION AND DURATION OF THE LINE-UP PERIOD AND THE PREPARATORY PERIOD

For each international sound-programme transmission a distinction is made between:

— the *line-up period* during which the administrations and private telephone operating agencies line up the international sound-programme link before handing it over to the broadcasting authorities;

— the *preparatory period* during which these broadcasting authorities do their own adjustments, tests and other work before the sound-programme transmission itself commences.

1. *Line-up period*

Duration

In principle, the duration of the line-up period should be 15 minutes. However, in the case of sound-programme transmissions involving more than two countries, the duration may be increased. On the other hand, in certain cases, by agreement between the administrations concerned, the duration may be less than 15 minutes, provided the line-up is properly carried out. This may be possible, for example, when there are two successive international sound-programme transmissions on the same route and the second involves extending the international sound-programme link already lined up for the first.

Note. — In the case of sound-programme circuits required in association with a multiple television programme broadcast by several transmitters, the line-up period can have a longer duration, to be fixed by agreement between the administrations concerned, e.g. of the order of 25 to 30 minutes.

At the end of the line-up period the international sound-programme link and the control circuits are handed over at the same time to the broadcasting authorities.

2. *Preparatory period*

Beginning and duration

When the tests during the line-up period are completed, the " international sound-programme link " is not made available to the broadcasting authorities at the two ends until the time fixed for the beginning of the " preparatory period ". The chargeable time for the sound-programme transmission commences at the beginning of the preparatory period.

As a general rule, in Europe, the duration of the preparatory period—i.e. the time between handing over the international sound-programme link to the broadcasting authorities and the moment when the programme proper begins—should be about a quarter of an hour, to allow the broadcasting authorities to carry out *all the tests and adjustments necessary* before proceeding with the sound-programme transmission.

However:

— the duration of the preparatory period may be extended at the request of the broadcasting authority using the international sound-programme link;

— the duration of the preparatory period for sound-programme transmission may be extended by the administrations concerned to more than a quarter of an hour in the case of complicated multiple transmissions (or sound-programme transmissions accompanying a multiple television programme), broadcast by several radio transmitters.

RECOMMENDATION N.5

CONTROL AND SUB-CONTROL STATIONS FOR SOUND-PROGRAMME CIRCUITS, CONNECTIONS, ETC.

1. *General*

For the establishment of a unidirectional international sound-programme circuit, the receiving end I.S.P.C. is the control station. The other terminal I.S.P.C. is a terminal sub-control station. If the international sound-programme circuit passes through one or more transit countries, an intermediate sub-control station is also designated for each transit country. The functions of the control and sub-control stations are the same as for ordinary telephone circuits. (See Recommendations M.8 and M.9.)

Note. — In the case of a reversible sound-programme circuit, setting-up reference measurements and maintenance measurements are carried out for each direction of transmission.

2. *Responsibilities*

2.1 The international sound-programme link is in all cases the sole responsibility of the telephone administrations or private operating agencies.

2.2 The national sound-programme circuits at the ends of the link may be the responsibility of either the administrations or the broadcasting authority or the two together depending on local arrangements in each particular country.

2.3 The I.S.P.C. or the repeater station at the receiving end (country C in Figure 2/N.1) is normally a control station for the international sound-programme connection. However, the choice of the station having this function is left to the discretion of the administration concerned.

2.4 The intermediate I.S.P.C.s are intermediate sub-control stations for the international sound-programme link.

2.5 The I.S.P.C. or the repeater station at the sending end (country A in Figure 2/N.1) is a terminal sub-control station for the international sound-programme connection.

However, the choice of the station having this function is left to the discretion of the administration concerned.

1.2 Setting-up, lining-up, monitoring, charging and releasing the international sound-programme link

It is assumed that the international sound-programme link is as shown in Figure 1/N.11. It is also assumed that the various sound-programme circuits to be interconnected to constitute the international sound-programme link are permanent circuits which are subjected to routine maintenance (see section 2.3 below).

RECOMMENDATION N.10

LIMITS FOR THE LOSS/FREQUENCY DISTORTION OF INTERNATIONAL SOUND-PROGRAMME CIRCUIT SECTIONS, CIRCUITS, LINKS AND CONNECTIONS

This Recommendation gives the limits, wherever possible, for the loss/frequency distortion of the various components of the connection shown in Figures 1/N.1 and 2/N.1. The limits are expressed in terms of the received level relative to the value of the received level at 800 Hz[1].

There is no distinction made between category A or B sound-programme circuits as far as loss/frequency distortion is concerned.

Some administrations arrange their apparatus in an I.S.P.C. so that at the point of interconnection the output impedance of every receive channel or circuit over the frequency band of interest is substantially lower than the input impedance of any send channel or circuit. This is so-called constant-voltage technique. Other administrations arrange for an impedance match at the point of interconnection and choose the value of this impedance to be equal to the design resistance of measuring instruments—this is the impedance-matching technique (previously referred to as the constant electromotive force technique). It should be noted that in both cases the through-level measurement results relative to the through-level at 800 Hz will be the same[1]. Furthermore the terminated-level measurement results relative to the terminated-level at 800 Hz will also be this same value [2].

Hence the limits recommended in the following tables are applicable regardless of the arrangement adopted by administrations at their I.S.P.C.s.

Two sets of limits are given in each case, one set applicable for I.S.P.C.s which use decibelmeters and another set for I.S.P.C.s which use nepermeters. The two sets of units have been chosen so that in decibels and decinepers the limits for a circuit are one-third of the limits for a link. The correspondence between the values in decibels and decinepers is therefore not exact but it is precise enough for all practical purposes.

[1] For international circuits 800 Hz is the recommended frequency for single-frequency maintenance measurements. However, by agreement between the administrations concerned, 1000 Hz may be used for such measurements, since it is a fact that 1000 Hz is widely used for single-frequency measurements on many international circuits.

Multifrequency measurements made to determine, for example, the loss/frequency characteristic will include a measurement at 800 Hz, and therefore the reference frequency for such characteristics can still be 800 Hz.

[2] This depends on the ratio of the impedances on the send and receive sides at the various frequencies being sensibly constant. (See Recommendation N.11, paragraph 4.)

1. *Limits for loss/frequency distortion of sound-programme circuit sections*

It is not possible or desirable at this time to recommend limits for circuit-sections.

2. *Limits for loss/frequency distortion of international sound-programme circuits*

The following Tables A, B and C give the limits recommended for the various classes of international sound-programme circuit referred to in Recommendation N.2.

International sound-programme circuits set-up between I.S.P.C.s in any particular continent should usually be routed on a single group link (one circuit section, that is, one equipment for modulation from audio-frequencies and one for demodulation to audio-frequencies). Long international sound-programme circuits between I.S.P.C.s in different continents should not comprise more than three circuit sections.

It should be noted that if a sound-programme circuit will always be restricted to sound-programme transmissions between the two terminal countries, the loss/frequency distortion limits can in principle be up to three times those shown in the tables for circuits.

TABLE A (N.10)

Limits for the received level relative to that at 800 Hz for a category A or B, 10 kHz, sound-programme circuit

Frequency range	Received level relative to that at 800 Hz	
Below 50 Hz	Not greater than 0 dB (0 dNp); otherwise unspecified	
50 to 100 Hz	+0.6 to −1.4 dB	+0.7 to −1.6 dNp
100 to 200 Hz	+0.6 to −0.9 dB	+0.7 to −1.0 dNp
200 Hz to 6 kHz	+0.6 to −0.6 dB	+0.7 to −0.7 dNp
6 to 8.5 kHz	+0.6 to −0.9 dB	+0.7 to −1.0 dNp
8.5 to 10 kHz	+0.6 to −1.4 dB	+0.7 to −1.6 dNp
Above 10 kHz	Not greater than 0 dB (0 dNp); otherwise unspecified	

TABLE B (N.10)

Limits for the received level relative to that at 800 Hz for a category A or B, 6.4 kHz, sound-programme circuit

Frequency range	Received level relative to that at 800 Hz	
Below 50 Hz	Not greater than 0 dB (0 dNp); otherwise unspecified	
50 to 100 Hz	+0.6 to −1.4 dB	+0.7 to −1.6 dNp
100 to 200 Hz	+0.6 to −0.9 dB	+0.7 to −1.0 dNp
200 Hz to 5 kHz	+0.6 to −0.6 dB	+0.7 to −0.7 dNp
5 to 6 kHz	+0.6 to −0.9 dB	+0.7 to −1.0 dNp
6 to 6.4 kHz	+0.6 to −1.4 dB	+0.7 to −1.6 dNp
Above 6.4 kHz	Not greater than 0 dB (0 dNp); otherwise unspecified	

TABLE C (N.10)

Limits for the received level relative to that at 800 Hz for a 6.4-kHz old-style sound-programme circuit

Frequency range	Received level relative to that at 800 Hz	
Below 50 Hz	Not greater than 0 dB (0 dNp); otherwise unspecified	
50 to 100 Hz	+0.6 to −1.4 dB	+0.7 to −1.6 dNp
100 to 200 Hz	+0.6 to −0.9 dB	+0.7 to −1.0 dNp
200 Hz to 3.2 kHz	+0.6 to −0.6 dB	+0.7 to −0.7 dNp
3.2 to 5 kHz	+0.6 to −0.9 dB	+0.7 to −1.0 dNp
5 to 6.4 kHz	+0.6 to −1.4 dB	+0.7 to −1.6 dNp
Above 6.4 kHz	Not greater than 0 dB (0 dNp); otherwise unspecified	

TABLE D (N.10)

Limits for the received level relative to that at 800 Hz for an international sound-programme link established wholly on 10-kHz sound-programme circuits

Frequency range	Received level relative to that at 800 Hz	
Below 50 Hz	Not greater than 0 dB (0 dNp); otherwise unspecified	
50 to 100 Hz	+1.8 to −4.2 dB	+2.1 to −4.8 dNp
100 to 200 Hz	+1.8 to −2.7 dB	+2.1 to −3.0 dNp
200 Hz to 6 kHz	+1.8 to −1.8 dB	+2.1 to −2.1 dNp
6 to 8.5 kHz	+1.8 to −2.7 dB	+2.1 to −3.0 dNp
8.5 to 10 kHz	+1.8 to −4.2 dB	+2.1 to −4.8 dNp
Above 10 kHz	Not greater than 0 dB (0 dNp); otherwise unspecified	

TABLE E (N.10)

Limits for the received level relative to that at 800 Hz for a sound-programme link composed wholly of 6.4-kHz sound-programme circuits

Frequency range	Received level relative to that at 800 Hz	
Below 50 Hz	Not greater than 0 dB (0 dNp); otherwise unspecified	
50 to 100 Hz	+1.8 to −4.2 dB	+2.1 to −4.8 dNp
100 to 200 Hz	+1.8 to −2.7 dB	+2.1 to −3.0 dNp
200 Hz to 5 kHz	+1.8 to −1.8 dB	+2.1 to −2.1 dNp
5 to 6 kHz	+1.8 to −2.7 dB	+2.1 to −3.0 dNp
6 to 6.4 kHz	+1.8 to −4.2 dB	+2.1 to −4.8 dNp
Above 6.4 kHz	Not greater than 0 dB (0 dNp); otherwise unspecified	

Modern carrier sound-programme equipment for a sound-programme circuit type A can easily meet the characteristic proposed above in Table A. Furthermore, experience shows that such a characteristic can easily be met by a circuit provided on equalized unloaded cable pairs up to 320 km long. Hence the adoption of this characteristic as a target for the future should not be embarrassing. Some older types of carrier sound-programme equipment will probably need additional equalizers to comply with the limits. When a circuit is to be equalized, the opportunity should be taken to obtain as good a level frequency characteristic as possible.

3. *Limits for the loss/frequency distortion on an international sound-programme link*

The following Tables D and E give the limits for two types of international sound-programme links. Table D is for a link established wholly on 10-kHz circuits and Table E for a link established wholly on 6.4-kHz circuits.

The majority of international sound-programme links are in practice established with three or less circuits in series and the limits recommended for a link are accordingly three times those recommended for a circuit.

Many links could be established without additional equalizers but links comprising four or more circuits will probably require equalization in which case opportunity could again be taken to obtain as good a loss/frequency characteristic as possible.

4. *Limits for the loss/frequency distortion of an international sound-programme connection*

It is not possible at the present time to recommend limits for the sound-programme connection but every effort should be made by administrations to provide national sound-programme circuits to as high a standard as possible so that the loss/frequency distortion of the sound-programme connection is not markedly more than that of the sound-programme link.

RECOMMENDATION N.11

ESSENTIAL TRANSMISSION PERFORMANCE OBJECTIVES FOR INTERNATIONAL SOUND-PROGRAMME CENTRES (I.S.P.C.)

1. *Transmission level at interconnection points*

The nominal relative level at interconnection points is not specified by the C.C.I.T.T. and administrations are free to decide the level themselves, bearing in mind, among other things, the need to ensure an adequate signal-to-noise ratio within the I.S.P.C. However, levels at interconnection points must be such that a signal level of 0 dBm0 (0 dNm0) on the incoming circuit gives rise to a signal level of 0 dBm0 (0 dNm0) on the outgoing circuit. It should be noted that many administrations, particularly those which have adopted so-called constant-voltage techniques, have chosen a nominal relative level of +6 dBr

(+7 dNr) at which to inter-connect. Figure 1/N.11 and the supporting text is an example of an international sound-programme connection in which each administration has chosen interconnection points to have a nominal relative level of +6 dBr (+7 dNr). However, other administrations have chosen other levels.

2. *Balance with respect to earth*

The balance with respect to earth (measured by the method defined in Figure 4B, Annex 3, *Blue Book*, Volume III) of nominally balanced apparatus should be at least 60 dB (70 dNp) in order to give an adequate suppression against longitudinal interference induced by power supplies, alarm circuits, etc.

3. *Access-points*

There should be a well-defined circuit access-point associated with the input to a sound-programme circuit at which the transmission test levels at all frequencies over the band are nominally the same. This access-point may be the interconnection point or separated therefrom by distortion-free loss or gain. A well-defined circuit access-point should also be associated with the output of a sound-programme circuit.

The nominal relative level at each access-point will be chosen by each administration, bearing in mind the dynamic range of their testing and transmission apparatus.

Measurements on a sound-programme circuit should be made between such circuit access-points.

Administrations may also find it convenient to arrange for sound-programme circuit sections to be equipped with similar access-points. *International* sound-programme circuit sections which can be connected to a variety of other circuit sections should always be equipped with such access-points.

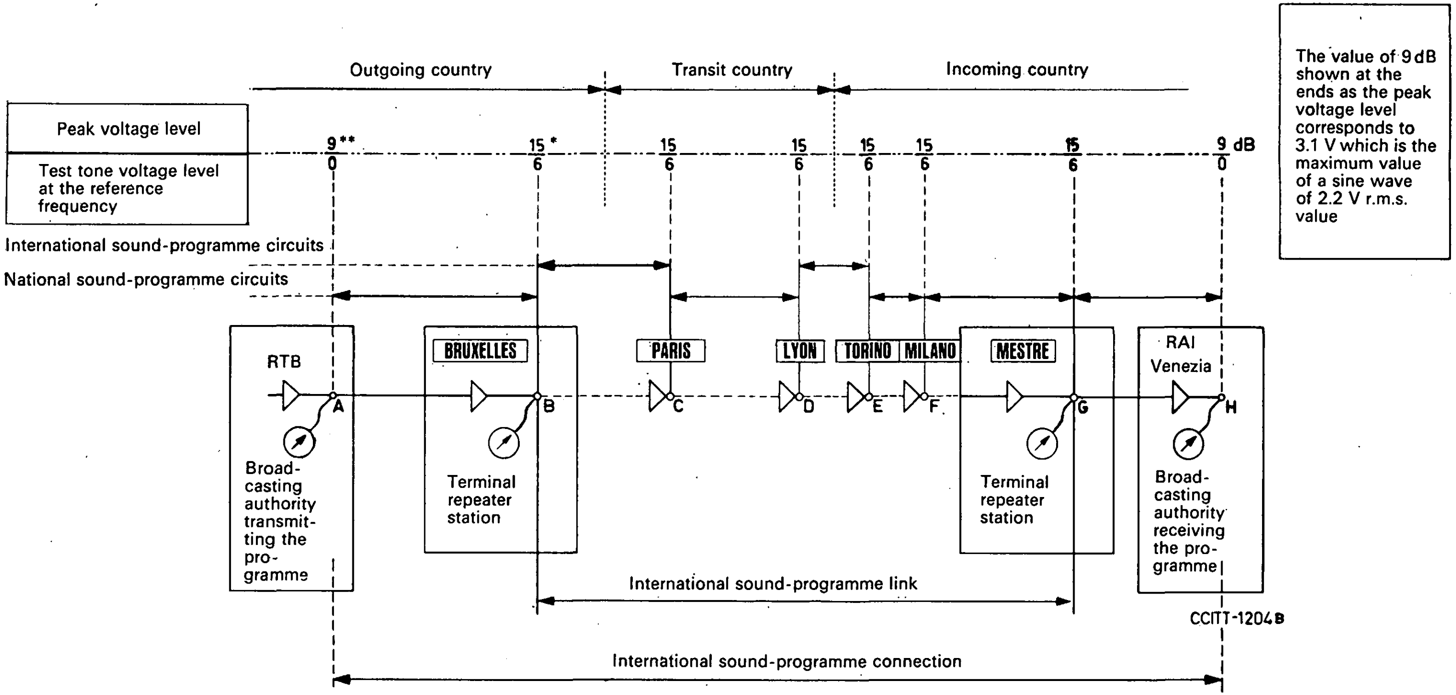
4. *Impedance at sound-programme interconnection points*

a) *Constant voltage technique*

If the modulus of the output impedance of any source is not greater than one-hundredth of the modulus of the lowest impedance that can be connected to it (bearing in mind that it is possible to connect two or more loads in parallel) then the change in level due to change of load will be negligibly small (less than 0.1 dB (0.1 dNp) approximately).

b) *Impedance matching technique*

If the return loss versus the nominal design resistance of the measuring instruments of the impedance presented by incoming and outgoing circuits to the points where they are interconnected is at least 26 dB (30 dNp) over the range 50 Hz to 10 kHz, the error due to mismatch will be insignificant, assuming that the impedance of testing apparatus has at least 30 dB (35 dNp) return loss versus the nominal design resistance, which can be, for example, 600 ohms non-reactive.



Volume meter or peak meter

Repeater station

* These levels are appropriate to national sound-programme circuits in the countries concerned

** The RTB in fact adopts levels of 15/6 at this point

FIGURE 1/N.11. — **Diagram of an international sound-programme connection in which all the countries concerned have chosen +6.0 dBr (+7.0 dNr) as the nominal relative level at points at which circuits are interconnected**

5. *Example of a through-level diagram of an international sound-programme connection on which every administration has chosen to interconnect circuits at a relative level of +6 dBr (+7 dNr) (nominal value)*

5.1 It is assumed that the international sound-programme link is as shown in Figure 1/N.11 and that the various sound-programme circuits to be interconnected to constitute the international sound-programme connection are permanent circuits which are subjected to routine maintenance.

5.2 The through-level diagram referred to is that of the international sound-programme connection and not that of the sound-programme circuits. In this examlpe the levels quoted are in all cases measured as 600-ohm through-levels.

5.3 On this through-level diagram:

a) the ends (sending or receiving) of a national or of an international sound-programme circuit are, in principle, those points at which it is intended that the circuit should be interconnected with other national or international sound-programme circuits;

b) the reference point for relative levels is normally the sending end of the international sound-programme connection, namely point A in Figure 1/N.11 (a different convention may be adopted by agreement between the telecommunication administration and the broadcasting authorities in one and the same country, provided that the through-levels on the international sound-programme link are not modified thereby);

c) the nominal value of 600-ohm through-level measured at the receiving end of each of the international sound-programme circuits included in the constitution of the international sound-programme link (for example, points C and E of Figure 1/N.11) is 6 dB (7 dNp) above the nominal value at the sending end of the international sound-programme connection; in other words, if at the sending end of the international sound-programme connection, this being a zero relative level point, there is a sinusoidal signal producing an r.m.s. value of 0.775 volt across the circuit at that point, the 600-ohm through-level at C and E must be +6 dB (+7 dNp) (that is, its r.m.s. value must be 1.55 volts);

d) the nominal value of the 600-ohm through-level at the sending end of an international sound-programme circuit (for example, point B of circuit BC, point D of circuit DE) is also +6 dB (+7 dNp).

5.4 Thus, for such an international sound-programme connection for which the administrations have all chosen a nominal value of +6 dB (+7 dNp) as the relative level at which they interconnect circuits, the setting-up and maintenance measurements made by the telephone administrations are always carried out by sending at the input to the international sound-programme link a 600-ohm through-level of +6.0 dB (+7.0 dNp) at the reference test frequency (800 or 1000 Hz). However, Recommendation N.13 requires that at all other frequencies, the 600-ohm through-level at this point shall not exceed −6.0 dBm (−7 dNm).

RECOMMENDATION N.12

MEASUREMENTS TO BE MADE DURING THE LINE-UP PERIOD THAT PRECEDES A SOUND-PROGRAMME TRANSMISSION

The national sound-programme circuits should be so adjusted that, when they are connected to the international sound-programme link, the level diagrams of the international sound-programme circuits are respected.

After the connection of the various circuits to form the international sound-programme link (conforming to the level diagrams of these circuits) it is necessary to verify, by means of an automatic equipment or by measurements at individual frequencies, that the received level at the distant incoming terminal I.S.P.C. is at the correct value at the following frequencies:

for an international sound-programme link composed entirely of 10-kHz sound-programme circuits	50, 800 and 10 000 Hz
for an international sound-programme link comprising at least one 6.4-kHz or 6.4-kHz old-type sound-programme circuit	50, 800 and 6400 Hz
for an international sound-programme link comprising at least one ordinary telephone circuit	300, 800 and 3400 Hz[1].

Also, and only if requested by the control station, a measurement of the psophometric noise power level is made at the distant terminal I.S.P.C.

Any necessary adjustments having been made, the national circuits are connected to the international sound-programme link at the terminal I.S.P.C.s. This is the end of the line-up period and the beginning of the preparatory period and is the instant when the complete connection is placed at the disposal of the broadcast authorities.

The latter then proceed to measure and adjust as necessary.

RECOMMENDATION N.13

MEASUREMENTS TO BE MADE BY THE BROADCASTING AUTHORITIES DURING THE PREPARATORY PERIOD

After the broadcasting authorities have taken possession of the international sound-programme connection, they make measurements on the complete connection in the band of frequencies effectively transmitted, from the point where the programme is picked up to the point where the programme is received.

The broadcasting authorities should, for their measurements, send to the origin of the international sound-programme connection a sinusoidal signal at the reference frequency (800 or 1000 Hz) only, whose maximum amplitude is 9 dB (1.04 Np) below that of the maximum instantaneous voltage that should never be exceeded at this point in the course of a sound-programme transmission.

[1] or the frequency appropriate to the telephone circuit used.

The duration of the period during which the signal at this level is sent should be kept as short as possible, for example of the order of 30 seconds. If necessary, the I.S.P.C.s should verify that the received level at the access-point on the international sound-programme circuit is equivalent to 0 dBm0 (0 dNm0).

When it is necessary, either for purposes of fault location or to maintain a watch on the continuity of the circuit, to send a continuous tone, or when making measurements at other frequencies than the reference frequency, the amplitude at the origin of the international sound-programme connection should be 21 dB (2.4 Np) below the " voltage that should never be exceeded " at this point during the course of a sound-programme transmission. Under these circumstances the level at the access-point on the international sound-programme circuit is equivalent to −12 dBm0 (−14 dNm0).

During the preparatory period there is no occasion to readjust the output levels at intermediate I.S.P.C.s since these have already been set during the line-up period.

Note. — The numerical values given above ensure that during the sound-programme transmission the peak voltage at a zero relative level point will not exceed that of a sinusoidal signal having an r.m.s. value of 2.2 volts.

The reasons for sending the reference frequency for short durations during this final line-up, at a voltage 9 dB (1.04 Np) below the peak voltage at the end of the connection are:

a) it is not desirable to subject the terminal equipments of sound-programme carrier systems to overloading by continuously transmitting a test signal corresponding to the peak voltage reached only momentarily during the transmission of an actual programme;

b) since administrations make their initial and maintenance measurements on international sound-programme circuits with a signal producing a nominal level of of 0 dBm0 (0 dNm0) at the I.S.P.C. test-point, it is convenient, to be able to verify during the preparatory period, that the received level is of the same value.

RECOMMENDATION N.15

MAXIMUM PERMISSIBLE POWER DURING AN INTERNATIONAL SOUND-PROGRAMME TRANSMISSION

General

To check that the maximum power transmitted during a sound-programme transmission does not exceed the limits allowed by administrations, it is recommended that broadcasting authorities and the terminal I.S.P.C.s of the international sound-programme connection should use volume-meters or peak programme meters, the same type of meter being used for preference by both the telephone administration and the broadcasting authority of a country.

Since the international sound-programme connection is accurately adjusted before it is made available to the broadcasting authorities, there will be no danger of overloading the amplifiers during the sound-programme transmission if care is taken not to exceed the permissible limit at the sending end of the international sound-programme connection.

Hence, this check can be done only by the broadcasting authority and telephone authorities of the transmitting country, and a check made further down the line would not seem to be very effective.

If so desired, monitoring equipment (electrical speech-level meters, peak-indicators) can be connected at the receiving end of the international sound-programme link and of the international sound-programme connection to obtain information about the general nature of the transmission. In this case, monitoring equipment at the two locations in the incoming country will have to be of the same type, but there is no need for the same kind of monitoring equipment to be used in both outgoing country and incoming country.

1. *Maximum level permitted on sound-programme circuits*

The peak power permitted on a sound-programme circuit should not exceed +9 dBm (+10.4 dNm) at a point of zero relative level on the sound-programme circuit.

(This corresponds to a peak voltage of 3.1 volts when measured as a 600-ohm through-level at a zero through relative level point. The r.m.s. value of the sinusoidal signal with this peak value is 2.2 volts.)

2. *Maximum level permitted on an international telephone circuit used to carry a sound-programme transmission*

The power permitted on the international telephone circuit carrying a sound-programme transmission should not exceed +9 dBm (+10.4 dNm) at a point of zero relative level on the international telephone circuit. In effect this permits zero relative points on the telephone circuits and the sound-programme circuit to be directly joined together without gain (from sound-programme circuit to telephone circuit) but with or without loss.

Note. — The sound-programme transmission usually carried by international telephone circuits used in this way is a spoken commentary; music, for example, would in general be seriously distorted by the restricted bandwidth of the telephone circuit. For such speech, a *peak* value of power of +9 dBm (+10.4 dNm) corresponds to a long-term *mean* power of about −6 dBm (−7 dNm). Bearing in mind that for international line systems designed according to C.C.I.T.T. Recommendations, a long-term mean power per channel of −15 dBm (−17 dNm) (at a zero relative point) is assumed, some administrations have deemed it advisable to reduce the permitted peak power of any sound-programme signals carried by international telephone circuits under their control to a value not exceeding +3 dBm (+3.5 dNm) at a point of zero relative level on the telephone circuit. Thus in effect a 6-dB (7-dNp) loss is introduced between the zero relative points of the sound-programme circuit and the international telephone circuit and this has the effect of reducing the mean speech power under these conditions to a value closer to the system design value. It should be borne in mind that the margin against crosstalk from other telephone channels into the telephone channel carrying the sound-programme is reduced by this technique. In particular, the return channel of the telephone circuit carrying the sound-programme can become a source of crosstalk. However, the improved go-to-return crosstalk attenuation of modern channel-translating equipment (necessary, if a speech concentrator is used) provides an opportunity to reduce the sound-programme level without incurring crosstalk trouble.

RECOMMENDATION N.16

IDENTIFICATION SIGNAL

During the preparatory period, at times when no test transmission is taking place, to indicate that the circuits are through, it is very desirable for broadcasting authorities to arrange that their studios and transmitting stations send " identification signals " over the international sound-programme connection and over the control circuits whilst they are not in use. During the preparatory period, particularly, the identification signal will serve to show for which sound-programme transmission the circuit is to be used.

This identification signal will not be broadcast, so that it will not be heard by listeners, but will be transmitted from end to end of the international sound-programme connection, from the outside broadcast point to the destination (I.S.P.C., radio transmitter centre or recording centre).

The level of the identification signal must conform to the requirements of the relevant Series M Recommendations.

RECOMMENDATION N.17

MONITORING THE TRANSMISSION

The transmission may be monitored in the terminal I.S.P.C.s either by means of loudspeakers, or apparatus with a visual display (peak programme meters, v.u. meters, oscilloscopes, etc.).

RECOMMENDATION N.18

MONITORING FOR CHARGING PURPOSES. CLEARING DOWN

The monitoring of an international sound-programme transmission for charging purposes is carried out at the terminal I.S.P.C. of the international sound-programme link.

The technical staff of the designated I.S.P.C.s should come to an arrangement among themselves so that at the end of the sound-programme transmission they have accurate knowledge of:

a) the time of handing over the sound-programme link to the broadcasting authority (beginning of chargeable duration);

b) the time at which the sound-programme link is released by the broadcasting authority (end of chargeable duration);

c) where appropriate, the times and duration of every interruption or incident which may have occurred (in order to allow the operating services to determine whether a rebate is due, and if so, its amount).

The times of the beginning and of the end of the chargeable duration, as well as the times of occurrence and duration of any breakdowns which may occur, are entered on a daily report. This daily report is sent on the same day to the service responsible for co-ordinating all the details necessary for the establishment of the international accounts.

The conditions governing charging for sound-programme circuits and control circuits are given in Recommendations E.330 and E.331 of Volume II of the *White Book.*

1.3 — Setting-up and maintenance of permanent international circuits for sound-programme transmissions

RECOMMENDATION N.21

SETTING-UP THE CIRCUIT

When each national section of the international sound-programme circuit and each section crossing a frontier has been equalized for loss/frequency distortion and, where necessary, for phase/frequency distortion, so as to meet C.C.I.T.T. Recommendations, these various sections are interconnected to form the complete international sound-programme circuit, and the following measurements are made:

a) *Measurement of received level*

A test signal of 800 Hz is applied to the sending end of the international sound-programme circuit at a level equivalent to 0 dBm0 (0 dNm0). The level is measured at the receiving end of the circuit (output of last amplifier) and is adjusted to the nominal value appropriate to the I.S.P.C. (for example, +6 dBm or + 7 dNm).

An automatic level recorder may then be used to trace the curve of received level with frequency at the receiving end of the circuit[1]. If no such recorder is available, individual measurements must be made at the terminal I.S.P.C. and at the frontier station at the following frequencies:

- for a 10-kHz circuit: 50, 80, 100, 200, 500, 800, 1000, 2000, 3200, 5000, 6000, 8500, 10 000 Hz; and if considered useful: 30, 40, 11 000, 12 000 and 15 000 Hz;
- for a 6.4-kHz circuit and for a 6.4-kHz old-type circuit: 50, 80, 100, 200, 500, 800, 1000, 2000, 3200, 5000 and 6400 Hz.

The equalizers are adjusted to bring the curve within C.C.I.T.T. limits, which are given in Recommendation N.10.

b) *Measurement of group-delay distortion*

If necessary, the group-delay distortion/frequency characteristic is plotted for the whole international sound-programme circuit.

c) *Measurement of circuit noise*

When, after all necessary adjustment, the international sound-programme circuit meets the C.C.I.T.T. Recommendations, noise measurements are made.

[1] For the sent level of frequencies other than the reference frequency the requirements of paragraph 5.4 of Recommendation N.11 must be respected.

These should consist of:

— measurement of the unweighted noise voltage at the end of the international sound-programme circuit, using a measuring set having a frequency range of about 30 to 20 000 Hz, and

— measurement of the weighted psophometric noise voltage, using a sound-programme circuit psophometer (see the weighting curve of this psophometer in Supplement No. 3.2 of Volume IV of the C.C.I.T.T. *White Book*).

The following are the limiting values at a point of zero relative level for various types of circuit:

Measurement	Cable circuit	Open-wire line
Unweighted voltage	31 mV	78 mV
Psophometric voltage	3.1 mV	7.8 mV

For convenience, the table below gives the voltages at a +6 dBr (+7 dNr) point and also the quantities in transmission units corresponding to the above limits.

With a 600-ohm instrument		Power level at a 0 dBr (0 dNr) point	
Voltage at a 0 dBr (0 dNr) point	Voltage at a +6 dBr (+7 dNr) point		
(mV)	(mV)	dBm0	dNm0
78	156	−20	−23
31	62	−28	−32
7.8	15.6	−40	−46
3.1	6.2	−48	−55

d) *Measurement of non-linearity distortion*

For circuits routed entirely on audio pairs and not equipped with pre-emphasis equipment the non-linearity distortion is measured at the end of the international sound-programme circuit by sending for a few seconds a sinusoidal signal at an appropriate frequency in the band to be transmitted at a level of +9 dBm0 (+10.4 dNm0).

For a circuit which includes at least one carrier section no measurement of non-linearity distortion should be made. However, if, in very exceptional cases, it should be essential, in order to provide service on such a circuit, to carry out a check of non-linearity distortion, for example, to locate a fault, the frequency of the sent signal should not exceed 1000 Hz at +9 dBm0 (+10.4 dNm0) and the period for which the tone is connected should be as short as possible—that is, not more than about four seconds.

The total harmonic-distortion coefficient for the sound-programme hypothetical reference-circuit (2500 km) must not exceed 4% (harmonic margin 28 dB or 32 dNp) at any frequency [1] within the transmitted band. For shorter and for less complex circuits, the distortion should be less.

Moreover, since end-to-end measurements of non-linearity distortion on circuits routed on carrier systems might give rise to serious disturbance to transmission on other channels, especially if the group is transmitted on a transistorized carrier system, it is permitted to make only local measurements of non-linearity distortion on terminal modulating and demodulating equipments. For example, a sound-programme circuit modulating and demodulating equipment could be connected back-to-back via a suitable network (and suitable amplifiers if necessary) and the measurement made on the resulting complete assembly.

e) *Record of results*

The final measurements made under the above headings when the circuit has been ined-up are reference measurements and should be carefully recorded.

RECOMMENDATION N.22

REFERENCE MEASUREMENTS ON INTERNATIONAL SOUND-PROGRAMME CIRCUITS

The received level at the terminal I.S.P.C. and at the frontier station is measured at the following frequencies:

— for a 10-kHz circuit: 50, 80, 100, 200, 500, 800, 1000, 2000, 3200, 5000, 6000, 8500, 10 000 Hz; and if considered useful: 30, 40, 11 000, 12 000 and 15 000 Hz;

— for a 6.4-kHz circuit and for a 6.4-kHz old-type circuit: 50, 80, 100, 200, 500, 800, 1000, 2000, 3200, 5000 and 6400 Hz.

The results of these measurements are carefully recorded on a line-up record [2] and also the values of unweighted noise and psophometric voltage measured at the end of the international sound-programme circuit.

[1] The European Broadcasting Union has stated that many of its members have expressed the opinion that for a circuit 1500 km long, acceptable limits for non-linearity distortion would be:

40 dB (46 dNp) at fundamental frequencies above 100 Hz,
34 dB (39 dNp) at fundamental frequencies of 100 Hz and below.

[2] See, as example, the model in the Appendix of Recommendation N.23.

RECOMMENDATION N.23

ROUTINE MAINTENANCE MEASUREMENTS

The following routine maintenance measurements should be made *every two months:*

a) *Measurement of received level*

The level at the end of the international sound-programme circuits should be measured at the following frequencies:

— for a 10-kHz circuit: 50, 100, 200, 800, 3200, 5000, 6000, 8500 and 10 000 Hz;

— for a 6.4-kHz circuit and for a 6.4-kHz old-type circuit: 50, 100, 200, 800, 3200, 5000 and 6400 Hz.

After this measurement, the level at 800 Hz is adjusted, if necessary, to its nominal value.

If it is found that the level for a particular frequency at the receiving end of the international sound-programme circuit is not within the specified limits, the reference measurements should be repeated, calling in the frontier stations to determine the faulty sections. Further overall measurements are then made to ensure that the specified limits are respected.

b) *Measurement of circuit noise*

At the time of the two-monthly maintenance measurements, the noise at the receiving end of the international sound-programme circuit should be measured using the C.C.I.T.T. programme circuit psophometer (see the weighting curve for this psophometer in Supplement No. 3.2 of Volume IV of the C.C.I.T.T. *White Book*).

c) *Measurement of non-linearity distortion*

After measurements of level have been made and any necessary adjustment has been carried out, the non-linearity distortion should be measured, to ensure that the circuit concerned can transmit sound-programme signals with the required quality.

Measurements are made under the conditions described in Recommendation N.21 above, paragraph c), and with the same restrictions concerning circuits on carrier groups or equipped with emphasis networks.

Provisionally, the C.C.I.T.T. recommends the use of a measuring instrument that indicates total harmonic power rather than a selective instrument of the wave-analyser type with which the final value of harmonic margin is obtained only after much calculation.

d) Notwithstanding any understanding with a renter that routine tests shall, in general, be carried out at certain times, the control station must agree with the renter of a permanently leased circuit on the time that that circuit shall be taken for tests each time a routine test is to be carried out.

Appendix

(to Recommendation N.23)

Line-up record for an international sound-programme circuit

Technical Service of	:	Suisse
Circuit designation	:	Stuttgart–Zürich R 3
Control station	:	Zürich
Sub-control station	:	Stuttgart
Type of circuit	:	10 kHz
Date of measurements	:	2 September 19..
Issue dated	:	1 October 19..

Level frequency characteristic

Levels measured at a +7 dNr point with a level of −14 dNm0

Frequency (Hz)	600-ohm through level (in decinepers) when 0.775 volt is applied at the (two-wire) sending end		
	Horb	Donau-eschingen	Zürich
30 [1]	−6.9	−6.6	−7.2
40 [1]	−6.8	−6.6	−7.1
50	−6.8	−6.5	−7.1
80	−6.7	−6.4	−6.9
100	−6.5	−6.4	−6.8
200	−6.5	−6.3	−6.7
500	−6.5	−6.2	−6.7
800	−6.6	−6.2	−6.6
1000	−6.7	−6.2	−6.5
2000	−6.5	−6.2	−6.5
3200	−6.5	−6.3	−6.5
5000	−6.5	−6.4	−6.4
6000 [2]	−6.6	−6.5	−6.6
6400 [3]			
8500 [2]	−6.7	−6.6	−6.8
10 000 [2]	−6.8	−6.8	−7.0
11 000 [1]			
12 000 [1]			
15 000 [1]			

Noise: Psophometric noise 2.4 mV, Flat unweighted noise 19 mV } at a +6 dBr (+7 dNr) point

[1] Measurements at these frequencies will be made only if considered useful.

[2] 10-kHz sound-programme circuits only.

[3] 6.4-kHz and 6.4-kHz old-type sound-programme circuits.

SECTION 2[1]

LINING-UP AND MAINTENANCE OF INTERNATIONAL TELEVISION TRANSMISSIONS

2.1 — International television transmissions — Definitions

RECOMMENDATION N.51

DEFINITIONS FOR APPLICATION TO INTERNATIONAL TELEVISION TRANSMISSIONS

1. The following definitions apply to international television transmissions:

a) *international television transmission*

The transmission of television signals over the international telecommunication network for the purpose of interchanging television material between television authorities in different countries.

b) *television authority (send)*

The television authority at the sending end of the international television connection.

c) *television authority (receive)*

The television authority at the receiving end of the international television connection.

d) *international television centre (I.T.C.)*

A centre at which at least one international television circuit terminates and in which international television connections can be made by the interconnection of international and national television circuits.

The I.T.C. is responsible for setting-up and maintaining international television connections and for the supervision of the transmissions made on them.

e) *international television connection* (Figure 1/N.51)

The unidirectional path between the television authority (send) and the television authority (receive) comprising the international television link extended at its two ends over national television circuits to the television authorities.

f) *international television link* (Figure 1/N.51)

The unidirectional transmission path for television transmissions between the I.T.C.s of the two terminal countries involved in an international television transmission. The

[1] In general, for C.C.I.R. Recommendations concerning television, see pages 51 to 105 of C.C.I.R. Volume V, Oslo, 1966.

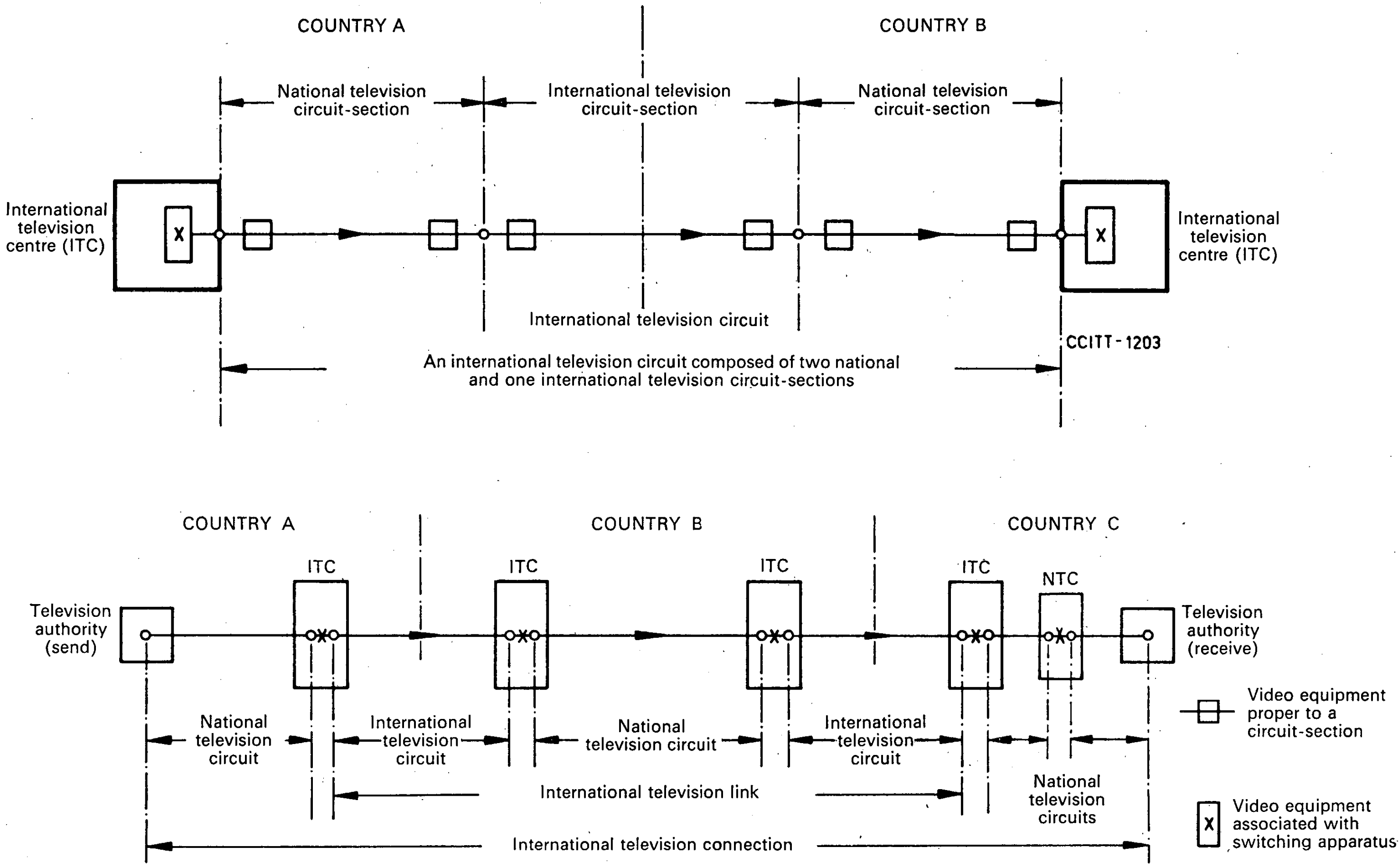


FIGURE 1/N.51. — **An international television link composed of international and national television circuits and extended on national television circuits at each end to form an international television connection** international television link comprises one or more international television circuits interconnected at intermediate I.T.C.s.

g) *international television circuit* (Figure 1/N.51)

The unidirectional transmission path between two I.T.C.s and comprising one or more television circuit-sections (national or international), together with any necessary video equipment.

h) *television circuit section* (Figure 1/N.51)

Part of an international television circuit between two stations at which the programme is transmitted at video frequencies.

RECOMMENDATION N.52

MULTIPLE TELEVISION TRANSMISSIONS AND CO-ORDINATING CENTRES

A multiple television transmission occurs when the same programme is transmitted to several television authorities, for broadcasting by their transmitting stations or for making recordings.

If the branching point of the television transmission is at the originating point of the programme each unidirectional path to a receiving television authority is considered to be an individual international television connection.

Otherwise, the term " derived television transmissions " is used. The telecommunication administrations concerned should agree on the choice of a control station. The branching points will be sub-control stations. To meet the needs of the telecommunication administrations, the control station should have the necessary staff and appropriate control circuits to the sub-control stations for the different sections.

The designation of the co-ordinating centre is a matter for the television authorities. The functions of a co-ordinating centre are:

- to co-ordinate the requests made by the television authorities participating in the transmission concerned,
- to make all necessary enquiries as to the availability of television circuits,
- to draw up the plan of the network of telephone circuits, sound-programme circuits and television circuits, required for the transmission in question,
- to ensure that the television transmission proceeds normally once the international television connections are handed over to the television authority,
- immediately to call in the control station and sub-control station concerned, in the event of breakdown or complaints concerning the technical performance of the connections.

RECOMMENDATION N.53

CONTROL CIRCUITS FOR TELEVISION TRANSMISSIONS

A control circuit (a telephone circuit) provides the television authorities with a direct telephone link between the programme source and the point where it is used (recording equipment, I.T.C. or television transmitter). This circuit is paid for by the television authority.

For setting up control circuits, a distinction is made between:

— " regular transmissions ", which are transmissions ordered once for all because they are to take place at regular intervals at fixed times on established circuits and always between the same points;

— " occasional transmissions ", which are transmissions not covered by the above definition.

In either case, these transmissions may be direct television transmissions or multiple television transmissions.

The vision control circuit is different from the control circuits associated with sound-programme circuits set up for transmitting the sound of the television programme (see Recommendation N.3).

In addition to control circuits for radio and television transmissions, the television authorities may book additional telephone circuits for co-ordinating the programme as it proceeds.

The conditions governing the provision and lease of control circuits for television transmissions are given in Recommendation E.350 in Volume II-A of the C.C.I.T.T. *White Book.*

RECOMMENDATION N.54

DEFINITION AND DURATION OF THE LINE-UP PERIOD AND THE PREPARATORY PERIOD

1. *Definition*

For each international television transmission a distinction is made between:

a) the *line-up period* during which the telecommunication administrations line up the international television link before handing it over to the television authorities;

b) the *preparatory period* during which the television authorities carry out their own adjustments, tests, etc., before the television transmission itself commences.

The time at which the preparatory period begins (point H on Figure 1/N.54) is determined by the television authorities. This is the start of chargeable time.

2. *Duration*

The lengths of the line-up period and the preparatory period are specified in Figure 1/N.54, the time being shown with reference to time H at which the connection is handed over to the television authorities.

All the adjustments between H-30 minutes and H, the line-up period, are the responsibility of the telecommunication administrations. They are generally carried out with the aid of standard signals, since, more often than not, the telecommunication administrations do not have the means to create live pictures. By agreement between a telecommunication administration and a television authority situated further back, it would nevertheless be possible, for a few minutes before the end of the line-up period, to transmit live pictures; this would be particularly useful when adjusting standards converters. The transmission of moving pictures during the line-up period does not, however, alter the telecommunication administrations' responsibility with regard to the quality of transmission required. This responsibility begins only at time H, which is the end of the line-up period and the beginning of the preparatory period.

Note concerning the duration of the line-up period:

When there are not enough circuits for television transmissions available, it may happen that circuits (mainly national circuits) are already in use for a television transmission during the period immediately preceding the time when it is required to establish the international link.

In these circumstances a reduction in the duration of the line-up period will have to be contemplated. It will be assumed that because a television transmission is already taking place there is no need to line-up the circuits referred to above before proceeding to incorporate them as part of the international television link. Lining-up of these circuits will have already taken place before the commencement of the television transmission over them.

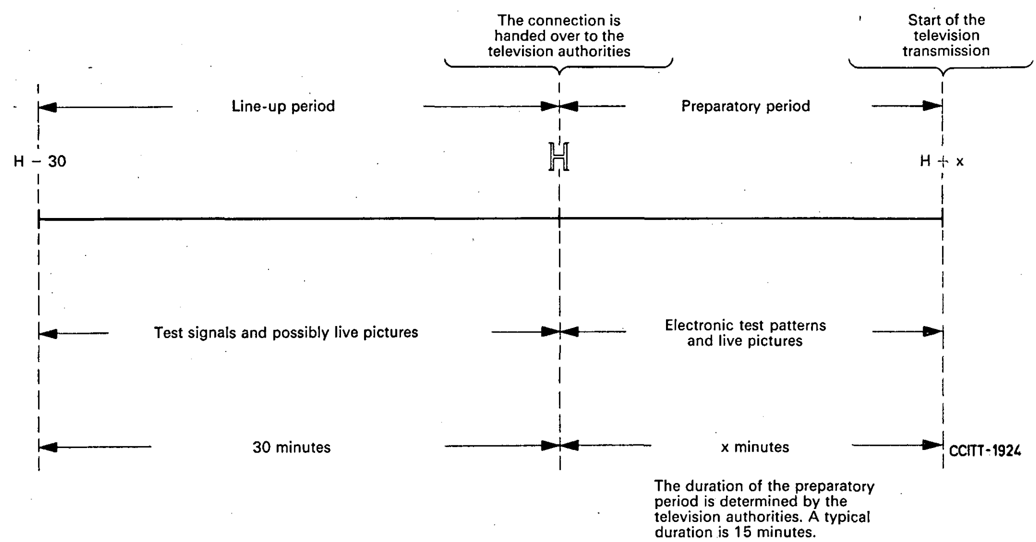


FIGURE 1/N.54. — **Duration of line-up period and preparatory period in the case of television transmissions**

RECOMMENDATION N.55

RESPONSIBILITIES OF CONTROL AND SUB-CONTROL STATIONS

1. *Responsibilities—Control and sub-control stations*

1.1 The international television link is in all cases the sole responsibility of the telecommunications administrations or private operating agencies.

1.2 The national television circuits at the ends of the link may be the responsibility of either the telecommunications administrations or the television authority or the two together depending on local arrangements in each particular country.

1.3 The I.T.C. at the receiving end (country C in Figure 1/N.51) is normally the control station for both the international television link and the international television connection. However, the choice of the station having this function is left to the discretion of the administration concerned.

1.4 The intermediate I.T.C.s where the international circuit appears at video frequencies are sub-control stations for the international television link.

1.5 The I.T.C. at the sending end (country A in Figure 1/N.51) is normally a sub-control station for the international television link and the sub-control station for the international connection. However, the choice of the station having this function is left to the discretion of the administration concerned.

2. *Responsibilities*

The functions of the control and sub-control stations are the same as for ordinary telephony (see Recommendations M.8 and M.9).

2.2—Line-up, supervision, charging and release of an international television connection[1]

It is assumed that the international television connection is as shown in Recommendation N.51. It is also assumed that the various circuits to be interconnected to constitute the international television connection are permanent circuits that are regularly maintained.

* The nomenclature adopted by C.C.I.T.T. Study Group IV (see Recommendation N.51) for international television transmission is not in accordance with that used by the C.C.I.R. in this text. The equivalent expressions are as follows:

C.C.I.R.	*C.C.I.T.T. (Volume IV)*
—	circuit-section
link	circuit
circuit	link
connection	connection
local line	national television circuit

Thus the " C.C.I.R. hypothetical reference circuit " is an assembly corresponding to a C.C.I.T.T. Study Group IV " international television link " in that it comprises three independently maintained international television circuits connected together at an I.T.C. without the need, in principle, for adjustment or correction.

RECOMMENDATION N.59

TEST SIGNALS

The test signals recommended by the C.C.I.R. for monochrome television are to be found in Supplement No. 5.1, which reproduces C.C.I.R. Recommendation 421-1 (Volume V, Oslo, pp. 66-68). A test signal that has been proposed for colour television is described in Supplement No. 5.3. Details of test signals for colour television will be published by the C.C.I.R.

RECOMMENDATION N.60

THROUGH LEVEL OF VIDEO SIGNALS AT VIDEO INTERCONNECTION POINTS

At video interconnection points, the blanking level taken as the reference level, the nominal amplitude of the picture signal, measured from the blanking level to the white level should be 0.7 V (0.714 V in Canada and the U.S.A.), while the nominal amplitude of the synchronizing signal, measured from the blanking level to the tips of the synchronizing pulses should be 0.3 V (0.286 V in Canada and the U.S.A.), so that the nominal peak-to-peak amplitude of the video signal should be 1.0 V (see Figure 1/N.60).

Theoretically, the amplitude should be measured with the useful d.c. component of the video signal restored, but in practice this is not necessary.

Note 1. — In the design of equipment, account should be taken of the losses in interconnecting cables when the video interconnection points are at some distance from the terminals of the modulating and demodulating equipment.

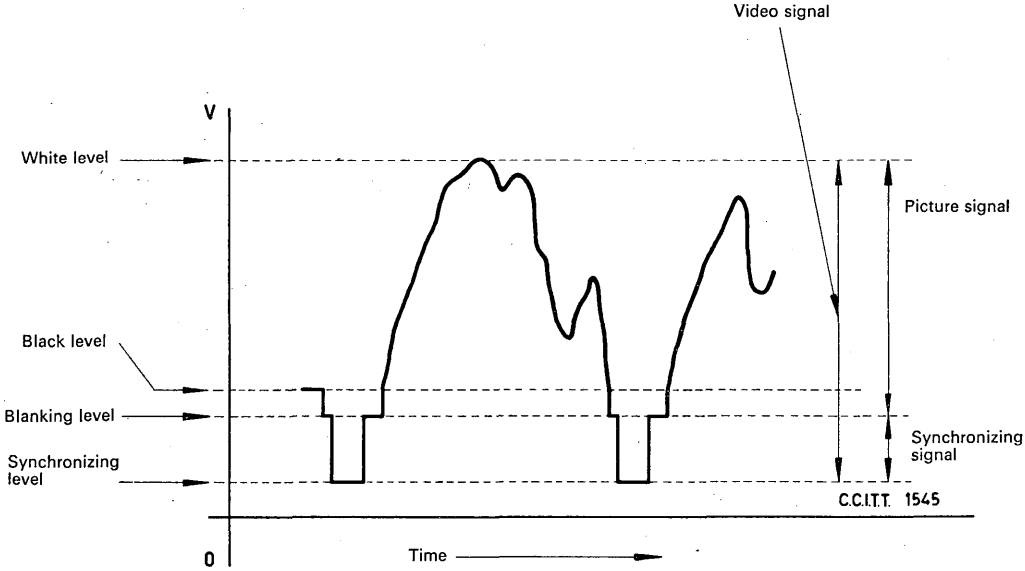
Note 2. — In Japan, for colour in system M, the above specification applies to the luminance and synchronizing signals. For the chrominance signal, further study is required.

Supplement No. 5.1 gives information concerning the characteristics of monochrome television signals used by various countries.

When the international television link is lined-up, the national television circuits are connected to the link by the terminal international television centres.

Whenever standard converters must be connected to the international television connection, it is recommended that live pictures should be sent out for a few minutes before the end of the line-up period (see Recommendation N.54). These live pictures are normally provided by the television authorities.

The international television connection is not made available to the television authorities at the two ends until the time fixed for the beginning of the preparatory period (see Recommendation N.54). The chargeable time for the television transmission commences at the beginning of the preparatory period.



V = Difference in potential between the terminal (not at earth potential) of the input (or output) impedance and earth (difference of potential positive in an upward direction)

FIGURE 1/N.60. — **Wave form of television video-signal**

RECOMMENDATION N.61

MEASUREMENTS TO BE MADE BEFORE THE LINE-UP PERIOD THAT PRECEDES A TELEVISION TRANSMISSION

The national television circuits should be so adjusted that, when they are connected to the international television link, the amplitude of the video signals at the video interconnection points is in accordance with Recommendation N.60.

RECOMMENDATION N.62

MEASUREMENTS TO BE MADE DURING THE LINE-UP PERIOD THAT PRECEDES A TELEVISION TRANSMISSION

Measurements during the line-up period are carried out by the telecommunication administrations.

In principle, they comprise adjustments of the international television link made with the aid of test signals Nos. 1, 2, 3(a) and 3(b). (Supplement No. 5.7 gives details of a test sequence adopted by the E.B.U. Some telecommunication administrations also use the sequence described in Supplement No. 5.7 during the line-up period. Supplement No. 5.4 gives a description of an electronic test pattern used by the Administration of the Federal Republic of Germany.)

RECOMMENDATION N.63

MEASUREMENTS TO BE MADE BY THE TELEVISION AUTHORITIES DURING THE PREPARATORY PERIOD

After the television authorities have taken over the international television connection, they make measurements on the complete connection in the effectively transmitted frequency band, from the point where the television programme is produced to the point or points where it is to be received.

The television authorities often use live pictures for testing during the preparatory period. If for any reason they should need to send test signals then it is desirable that the telecommunication administrations should recommend the television authorities in their countries to send, for their measurements, to the origin of the international television connection the same test signals as those used by the telecommunication administrations. The level should be in accordance with Recommendation N.60, so that the staff at intermediate video interconnection points can, if necessary, compare the results of the measurements made by the television authorities with those obtained by the telecommunication administrations during the line-up period. There is no occasion to readjust the output levels of the station equipment since these have already been set during the line-up period.

RECOMMENDATION N.67

MONITORING TELEVISION TRANSMISSIONS. USE OF THE FIELD BLANKING INTERVAL

Technical control by the telecommunication administrations of a television transmission in progress should be possible at any time:

— at national and international television centres in the connection,

— at the last staffed-station immediately preceding the frontier of each country and at a point in the station which will include as much as possible of the station equipment in the direction of transmission concerned (by providing monitoring-demodulators if necessary).

These centres and stations should be equipped with an oscilloscope (the horizontal sweep frequency of which is synchronized to the line frequency) for monitoring the electrical signal and a picture-monitor for monitoring the complete picture.

The C.C.I.R. has recommended (C.C.I.R. Recommendation 420-1) a special signal to be inserted by television authorities in the field blanking interval of a 625-line television signal. The signal is illustrated in Figure 1/N.67 and is made up as follows:

Bar signal

— amplitude: white 0.7 ± 0.007 V

— duration: $5 \dfrac{H}{32}$

— rise and fall times: approximately 100 ns or, alternatively, may be derived from the shaping network of the sine-squared pulse.

Sine-squared pulse

— half-amplitude duration: 180±20 ns.

5-riser staircase signal

— height of risers: 0.14 V approximately:

a) This signal should be inserted in lines 17 and 330. The numbering of the lines is as follows: line 1 is the one starting at the instant indicated by O_v in Figure *1b* of C.C.I.R. Report 308-1; at this instant, the front edge of the line synchronization pulse coincides with the beginning of the sequence of field synchronization pulses. The lines are numbered according to their arrival in time, so that the first field comprises lines 1 to 312 as well as the first half of line 313, whereas the second field comprises the second half of line 313 and lines 314 to 625.

b) This signal shall be removed or replaced only by the television authority situated at the lower end of the television connection.

c) Any additional national signals which may be inserted should be removed prior to the sending of the television signal over an international television link, if such a removal is requested by the television authority situated at the lower end. Exception is made for the triggering pulse when used by some organizations; in this case, such a pulse must be inserted at the beginning of lines 16 and 329 and its duration should not exceed 2 μs.

The following Annex reproduces a provisional recommendation concerning the method of inserting the test line signal.

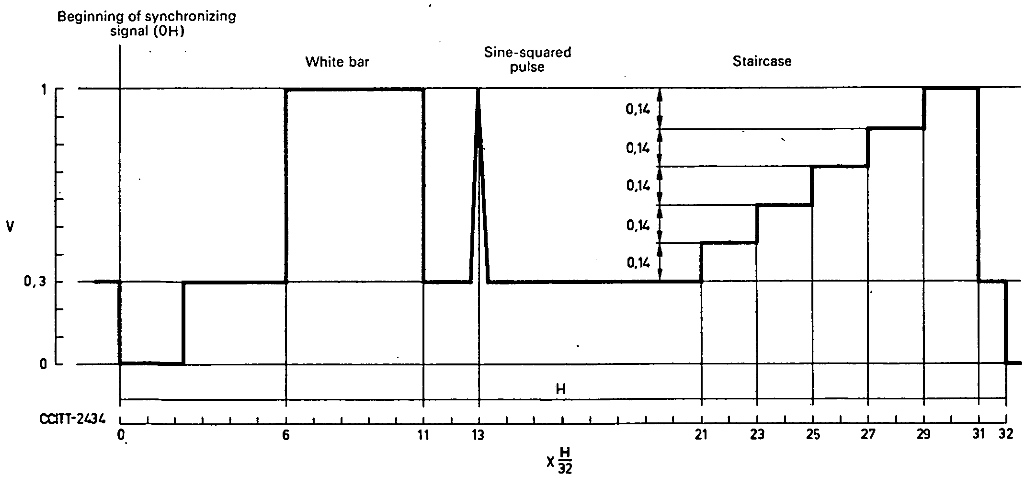


FIGURE 1/N.67. — **Monitoring signal for insertion in field-blanking interval**

ANNEX

(to Recommendation N.67)

Proposed Provisional Recommendation

Considering

that C.C.I.R. Recommendation 420-1 (Oslo, 1966) provides for the insertion of special signals in the field-blanking interval of a television signal;

that the insertion of such signals is a useful means of exercising constant supervision of the overall equivalent of an international television connection;

that the test signal, inserted in line 17 and emitted from end to end of the international connection, may be considered to serve the same purpose as a reference pilot (line, group, supergroup, etc.) in the sphere of line transmission;

that the insertion and branching of such signals can reasonably be made only at video connection points where the connection appears at video because, for technical and economic reasons, the intermediate frequency junction points are unsuitable for this purpose;

considering moreover

that it is advisable to keep line 18 for the possible insertion of an additional international signal;

that the additional special signals can be introduced (lines 19 to 21) for national needs;

it is *recommended* that

the test signal inserted in line 17 of the television signal should be regarded as an international test signal and that it should be emitted from the starting-point of the connection (production centre or the most upstream " 625 " output point of the standard converter) up to the destination point;

this signal should be available at any video connection point in order to facilitate assessment of the signal content and to readjust the equivalent television connection if necessary;

the test signals inserted in lines 19 to 21 of the television signal should be regarded as national signals and should be removed at the video connection point nearest to the frontier so that the downstream countries on the circuit may use them for their own needs;

the removal of the national signals at the point nearest to the frontier be made in any event and therefore *compulsorily* unless bilateral agreements exist between the administrations situated on both sides of the frontier, whereas points 4 of C.C.I.R. Recommendation 420-1 and Report 314 specify removal only *on request*;

and it is *requested* that:

administrations of countries where national broadcasting organizations have the sole right of transmitting television signals should approach those organizations in order that the principles of this recommendation may be applied as widely as possible.

RECOMMENDATION N.68

MONITORING FOR CHARGING PURPOSES; RELEASE OF LINE

The monitoring of an international television transmission for charging purposes is carried out at the terminal I.T.C. of the international television link.

The technical staff of the designated I.T.C. should come to an agreement among themselves so that at the end of the television transmission they have accurate knowledge of:

a) the time of handing over the television link to the television authority (beginning of chargeable duration);

b) the time at which the television link is released by the television authority (end of chargeable duration);

c) where appropriate, the times and duration of every interruption or incident which may have occurred (in order that the operating services can determine whether a rebate is due and, if so, its amount).

The times of the beginning and of the end of the chargeable duration, as well as the time of occurrence and duration of any breakdowns which may occur, are entered on a daily report. This daily report is sent on the same day to the service responsible for co-ordinating all the details necessary for the establishment of the international accounts.

The conditions for the provision and lease of circuits for television transmissions are given in Recommendation E.350 of Volume II-A of the C.C.I.T.T. *White Book.*

2.3 — Setting-up and maintenance of permanent circuits for television transmissions

RECOMMENDATION N.71

SETTING-UP THE CIRCUIT

Before starting to make measurements on the international television circuit, it is necessary to ascertain that the performance of the transmitting apparatus in the repeater stations complies with the requirements of the relevant specifications.

When each national section of the circuit and each section crossing a frontier have been corrected as regards attenuation and phase distortion in compliance with the relevant recommendations, these various sections are joined up to make the complete television circuit and the following measurements are made:

a) *steady state characteristics*

The steady state measurements (loss/frequency characteristics and group delay frequency) are carried out as indicated in Supplement No. 5.1.

b) *insertion gain*

This is measured as indicated in Supplement No. 5.1.

Provisionally, the variations in the insertion gain with time of an international circuit should not exceed:

— short-term (e.g. 1 second) variations ± 0.2 dB

— medium-term (e.g. 1 hour) variations ± 0.5 dB.

c) *noise*

Noise measurements should be carried out as indicated in Supplement No. 5.1.

Provisionally, the C.C.I.T.T. recommends that, for international circuits not more than 400 km long and for 625-line systems, a signal-noise ratio of 60 dB should be adhered to for continuous random noise. The signal-noise ratio for periodic noise has not yet been fixed. The question is now under study.

d) *non-linearity distortion*

See paragraph 3.4 of Supplement No. 5.1.

Provisionally, the m/M ratio should not be below 0.85, whether the intermediate lines of the test signal are at white or black level.

e) *linear waveform distortion*

See paragraph 3.5 of Supplement No. 5.1.

For information, Supplement No. 5.5 gives some details of provisional performance targets being studied by the United Kingdom for national television circuits analogous to international television circuits.

RECOMMENDATION N.73

ROUTINE MAINTENANCE MEASUREMENTS

Routine maintenance of international television circuits should be divided into two categories:

— station maintenance (see in Supplement No. 5.6 a note by the United Kingdom Administration concerning network switching equipment performance),

— circuit maintenance.

Before making routine measurements of radio-relay equipment or transmission equipment on coaxial cables used in the routing of international television circuits, it is necessary for telecommunication administrations to ensure that all station equipment is in good working order. Since the periodicity of this inspection depends largely on the design of the equipment, administrations are free to decide on the periodicity, according to their experience. Nevertheless, no routine maintenance measurements on television circuits should be made until the station equipment has been inspected and any necessary adjustments made.

ROUTINE MAINTENANCE MEASUREMENTS

For the routine maintenance of the circuit the following measurements should be made at the intervals shown in the following table:

Measurement	Periodicity
1. Insertion gain using test signal No. 2	Daily
2. Noise	Weekly
3. Non-linearity distortion using test signal No. 3	Monthly
4. Waveform tests using test signals Nos. 1 and 2	Monthly

The results of these routine maintenance measurements should be compared with the results of the reference measurements. If the difference obtained exceeds the permissible limits, the circuit should be considered as faulty and the fault localized.

The permissible maintenance limits have not yet been recommended by the C.M.T.T.

Supplement No. 5.4 gives details of an electronic test pattern used by the Federal German Administration (and others) which eliminates the need for some tests and increases in periodicity of others.

MAINTENANCE QUESTIONS
TO BE STUDIED BY STUDY GROUP IV
FOR THE PERIOD 1968-1972

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MAINTENANCE QUESTIONS TO BE STUDIED BY STUDY GROUP IV FOR THE PERIOD 1968-1972

Question No.	Title
1/IV	Stability of the international network
2/IV	Short breaks in transmission
3/IV	Phase changes
4/IV	Terminology for carrier systems
5/IV	Maintenance of groups, supergroups, etc. (not routed over a communication satellite system)
6/IV	Maintenance of groups, supergroups, etc. routed over a communication satellite system
7/IV	Maintenance of radio-relay links
8/IV	Limits of impulsive noise for data transmission
9/IV	Automatic re-establishment of the service by wideband switching
10/IV *	Measuring instrument specifications
11/IV *	Automatic transmission measuring equipment
12/IV *	Automatic noise measurement
13/IV *	Maintenance equipment for sound-programme circuits
14/IV	Methods to be recommended in order to reach the noise and crosstalk objectives on circuits for sound-programme transmission
15/IV	Application of quality control to maintenance measurements
16/IV	Maintenance of new systems specified by the C.C.I.T.T. and keeping Volume IV of the C.C.I.T.T. *White Book* up to date
17/IV	Effect on maintenance of the introduction of new components and of modern equipment design
18/IV	Maintenance of telephone-type circuits
19/IV	Maintenance of sound-programme circuits
20/IV	Maintenance of television circuits
21/IV	Measurements on switched connections
22/IV	Measuring the reliability of international leased circuits
23/IV	Influence of human factors on reliability

IMPORTANT NOTICE

1. An asterisk indicates that a question is urgent, i.e. that the study of the question has to be completed before the Vth Plenary Assembly.

2. Since Special Study Group D was set up by the Plenary Assembly, all questions relating to pulse code modulation (p.c.m.) have been assigned to this Study Group for the time being.

The Chairman of Special Study Group D will make arrangements with the other Chairmen for effecting liaison with the other Study Groups concerned as work progresses.

3. When a question is of interest to more than one Study Group and no joint study group has been set up to deal with it, the mention of the other Study Group(s) concerned is intended for the information of the members of the Study Group to which the question has been assigned, to enable them to arrange for the necessary co-ordination *within their national* Administrations, in accordance with a decision of the IVth Plenary Assembly.

MAINTENANCE QUESTIONS TO BE STUDIED BY STUDY GROUP IV FOR THE PERIOD 1968-1972

Question 1/IV — Stability of the international network

(continuation of Question 1 of Study Group IV, studied in 1964-1968)

— Transmission stability of international circuits.

— Long-term variations in overall loss as a function of time.

— Causes of these variations.

— Methods for improving transmission stability.

Note 1. — Reference should be made to the conclusions reached as a result of the observations made from 1964 to 1968. These appear in Supplement 4.1 of this volume of the *White Book.*

Note 2. — In studying the cause of variations, the effect of regular readjustment to the nominal value of circuit equivalent should be taken into account.

Note 3. — For finding the deviation of the mean from the nominal value (M) and the standard deviation about the mean (S), direct methods of calculation are used.
Another method for finding (M) and (S) is described in Supplement No. 10, Annex 5, of Volume IV of the C.C.I.T.T. *Blue Book.*

ANNEX

(to Question 1/IV)

Future presentation of the results of measurements in connection with the stability of the international network and information to be submitted to Study Group IV

1. *Procedure to be followed in tabulating the basic data for analysis*

To enable Study Group IV to prepare statistics from which the overall stability of the international network can be assessed, the procedure given below should be followed.

1.1 Any measurement results which are used for computation should be obtained before any adjustment is made to circuits on groups.

1.2 The results of all routine maintenance measurements made during each year should be transmitted to a special rapporteur of Study Group IV by 1 April of the following year. This special rapporteur, who should preferably have access to a computer, will compile the statistics for the study group.
The following appendix shows a model of the printed sheet to be used and how it should be completed.

2. *Information for the technical services*

2.1 Each administration should examine the results obtained for each successive set of routine measurements on all circuits between two international centres, and note the variation in the transmission loss of the circuits to obtain an indication of any significant changes. It should be possible to deduce whether the circuits are being maintained satisfactorily and how close the values are to those given in Recommendation M.16 which at present are used as the criterion of stability.

2.2 When administrations are analysing the results of the measurements obtained from the periodical routine maintenance tests, they may also wish to assess the performance of all the circuits in a given supergroup or a number of supergroups differently routed, for example. This may be readily done by suitable arrangement of the data, but the details are left to the administrations concerned.

3. *Information to be submitted to Study Group IV*

3.1 To enable Study Group IV to prepare statistics from which the overall performance of the international network can be assessed and studied, the procedure outlined below should be used in submitting the results to the special rapporteur.

3.2 The circuit measurements should be classified as follows:

i) category A circuits routed on a single group with a regulator;

ii) category A circuits routed on a single group without a regulator;

iii) category A circuits not included in classes i and ii above;

iv) category B circuits routed on a single group;

v) category B circuits routed on two or more groups in tandem.

Where a circuit is routed on a single group which is regulated in only one direction of transmission, the measurement of the circuit in the regulated direction must be placed in class i above and the other measurement in class ii.

As from 1 January 1968, the results for satellite circuits will be included in those for category B circuits. These circuits will be studied later, and measurement classes will then be defined for them.

Separate result sheets should be used for measurements made manually and those made automatically, since separate analysis will have to be made in the two cases.

3.3 For recording the results of measurements in each of the classes i to v defined above, a form similar to that reproduced in the appendix to this annex will be used. The forms, which will be sent by each administration to the rapporteur, will give the results of measurements for each direction of transmission during the period of one year for circuits for which the administration concerned is the control. Each line of the form will be devoted to one country-to-country relation, and forms giving the results of automatic measurements should bear a note to that effect. (Where there is more than one traffic route between two countries, the results for all the routes between the two countries should be combined before entering them in the appropriate class interval columns.)

3.4 The group reference pilot measurements made in accordance with M.52 for the *received* pilot level on all groups on a given relation should be analysed in a similar way.

Measurements made of incoming group and supergroup pilots in the terminal control station should be analysed in the same way as for circuits, for all the groups and supergroups of a given relation.

To obtain results it is requested that the level of each pilot should be recorded once a week on a particular day.

If the group has an automatic regulator, measurements should be made at the *input* and the *output* of the regulator.

If the maintenance period is less than one week, one only of the measurements recorded in the course of the week will be used for analysis purposes.

The results of the measurements on groups between any two administrations should be combined and entered on forms similar to that in the appendix.

3.5 The measurements of the group pilots should be classified as follows:

i) group pilots measured at the input to the regulator,

ii) group pilots measured at the output of the regulator,

iii) pilots on groups without a regulator,

iv) pilots on category B groups measured at the input to the regulator,

v) pilots on category B groups measured at the output of the regulator.

Measurements of supergroup and other pilots can be classified in the same way.

APPENDIX (to Annex to Question 1/IV)

The form of the printed sheet to be used for the submission of measurement results is given on the following page. The sheet is divided so as to correspond to the 80 columns on a punched card. It is very important that the sheet should be filled in as follows:

Columns 1 to 3. — Enter the name of the country to which the sheet applies, i.e. the controlling country for the circuits or groups, using the code in the Routine Maintenance Programme. Always begin with column 1 regardless of the number of letters in the code (1, 2 or 3).

Columns 4 to 6. — Enter the name of the foreign country with which the measurements have been carried out, using the same code as for columns 1 to 3; always begin with column 4 regardless of the number of letters in the code.

Column 7. — a) For circuits: Enter the letter E on the line for the measurements carried out by the foreign country and the letter D on the line for the measurements carried out by the controlling country; always begin with the letter E.

b) For groups and supergroups: no entry to be made in column 7.

Columns 8 to 75. — These columns show the number of measurements classified according to the deviation in centinepers, of the received level from the nominal value; these deviations are divided into 27 steps.

Each of these steps has been divided into columns as follows:

To allow for numbers with four digits, each of the three central measurement steps has been divided into four columns; these columns are headed by m (thousands), c (hundreds), d (tens) and u (units).

Four steps on either side of the three steps mentioned above have each been divided into three columns: these columns are headed by c (hundreds), d (tens) and u (units) and may thus contain numbers with three digits;

Each of the other steps has been divided into two columns and may thus contain numbers with two digits.

Numbers which do not require all the columns available should *not* be preceded by a zero.

Columns 76 to 78. — In the case of the results of measurements made in the 2nd half of 1967 the figures 2.67 should be entered; for subsequent annual periods the figures 68, 69, etc. should be entered in columns 77 and 78 only, column 76 being left blank.

Columns 79 and 80. — Class of measurements: column 79 indicates the class of measurement as listed in point 3.3.2 for circuits and in 3.3.5 for groups and supergroups in document COM IV—No.140 (1964-1968). Column 79 should therefore show the digits 1 to 5 as follows:

CCITT-2625

STUDY GROUP IV	Observations on the stability of the international network

COUNTRY: FRANCE

Deviation in cNp of the received level from the nominal value

PERIOD			CLASS	
2	6	7	2	C
76	77	78	79	80

Control country	Foreign country	D / E	< - 62,4	- 62,4 - 57,5	- 57,4 - 52,5	- 52,4 - 47,5	- 47,4 - 42,5	- 42,4 - 37,5	- 37,4 - 32,5	- 32,4 - 27,5	- 27,4 - 22,5	- 22,4 - 17,5	- 17,4 - 12,5	- 12,4 - 7,5	- 7,4 - 2,5	- 2,4 + 2,5	+ 2,6 + 7,5	+ 7,6 + 12,5	+ 12,6 + 17,5	+ 17,6 + 22,5	+ 22,6 + 27,5	+ 27,6 + 32,5	+ 32,6 + 37,5	+ 37,6 + 42,5	+ 42,6 + 47,5	+ 47,6 + 52,5	+ 52,6 + 57,5	+ 57,6 + 62,5	> + 62,5
			d u	d u	d u	d u	d u	d u	d u	d u	c d u	c d u	c d u	c d u	m c d u	m c d u	m c d u	c d u	c d u	c d u	c d u	d u	d u	d u	d u	d u	d u	d u	d u
F	GB	E	1							1			2	10	94	146	73	38	3										
		D					1				3	5	9	8	23	152	48		12	1		1							
F	DRF	E						2				7	9	27	63	128	23	4	5		1								
		D							1		3	2	10	19	52	124	19	7	2				1						
F	B	E								1	3	1	4	10	24	75	12	3		1									
		D					1			2		2		10	25	82	18	11	2										
F	I	E							1		3			9	31	38	19	6		1									
		D	1					2		2	1	1	1	13	22	46	30	7	4		1								
F	CS	E			1				2				1	3	5	12	2	1		1									
		D										1		1	7	12	3		1										
1 2 3	4 5 6	7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25 26	27 28 29	30 31 32	33 34 35	36 37 38 39	40 41 42 43	44 45 46 47	48 49 50	51 52 53	54 55 56	57 58 59	60 61	62 63	64 65	66 67	68 69	70 71	72 73	74 75

1 for i
2 for ii
3 for iii
4 for iv
5 for v

Column 80 should indicate whether it is circuits or groups and supergroups that are concerned as well as the measurement procedure (manual or automatic).

The following code is proposed:

C — for measurements carried out *manually* on circuits;
A — for measurements carried out *automatically* on circuits;
P — for measurements of group pilots;
S — for measurements of supergroup pilots.

The example shown on the printed sheet on the preceding page refers to category A *circuits* set up on a single group without regulator (2/C in columns 79 and 80), measurements made during the second half of 1967 (2.6.7 in columns 76 to 78).

The example refers to measurements carried out by France (F) on circuits which it controls with a number of other countries.

Question 2/IV — Short breaks in transmission

(former Question 2 of Study Group IV, studied in 1964-1968)
(concerns also Study Groups IX and Special A)

a) Statistical study of the duration and frequency of occurrence of short breaks in transmission and of sudden level variations on an international telephone circuit.

b) Investigation into the most likely causes of these incidents in transmissions.

c) Precautions to be recommended for reducing the scale of short breaks, interruptions or level variations to a minimum.

Note 1. — Study of this question should make it possible:

— to inform the services concerned of the degree and the frequency of a) short breaks in transmission; b) sudden level variations on the circuits;
— to make investigation into the causes of these incidents of short duration interfering with the reception of signals, by making a detailed analysis of the distribution of these incidents.

Note 2. — See Annex 1 below for " instructions for carrying out future tests ".

Note 3. — Some information about the investigations carried out up to 1960 will be found:

— on pages 518 to 522 of Volume I of the C.C.I.F. *Green Book* (investigations up to 1954);
— on pages 434 to 438 of Volume I of the C.C.I.T.T. *Red Book*, for investigations undertaken between 1954 and 1956; and
— in section 3 of Supplement No. 9 in Part III (documentary) in Volume IV of the *Red Book* (investigations from 1956 to 1960);
— in section 2 of Supplement No. 10 in Part III (documentary part) of Volume IV of the *Blue Book* for investigations from 1961 to 1964;
— in Supplement No 4.2 of Volume IV of the *White Book* for investigations during 1964-1968;
— in Annex 2 below concerning a study for data transmission made by the U.S.S.R. Administration in 1964-1968;
— in Annex 3 below concerning data transmission studies in Europe during 1961-1964.

ANNEX 1

(to Question 2/IV)

Instructions for carrying out future tests of short breaks in transmission

1. *Setting up of test circuits*

To simplify the identification of causes of interruptions, the selected circuits should, as far as possible, be set up on a single type of transmission system, i.e.:

— symmetric pairs,
— submarine cables,
— land coaxial cable,
— radio-relay link, etc.

2. *Forms to be used*

Only two types of form should be used (examples of these are given in the following Appendices 1 and 2). Form A will be used to record " Breaks observed during day-time and night-time throughout the test series " and Form B will give the results for each of the following categories of interruptions:

— 0.5 ms to 1 minute
— 5 ms to 1 minute
— 20 ms to 1 minute
— 300 ms to 1 minute

For interruptions of more than 300 ms, an attempt will also be made to assess the probability that a break in one direction of transmission of a circuit is accompanied by a simultaneous break in the other direction of the same circuit. This probability will be expressed as a percentage of the number of cases observed.

3. *Breaks of short duration in the group and supergroup frequency-bands*

Knowledge of these interruptions would be very useful for very high-speed data transmission. Administrations having the means to carry out these measurements are invited to collect material on the international network, if practicable, or on a national basis, and to make the results available to Study Group IV.

4. *Information on existing equipment for short-break measurements*

Administrations having measuring equipment capable of detecting and recording breaks of duration as short as 0.5 ms are asked to submit information on the respective characteristics to Study Group IV to enable it to specify a standard apparatus.

Study Group IV will make further studies under Question 10/IV concerning specifications of apparatus for measuring short breaks.

5. *Definitions*

The following definitions should apply for the purposes of the tests:

5.1 *Work*

Operations which adversely affect the circuit, group, etc., and which can be either:

— any operation by persons other than the staff of the administration or private operating agency, e.g. public works employees, civil engineers;

— any operations (other than maintenance operations on the circuit, group, etc. under consideration) by the staff of the administration or private operating agency from which an adverse effect on the circuit, group, etc. under consideration, was not to be expected as a matter of course, e.g. maintenance or other operations on another circuit, group, etc.

5.2 *Maintenance*

Permitted operations (for example, testing, measuring, readjusting or repair) made on a circuit, group, etc., which, by causing a break or breaks of significance, adversely affect the circuit, group, etc.

5.3 *Series of breaks*

The following definitions have been accepted provisionally:

a) Any period during which the interruption rate is 3 or more breaks per minute is called a " *3-break per minute* " series of breaks.

b) Any period during which the interruption rate is 7 or more breaks per 10 minutes is called a " *7*-break *per 10 minutes* " series of breaks.

The end of such a period may be some distance from the beginning, for example, 1 hour. It occurs only when the interruption rate falls below 7 interruptions per 10 minutes.

When it is necessary to identify a series of interruptions with respect to time, this should be done by mentioning the moment at which the series begins and by specifying the type of series.

Separate recording is not made of periods at the " 3-break per minute rate " if these periods occur within a period at which the interruption rate is 7 or more per ten minutes.

Some care is therefore necessary to ensure that there is no " double recording " of breaks and series of breaks.

The definitions of series of breaks may possibly be revised when a new series of observations on the international network is arranged.

APPENDIX 1 (to Annex 1 to Question 2/IV)

FORM A

Circuit:

Breaks observed during the day and night throughout the 9th series of tests

Cause of short breaks in transmission			Isolated breaks												Series of breaks	
			< 1 ms	1 to 5 ms	5 to 10 ms *	10 to 20 ms	20 to 100 ms	100 to 300 ms	300 ms to 1 s	1 s to 2 s	2 s to 5 s	5 s to 30 s	30 s to 1 min	> 1 min	7 per 10 min	3 per min
Faults	Power supplies															
	Cables															
	Radio-link fading															
	Equipment	Terminal of carrier frequency line														
Maintenance	Power supplies															
	Terminal equipment															
	Frequency gen. equipt.															
	Line															
Work	Power supplies															
	Cables															
	Station															
	Other															
Cause unknown																
Total																

* Administrations using instruments that do not distinguish durations of less than 5 ms should enter all breaks of 10 ms or less in this column.

APPENDIX 2 (to Annex 1 to Question 2/IV)

FORM B

Hourly incidence of breaks over the test period

Category of breaks: (duration): ....ms to 1 minute

	0800 to 0900	0900 to 1000	1000 to 1100	1100 to 1200	1200 to 1300	1300 to 1400	1400 to 1500	1500 to 1600	1600 to 1700	1700 to 1800	1800 to 1900	1900 to 2000	2000 to 2100	2100 to 2200	2200 to 2300	2300 to 2400	2400 to 0100	0100 to 0200	0200 to 0300	0300 to 0400	0400 to 0500	0500 to 0600	0600 to 0700	0700 to 0800
Week 1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
Totals																								

The total number of breaks within each hourly period is required for the category of breaks in question.

ANNEX 2

(to Question 2/IV)

Study of short interruptions in telephone channels designed for data transmission

(by the U.S.S.R. Telecommunications Administration)

1. Variation of overall telephone circuit loss on cable routes is the consequence of a great number of different causes and, as a rule, follows the normal (Gaussian) law of distribution. However, recent studies have shown that there are short and long level variations (mostly reductions) which do not obey this law. These level variations are one of the main factors to which errors in data transmission channels and failures of channels are attributable.

Therefore, the indication by COM Sp. A concerning the necessity to study short interruptions endangering data transmission is opportune (document COM Sp.A—No. 106 (1964-1968), page 16).

2. In the U.S.S.R. measurements of the distribution of level reductions according to value and duration were carried out on telephone channels of the trunk network with the help of an impulsive noise and interruption analyser. The block diagram and brief description of the device are given in Appendix 1.

Analysis of the results of measurements lasting several hundred hours revealed that the probability of a pilot level being lower than the given threshold varied with time very considerably and was substantially different on various routes.

Figure 1 shows several examples of the distribution of total level reduction duration as a function of level reduction value on various long-distance non-switched channels (3000-4000 km).

All reductions including those of more than 300 ms were taken into account. Most of the curves show a sloping equiprobable section in the area where the level reduction is more than 1.5 Np which is explained by a great share of complete level drops (more than 2.0 to 2.5 Np).

The operation feasibility of data transmission equipment is limited. Level reductions of 2.0 Np and more usually give rise to an increase in error rate. At the same time there is a very low probability that smaller values of level reductions (less than 1 or 2 Np) would produce errors in transmitted information.

Bearing in mind these considerations, it would be advisable to take interest only in considerable level reductions (more than 2.0 Np) which may be provisionally called *interruptions*.

Thus, while measuring the possibility to use a telephone channel for data transmission at an average rate (600-2400 bauds) it is possible to measure solely the probability of total interruption duration P_b instead of plotting the whole distribution curve of level reduction values.

Using the measured value of interruption probability, one may approximately determine the usefulness of the channel for data transmission and the error rate in it. During an interruption, i.e. when there is no information, the provisional error probability is equal to ½; hence one may calculate the error rate due to interruptions according to formula:

$$P_e = \tfrac{1}{2} P_b.$$

The degree of inaccuracy of this assessment may be reduced by excluding the short interruptions of less than a single unit interval which produce errors with low probability. Furthermore,

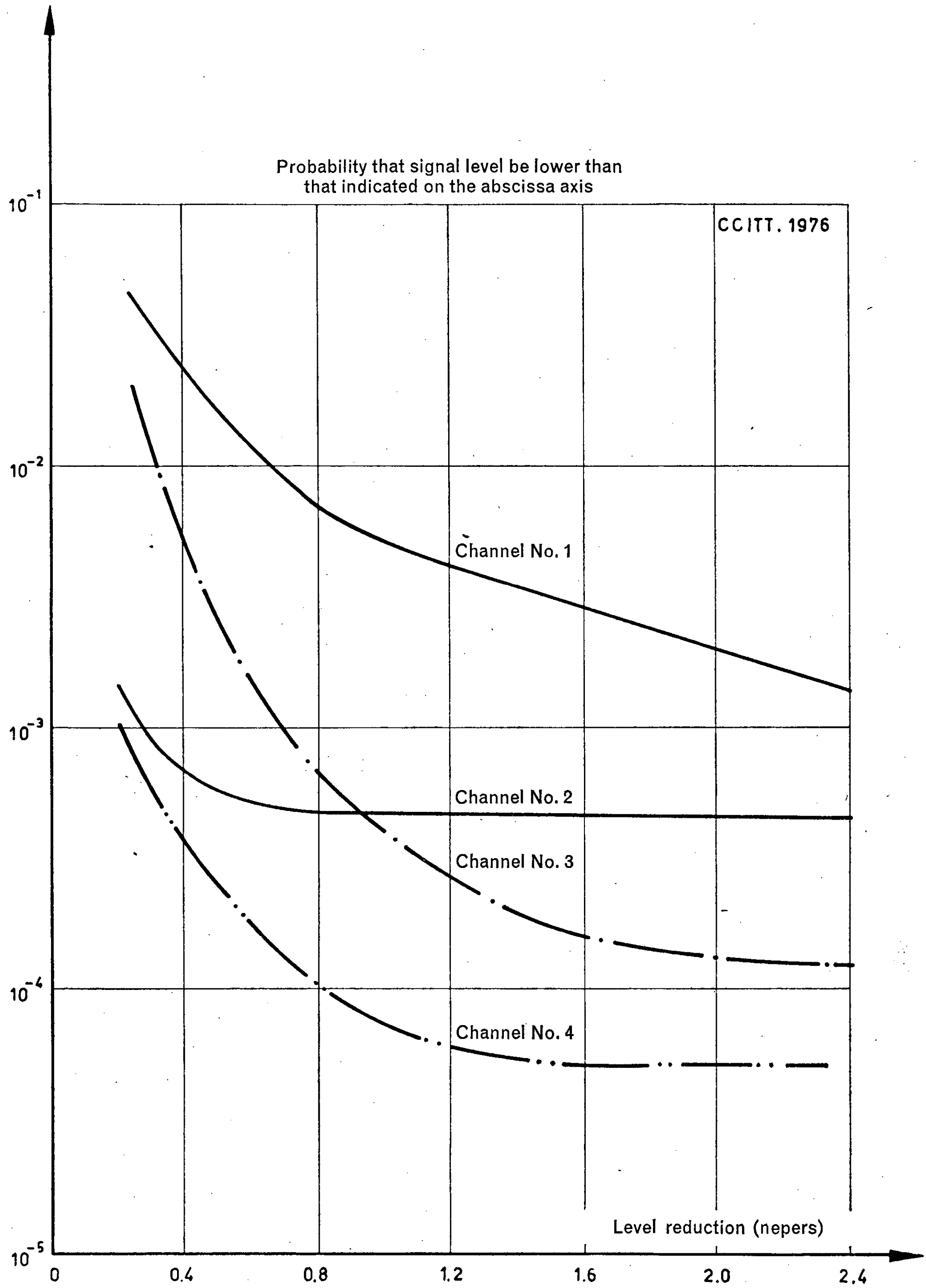

FIGURE 1. — **Examples of distribution of level reductions**

interruptions of more than 300 ms may be neglected considering that they do not influence the error rate but give rise to a reduction of system reliability (occurrence of failures).

3. Better accuracy, as indicated above, could be obtained by using the interruption distribution versus duration curve. Furthermore, knowing the duration of interruptions it is possible to locate them and eliminate their causes.

Interruption duration measurements carried out on various non-switched channels of the U.S.S.R. trunk network showed that the distribution of interruption durations is very nearly the same for channels of various lengths and for channels on various routes. An example of interruption distribution versus duration on one of the channels is shown in Figure 2 (Curve *a*).

The curve illustrates that 75% of interruptions lasted less than 150 ms. Therefore, it is to be understood that channels intended for telephone conversations, during which interruptions of less than 0.15 s are hardly perceptible, cannot always be used for data transmission. This circumstance urgently demands the individual testing of each channel intended for intermediate rate data transmission despite the fact that this channel may be successfully used for telephone calls.

If interruptions influencing the error rate are the only ones to be taken into account, the studies may be confined to interruptions lasting more than 300 ms (Curve *b* in Figure 2).

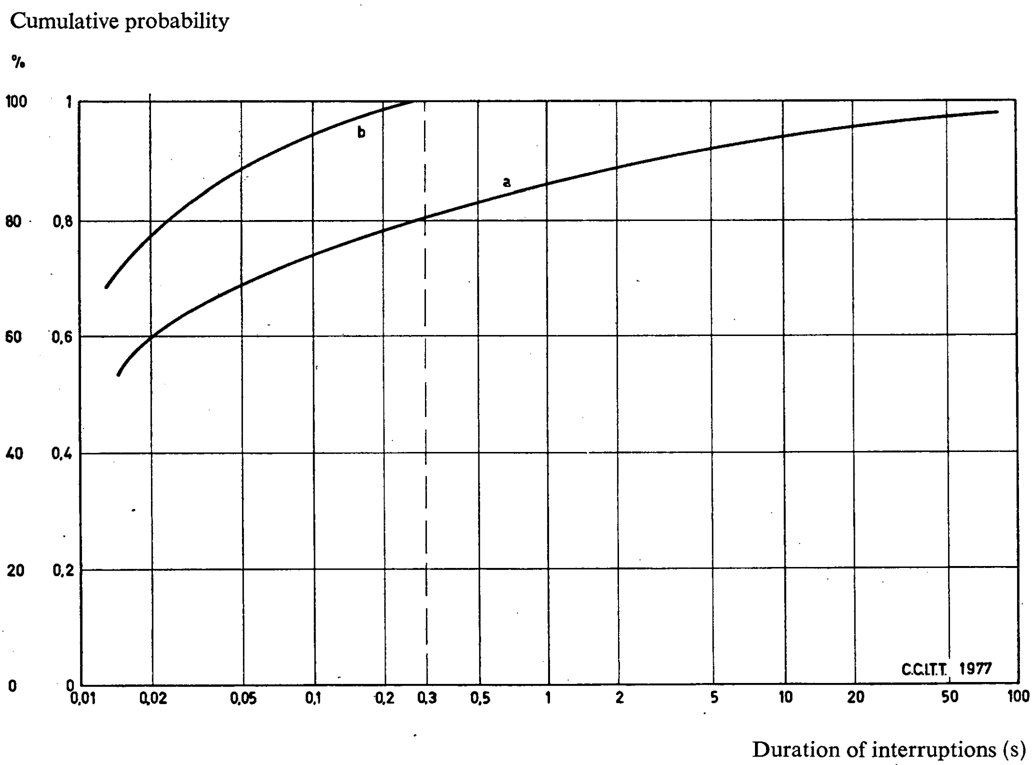

FIGURE 2. — **Example of cumulative distribution of interruption durations**

4. The interruption characteristics of a telephone channel considered above give an average assessment within long periods of time. However, this is insufficient to determine the possibility of using a channel for data transmission within short periods. To obtain such an assessment it is necessary to describe the distribution of interruption occurrence in time. The previous assumption concerning the independence of interruption flow had to be revised (together with the assumption of independence of errors). Measurements carried out in the U.S.S.R. on a large number of point-to-point and switched channels in trunk and local networks showed that there was a strong tendency to interruption grouping.

This may be illustrated by an example of distribution of intervals between successive interruptions measured on several channels of one of the main routes (see Figure 3). It is known that the distribution of intervals between independent events of the Poisson flow should obey the exponential law of the form:

$$F(x) = 1 - e^{-\lambda x},$$

where λ is a parameter of the Poisson law.

Figure 3 reveals a considerable difference between the experimental and exponential curves which means rejecting the hypothesis of the independence of interruptions.

It was assumed while plotting the experimental curve in Figure 3 that the intervals between interruptions were much longer than the interruptions themselves; thus it was possible to reduce an interruption to a point and to consider it as " an event ".

Measurement of the distribution of duration of intervals between interruptions was carried out with the help of the device described in Appendix 2.

5. Analysis of Figure 3 makes it possible to state the hypothesis that interruptions are grouped in " bursts " representing independent events obeying Poisson's law.

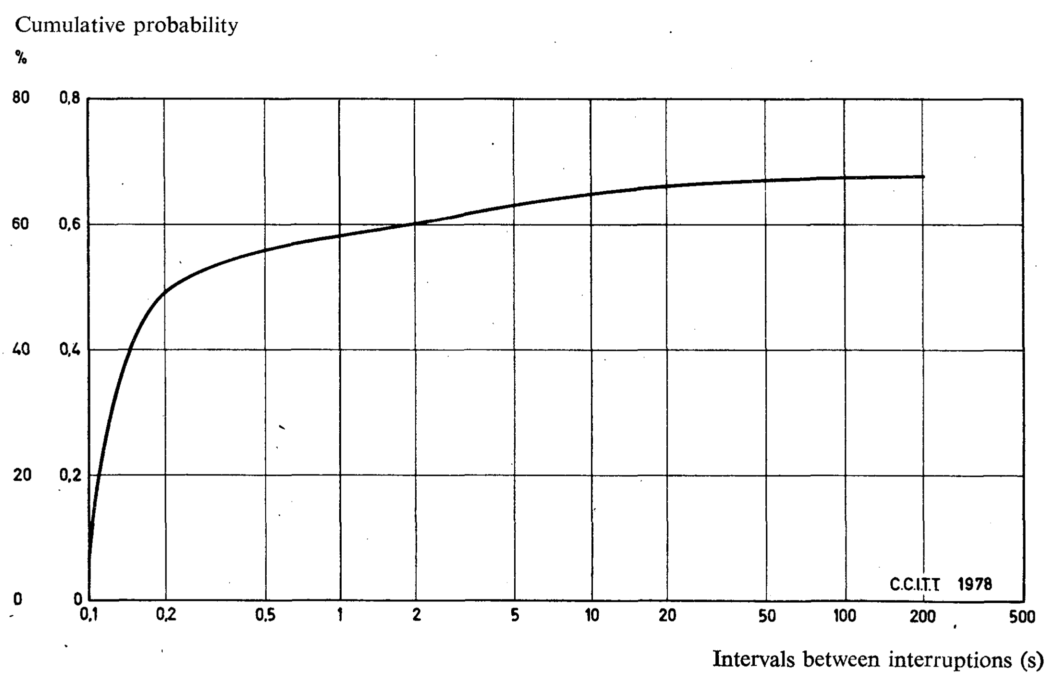

FIGURE 3. — **Example of a function of distribution of intervals between interruptions**

By a burst of interruptions we mean several interruptions (in the special case, a single interruption) the intervals between which do not exceed the burst-build-up criterion " τ ". Burst-build-up criterion has to be chosen so as to ensure a maximum degree of independence for the bursts and at the same time a minimum number of independent interruptions combined in bursts. It may be assumed that the burst-build-up criterion " τ " lies in Figure 3, on the abscissa axis at least behind the last point of curve inflection ($\tau = 10$ s).

Experimental studies of the flow of interruption bursts with the burst-build-up criterion $\tau = 10$ seconds on various channels of the U.S.S.R. trunk network showed that the bursts were independent and obeyed Poisson's law.

Several sections with various parameters λ are shown in Figure 4. Measurements were conducted with the help of the interruption burst counter described in Appendix 3.

During long test periods (of several hundred hours) the Poisson parameter is a variable quantity which is an indication of an unstationary Poisson flow. However, it proved to be possible to divide the burst flow, which was on the whole unstationary, into a number of stationary sections, several hours long, within which the parameter remained a constant quantity:

$$\lambda(t) = \lambda.$$

This circumstance may be very useful since the stationary Poisson flow can easily be assessed by its sole parameter λ. Even the short measurement of this parameter makes it possible to assess to a certain degree of probability the state of a channel within a stationary period lasting many hours.

The use of similar procedure to measure the flow of interruptions that have not formed bursts does not make it possible to predict the flow intensity in the same easy way because the flow is unstationary.

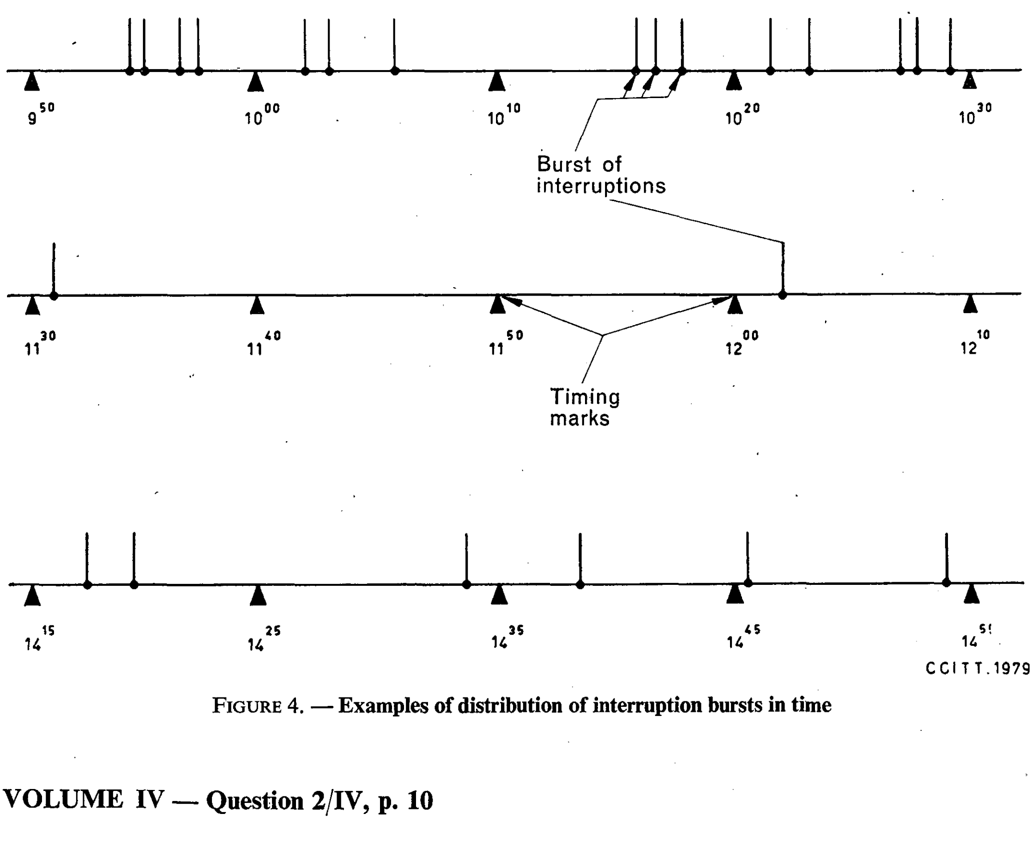

FIGURE 4. — **Examples of distribution of interruption bursts in time**

6. The determination of interruption burst distribution presents a certain interest. It may be obtained by the measurement of two characteristics:

— interruption number distribution in a burst,

— burst duration distribution.

These two distribution functions plotted from the results of measurements of long-distance cable channels on trunk lines in the U.S.S.R. are shown in Figures 5 and 6.

The number of interruptions occurring in bursts was determined with the help of the device described in Appendix 2 whereas the duration of bursts was measured with the help of the device described in Appendix 3. In all cases the burst-build-up criterion adopted was equal to 10 seconds.

As seen from Figure 5, the number of interruptions occurring in bursts is sufficiently large (approximately 30% of bursts have more than 5 interruptions). Figure 6 indicates that the duration of bursts is considerable (approximately 30% of bursts are longer than 10 s).

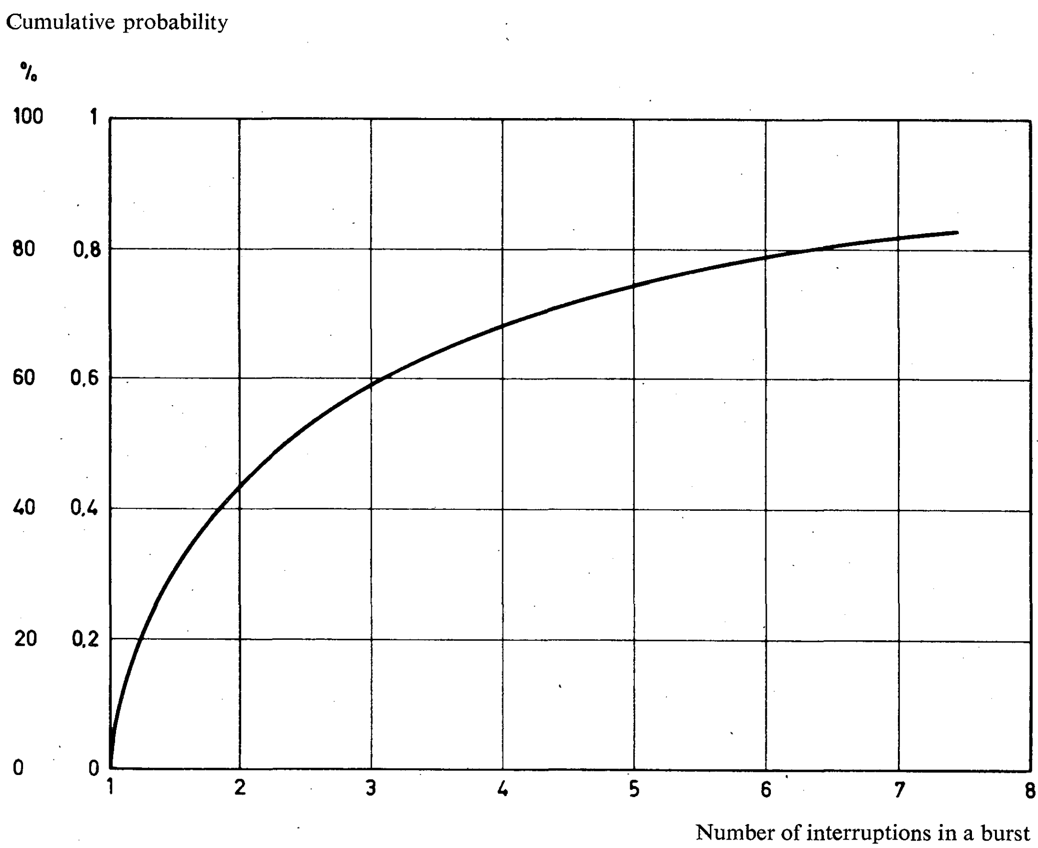

FIGURE 5. — **Example of a function of distribution of interruption number in a burst**

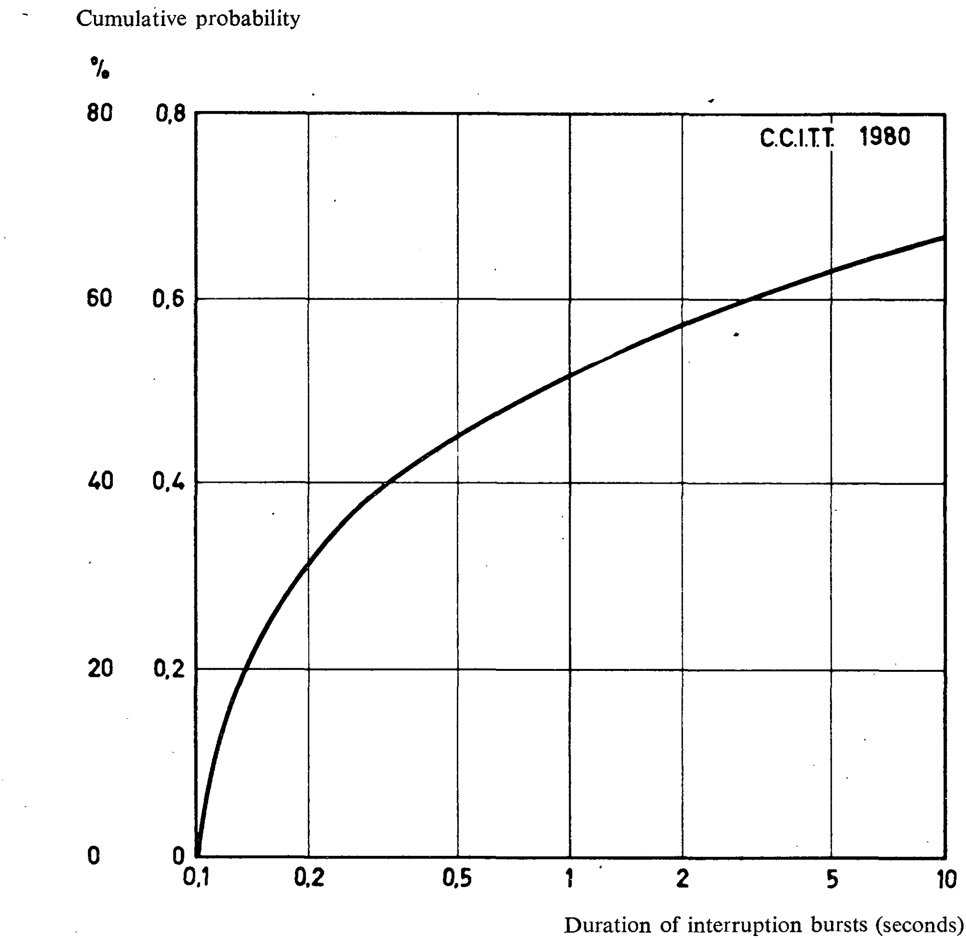

FIGURE 6. — **Example of a function of distribution of duration of interruption bursts**

APPENDIX 1 (to Annex 2 of Question 2/IV)

Interruption analyser

The analyser is intended for the study of the distribution of interruptions in telephone channels. The analyser makes it possible to obtain the distribution of values of signal level variations and the distribution of level reduction duration at one of the thresholds.

The device provides for multichannel application. The measurement results appear in binary notation on an electronic display which contains 20 electronic counters. Every counter can register up to 2^{20} pulses. Measurement results are photographed at the operator's will or automatically with an interval of 30 minutes or under the action of an overflow signal from one of the counters.

The analyser (Figure 7) comprises three principal units: level reduction analysing unit, duration analysing unit and counter unit.

The principles of the analyser operation are as follows. A pilot signal passes from the channel to the input of the amplifier A1. The amplified signal is applied to the modulator M where the signal frequency band is translated in the frequency band of 16.6 to 19.2 kHz. After detection by detector D and filtration by filter F2 the signal reaches the threshold circuits TC0-TC7.

Signal band translation makes it possible to detect easily even the shortest interruptions (0.3 ms and less).

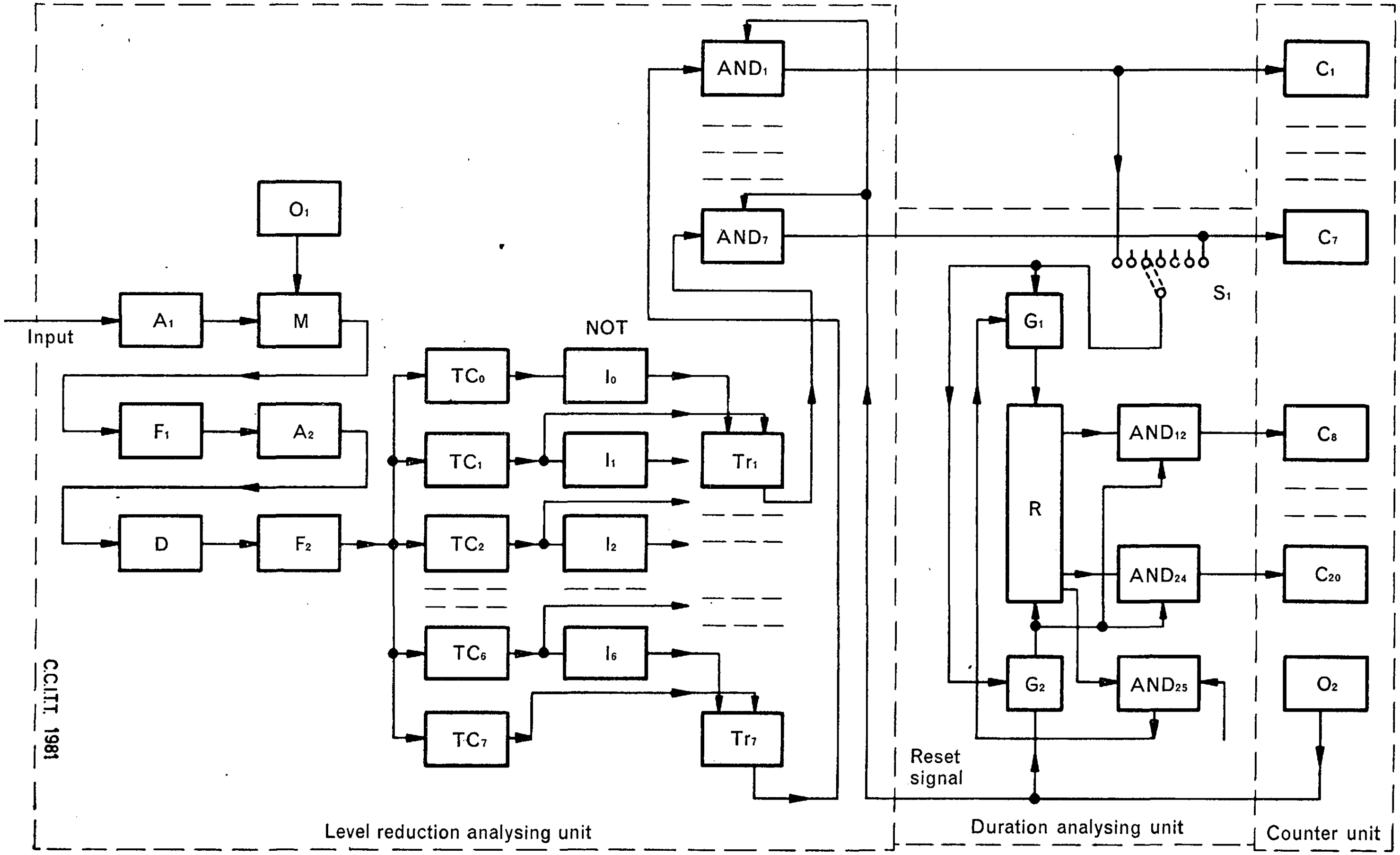

FIGURE 7. — **Interruption analyser block-diagram**

Triggers Tr1-Tr7 together with threshold circuits and NOT circuits give shape to the pulses being equal to the period of pilot level reduction. These pulses are applied to the first inputs of AND1-AND7 circuits, while the pulses from oscillator O2 are applied to their second inputs. From AND circuit inputs the pulses pass onto the counters C1-C7 which register the total time of pilot level reductions below each of the thresholds.

The duration of level reduction is analysed at the output of one of the AND circuits. Switch S1 selects the threshold analysed. Pulses from the AND circuit output are applied through gate G1 to the register R and simultaneously switch off the reset pulses from register R by means of gate G2.

Under the action of pulses, the register prepares in succession AND12-AND24 circuits. The number of pulses determines the duration of a period when the threshold is exceeded and defines the index of the AND circuit prepared as a result of the arrival of these pulses. At the end of the period when the threshold was exceeded, the pulses at the AND circuit output disappear. As a result the gate G2 is on and the first pulse from the oscillator O2 resets the register R to zero. Reset pulses, after their passage through the AND circuit, are registered by counters C8-C20.

If the number of pulses applied to the register exceeds its capacity the register is stopped by AND25 circuit and G1 until the arrival of a reset pulse.

APPENDIX 2 (to Annex 2 of Question 2/IV)

Device for measuring the duration of interruptions and intervals between them

To obtain the distribution of the duration of interruptions and intervals between them, a device was used in conjunction with a 20-channel electronic display described in Appendix 1.

Figure 8 shows the block diagram of the device.

When there is a pilot level reduction, the amplitude selector shapes a pulse which is applied through the differentiating circuit DC to the squaring circuit SC. The squaring circuit makes it possible for the first trigger of the commutator to be driven by both the leading and trailing edges of the pulse generated by an amplitude selector. The commutator comprises binary counters (triggers Tr1-Tr5) and a decoder.

The pulse corresponding to the moment of decrease in signal amplitude below the selected threshold passes to the input of the first trigger Tr1. The trigger trips over. The states of triggers Tr1-Tr5 indicate the arrival of one pulse.

The states of commutator triggers are determined by a decoder. From the decoder outputs pulses are applied to the AND circuit inputs. Timing frequency pulses are permanently applied to the second inputs of AND1-AND20 circuits (with pulse repetition rate equal to 300 μs); after passing the corresponding AND1-AND20 coincidence circuits these pulses are applied to the pulse counters. At the end of interruption the pulse corresponding to the moment of pilot level recovery in the channel is applied to the input of trigger Tr1 from the amplitude selector output. At this moment the potential is applied from the decoder circuit to the AND2 circuit. Counter 2 begins the counting of timing pulses. Counter 1 stops the counting.

Thus, using the first counter reading and knowing the timing pulse repetition rate one can determine the interruption duration; using the readings of the second counter it is possible to determine the intervals between interruptions. The counter capacity is 2^{20}. The total number of counters is 20.

The circuit operates similarly when the next interruption occurs. Counter 2 stops whereas counter 3 begins counting.

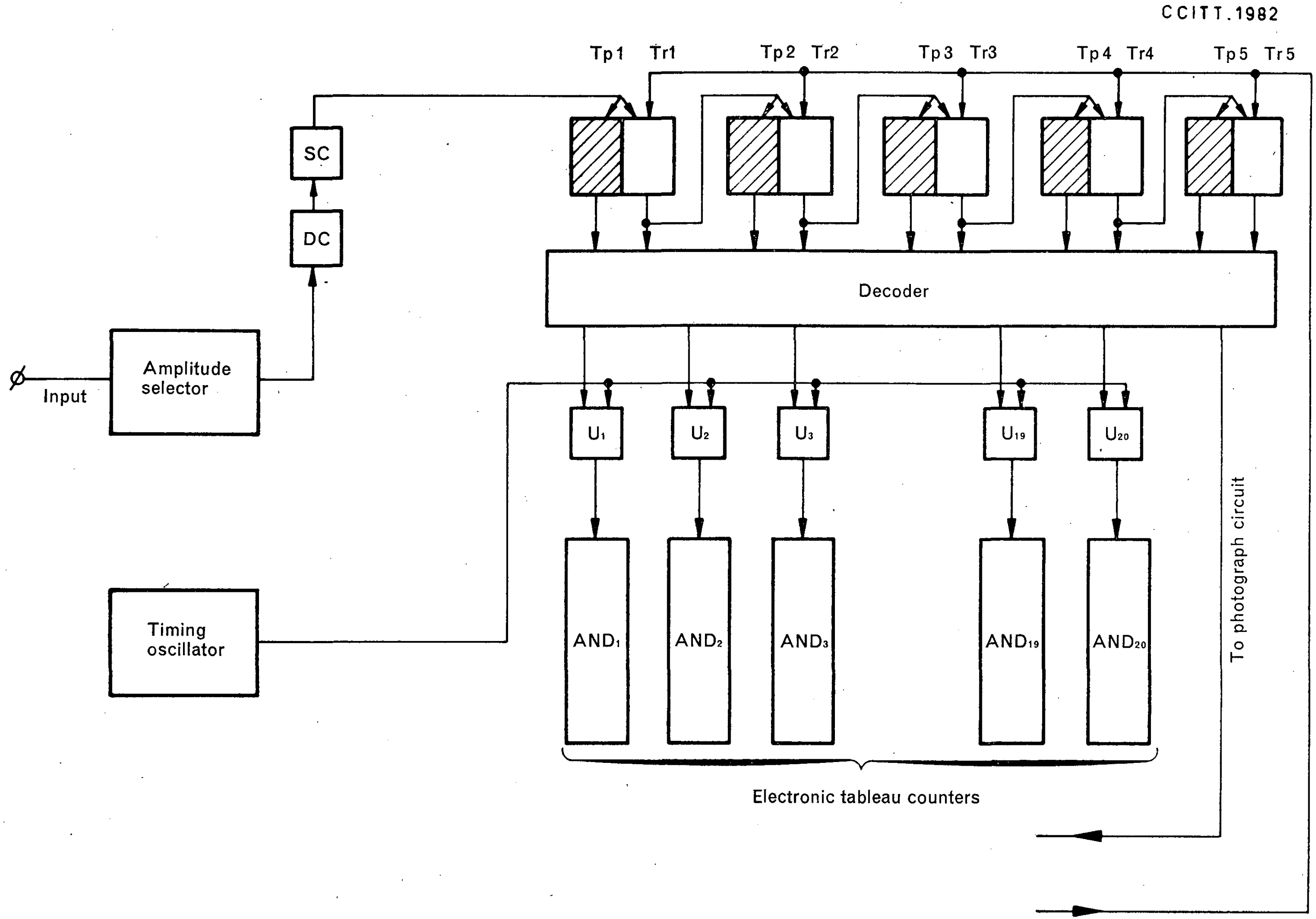

FIGURE 8. — **Block-diagram of set for measuring of duration of interruptions and intervals between them**

At the moment of arrival of the 21st pulse the display is photographed, triggers and counters are reset. The display comprises a clock, the readings of which are photographed.

When one of the counters reaches overflow in the case of a long interruption or long interval a photograph is taken. Under these circumstances triggers and counters are reset by a counter overflow signal. The period of time from the moment a photograph is taken up to the moment the device is ready for work is approximately 10 seconds.

The camera used has an automatically operated shutter for 10-15 pictures.

APPENDIX 3 (to Annex 2 of Question 2/IV)

Interruption burst recorder

To register bursts of interruptions, a self-recording unit with a sufficiently high tape-speed and with a low-inertia recording instrument is employed. The function of shaping a signal which is applied to the self-recording unit is performed by an interruption-burst shaping-circuit.

By an interruption burst we mean a sequence of interruptions in which the interval between two successive interruptions does not exceed the prescribed value (the so-called burst-build-up criterion).

Block diagram of the device is shown in Figure 9.

The input signal is applied to an amplifier and then to a threshold circuit. When the reduction of the signal level is more than 2 Np during the time period covering more than 0.5 ms the threshold circuit is operated. A Schmidt trigger shapes the pulse the duration of which is equal to level reduction duration in the channel.

From the output of the Schmidt trigger the signal is applied to the delay network which gives shape to a signal having duration $t + \tau$, where:

t = interruption duration,

τ = burst-build-up criterion.

As a result of this, separate interruptions are grouped into interruption bursts. From the output of the Schmidt trigger a signal leading edge is applied to the second delay network which introduces a delay $\tau_1 = 0.3$ s. From the output of the Schmidt trigger and delay network τ_1 the signals pass to the input of the time comparator. At the comparator output a signal appears having a delay equal to 0.3 s. The two signals received through resistors R1 and R2 are applied to the amplifier input and then to a self-recording unit.

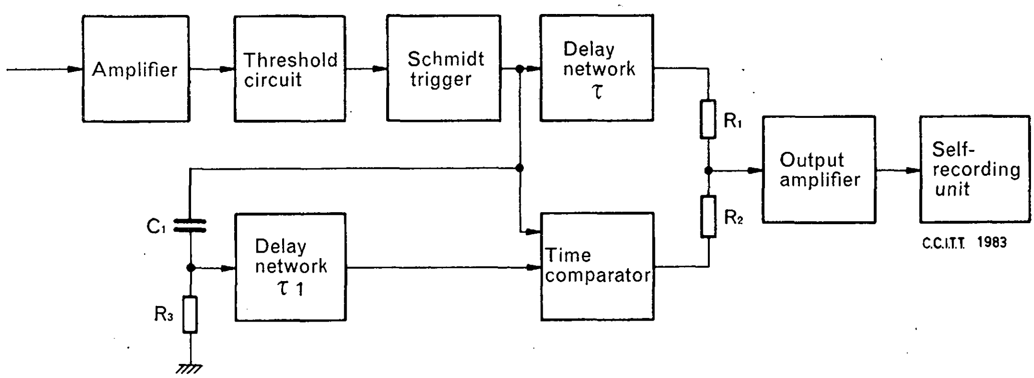

FIGURE 9. — **Block-diagram of the device for registration of interruption bursts**

As a result of the circuit operation, a sequence of interruptions of which none exceeds 0.3 s is converted in a signal with amplitude A. If there are interruptions of more than 0.3 s, the signal amplitude at the amplifier output reaches the value $2A$ in 0.3 s.

Thus, with interruptions of less than 0.3 s, a step of unit amplitude is registered on the tape, which is an indication of a burst of short interruptions, whereas with interruptions of more than 0.3 s the amplitude of a step is doubled.

The duration of bursts of interruptions and the moments of their occurrence may be determined with the help of the tape with an accuracy which is limited by the tape speed and the degree of irregularity of its feed.

If necessary, timing marks may be recorded on the additional track of the self-recording unit.

ANNEX 3

(to Question 2/IV)

Circuit outages and data transmission

Data transmission tests over a multipoint circuit, which links London, Paris, Frankfurt and Rome, were carried out by the I.B.M. (W.T.E.C.) with the co-operation of the British, French, German and Italian Administrations.

The I.B.M. (W.T.E.C.) submitted a report on these tests to Special Study Group A (Contribution COM Sp. A—No. 64—1961-1964). Special Study Group A considered that it would be useful to draw the attention of Study Group IV to the circuit outages recorded during the test period and, for this purpose, the following extract is given from this contribution.

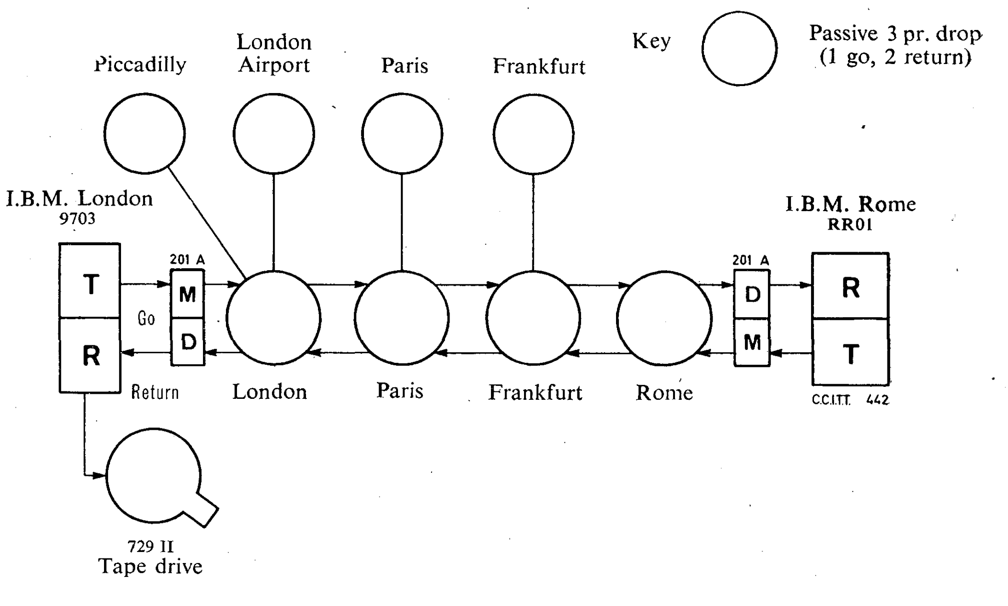

FIGURE 1. — **London-Rome network for 2000 bits/s test**

Introduction

This contribution describes a data transmission test of a multipoint telephone network in Europe. The results obtained are intended to provide an indication of how a typical long-haul, leased, voice-grade facility might be expected to operate at 2000 bits per second.

The test ran from April to June 1962 over a circuit from London to Rome in a special network, designed to simulate the European circuit that will be used with an I.B.M. airline reservation system.

Figure 1 shows the lay-out of the test system. The circuit was a four-wire, full duplex, voice-grade facility from London via Paris and Frankfurt to Rome. Except for a short (approximately 50 km) microwave link across the English Channel, the trunk circuit was effected by three carrier systems in tandem over coaxial cable and symmetric pair cables. Drops were made at London, Paris, Frankfurt and Rome on baseband facilities. These connections were designed to provide the necessary operating levels required for a large multipoint system. There were no equalizers or amplifiers in the drops themselves, and with the exception of the I.B.M. London and the Rome drops, they were all passive and terminated in 600 ohms.

Outages

Probably the most significant results obtained from this test were those that related to outages. The definition of an outage is somewhat arbitrary depending to a great extent on how the line is used. For example, a one-second break in a voice transmission might not be considered too serious. However, if data were being transmitted at 2000 bits/s, the same break would cause several messages to be lost.

Loss of effective transmission can be caused by complete loss of carrier or a change in the line characteristics of sufficient magnitude to produce abnormal operating conditions. In this report, an outage will be considered as either:

1. Any period of time that the carrier could not be detected by the receiving modem in either direction of transmission (the minimum loss of carrier time the modem can detect is 6 milliseconds);

or:

2. Those periods during which a large number of consecutive messages were in error due to a prolonged abnormal line condition. (Such a situation, if it has occurred while the machine was attended, would have caused the test to be stopped and the line condition would have been reported to the telephone company as an outage condition.)

An analysis of the data (see the following Figures and Tables) shows that more than 95% of the lost sync. messages occurred owing to prolonged abnormal line conditions.

A preliminary evaluation of the test results included outages reported during the time the I.B.M. modems were in use, 11 June-20 June 1962. A more recent study failed to establish sufficient proof that these suspected outages were caused by line conditions. For this reason, the analysis of outages will be confined to those that occurred during the test period 21 April to 10 June 1962.

The line was monitored for outages during this period for 822.1 hours (equivalent to 34 days, 6 hours, 6 minutes). Table I shows the number and duration of these outages in eight time ranges. From this table, it is apparent that most outages are relatively short and have a negligible effect on total line availability. They do, however, affect line efficiency in terms of error rates. Line availability is mainly determined by the longer outages of which there are relatively few. A measure of the line availability can be given as:

$$\frac{\text{test time} - \text{outage time}}{\text{test time}} \times 100\%$$

$$= \frac{822.1 - 47.3}{822.1} \times 100\% = 94.25\%$$

TABLE I

Outage frequency and time lost by range of duration

Range of outage	minutes duration	Number of outages	Relative frequency (%)	Time lost h	m	s	Percentage of total time lost
6 ms to 60 ms	0.0001 to 0.001	685	69.68	0	0	30	0.017
60 ms to 600 ms	0.001 to 0.01	83	8.44		0	22.8	0.013
600 ms to 6 s	0.01 to 0.1	105	10.68		2	57.6	0.104
6 s to 60 s	0.1 to 1	68	6.92		29	35.4	1.042
1 m to 10 m	1 to 10	23	2.34		62	40.8	2.208
10 m to 1 h 40 m	10 to 100	14	1.42	6	22	53.4	13.489
1 h 40 m to 16 h 40 m	100 to 1000	4	0.41	12	17	24	25.979
over 16 h 40 m	1000 and up	1	0.10	27	2	0	57.143
	Total	983		47	18	21.3	

It should be kept in mind that the sample period is quite small for long outages and a longer test might produce a more significant figure of line availability.

Most outages were evenly distributed on a day-to-day basis throughout the test period. If the starting times of outages are examined on a two-hourly basis as shown in Figure 2, there is

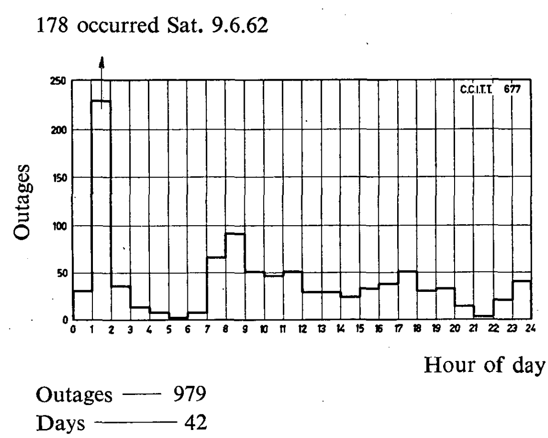

FIGURE 2. — **Distribution of all outages versus hour of day**

TABLE II

Outages longer than 10 minutes

	Time [1] outage started	Date	Length of outage h	m	s
	0030	8 May		24	12
	0130	25 April		14	30
	0330	29 April		20	
	0400	23 May	1	53	24
	0900	8-9 May	27	2	
	0930	5 May		11	6
	1000	26 May		12	36
	1100	1 June		14	
	1100	3 May	5	35	
Business hours	1130	10 May		33	
	1230	28 May	1	37	
	1300	27 April	2	50	
	1300	7 May	1	59	
	1430	25 May		18	12
	1530	25 May		26	
	1600	1 June		15	24
	1630	26 May		40	42
	1700	1 June		28	12
	1900	24 April		27	54
	Total time lost		45	42	12

[1] Time given to nearest half-hour.

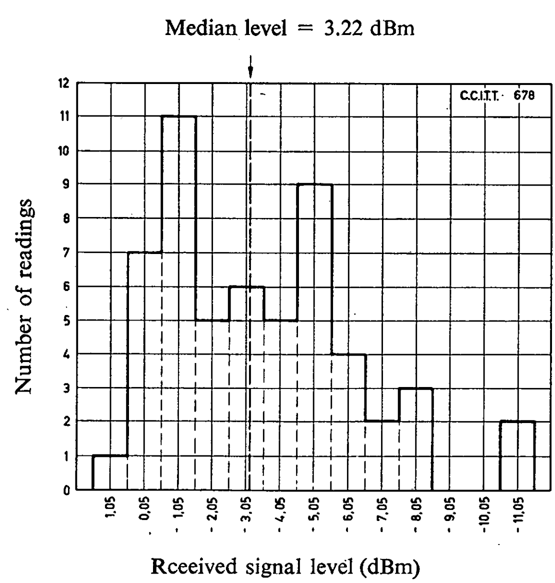

FIGURE 3. — **Distribution of received signal level at Rome, 21 April 1962 to 10 June 1962**

more tendency for outages to occur during the day than at night (the instance between 1 a.m. and 2 a.m. on 9 June is an exception).

The probability of outages occurring during the day rather than at night is more noticeable for outages of more than 10 minutes. This is shown in Table II. Of the 19 outages in this category, 14 occurred during normal European business hours and were reported as line faults to the G.P.O.

Question 3/IV — Phase changes

(new wording for former Question 3/IV—1964-1968)
(in conjunction with Study Group IX—Question 28/IX)

What are the causes of phase changes (sudden or continuous) in the international network of telephone-type circuits and groups, supergroups, etc.?

What are the magnitudes of these phase changes and how often do they occur?

ANNEX
(to Question 3/IV)

History of the question

This question was originally drafted on behalf of the telegraph services for the purpose of forming recommendations for the use of frequency-modulated systems of voice-frequency telegraphy.

In 1957-1960, Study Group IV came to the conclusion that sudden phase-changes are a problem of secondary importance. Their effect can be regarded as negligible in relation to the effect of the sudden variations in level and interruptions to be found on circuits. This conclusion does not affect the need for precautions to ensure that carrier generator changeovers are made as rarely as possible and at times of light traffic. It will be noted that the precautions to be taken are primarily aimed at avoiding the short interruption which generally accompanies a changeover of generators.

Study Group IV nevertheless noted that, although the question of phase-changes was not pressing as regards the then-existing network, the provisions to be made for the future network should nevertheless be studied forthwith. With the transmission of pictures and data, phase-changes would become much more important.

In 1961-1968 Study Group IV arrived at the following conclusions:

Experience so far obtained tends to show that sudden phase changes that occur are very often accompanied by short interruptions in transmission.

There is no reason to suppose that any particular value of phase change is most probable. All values up to 180° (effective change) seem to be equally likely.

Some causes of sudden phase changes are as follows:

a) *Carrier frequency supply changeover*

The most likely cause is phase change in carrier frequency supplies, occurring especially at the time of changeover of carrier frequency generators. The incidence of phase changes in carrier supplies due to maintenance operations will probably not exceed once per month per carrier generating equipment which it is considered will cause a low incidence of disturbance to transmission by comparison with disturbances due to other causes. (Recommendation M.54 recommends that changeover of carrier frequency generators for maintenance purposes should be effected as rarely as possible.)

b) *Amplifier changeover*

A 180° phase change might be due to an inversion of the input or output connections of a normal amplifier with respect to those of the corresponding reserve amplifier.

c) *Causes involving the broadband channel of a radio-relay link*

During switching to a standby broadband channel, phase changes will be masked by breaks in transmission probably of a few milliseconds duration.

The precise value of any phase change caused by a change in path-length in diversity reception is not known at present, and this point should be further pursued. In this respect, C.C.I.R. Study Group IX may be able to help.

Question 4/IV (also 27/XV) — Terminology for carrier systems

(new question)

Is it necessary to amend or complete some of the definitions appearing at present on page 70 of Volume III of the *Blue Book*, and repeated in Recommendation G.211 of Vol. III of the *White Book*, in view of the generalization of non-telephone signal transmission in networks? If so, what amendments or additions are proposed?

Note. — The chief purpose of this question is to harmonize certain terms used by Study Group XV and by Study Group IV.

In the *Blue Book*, Volume IV, Recommendation M.30 contains a number of definitions having the same wording as definitions in Volume III, page 70. In Volume IV of the *White Book*, Recommendation M.30 gives, for some of these definitions, a different wording, which seemed to Study Group IV to be more suited to its needs.

Question 5/IV — Maintenance of groups, supergroups, etc. (not routed over a communication satellite system)

(new question)

What modifications and additions should be made to the instructions for lining-up and maintenance applying to international groups, supergroups, etc. (excluding those routed on communication satellite systems)?

Note. — See in the following Annex 1 the draft of a Recommendation, proposed in 1964-1968 for group links for wideband transmission. See also, in Annex 2, Recommendation M.91 (incomplete) dealing with the characteristics for such wideband group links.

ANNEX 1

(to Question 5/IV)

Preliminary draft of a new Recommendation (Recommendation M.90) for study— Use of group links for wideband signal transmission

Composition and nomenclature

Figure 1/M.90 illustrates the composition of a group link used for wideband signal transmission and the nomenclature used, which is defined as follows:

1. *The group link*

This is the whole of the means of transmission of specified bandwidth (nominally 48 kHz) extending between agreed test points in the renter's premises.

The renter's equipment is not included in the group link. (In general such a group link can be made up of a number of group sections. It should be noted, however, that in order to achieve particular transmission characteristics some restriction is placed upon the degree of complexity of routing.)

2. *Terminal section*

The lines and apparatus connecting the equipment in the renter's premises with the terminal centre concerned. The extent of this section lies between the agreed test point in the renter's premises and the corresponding test point in the terminal centre.

3. *Terminal centre*

The nearest national installation (e.g. repeater station) to which the renter's equipment is connected by the terminal section. This centre will normally be staffed and equipped to make transmission measurements.

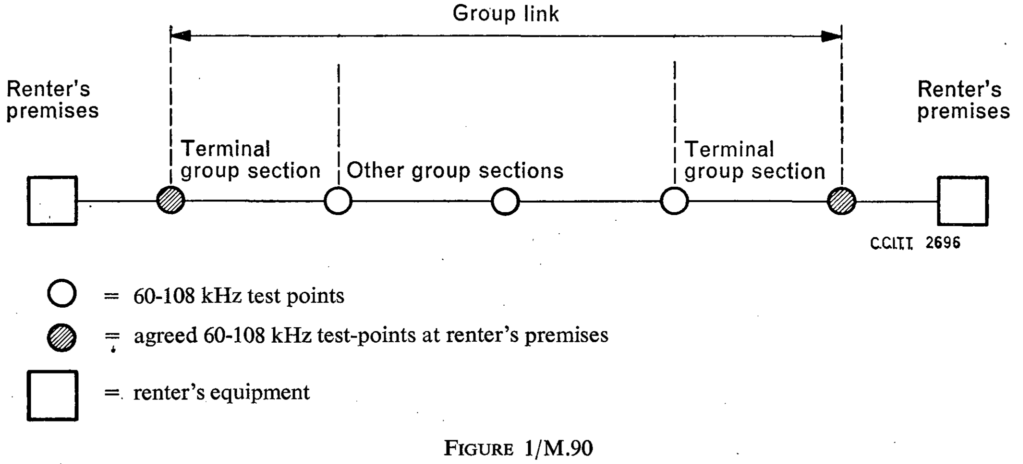

FIGURE 1/M.90

ANNEX 2

(to Question 5/IV)

Incomplete text of a new Recommendation (Recommendation M.91) approved in principle by the IVth Plenary Assembly

RECOMMENDATION M.91 — Setting up and lining up international group links for wideband signal transmission.

1. *General*

The provisions of Recommendation M.46 shall be applied in so far as they are applicable to this type of group link.

2. *Pilot frequency*

Administrations may agree to use a pilot frequency other than those recommended in Recommendation M.46. For information, some administrations have chosen 104.080 kHz for these types of group link.

3. *Types and characteristics of international group links for wideband signal transmission*

(Text to be drawn up by Study Group IV in 1968-1972. The text will be based on parts B and C of Recommendation H.14.)

Note. — The text of this Recommendation has been approved by the IVth Plenary Assembly by having been included in the final report of Study Group IV. However, it was not possible to draw up the text of paragraph 3 without delaying the publication of Volume IV. The text will therefore have to be drawn up by Study Group IV in 1968-1972.

Question 6/IV — Maintenance of groups, supergroups, etc. routed over a communication satellite system

(new question)

What modifications and additions should be made to the instructions for lining-up and maintenance, applying to international groups, supergroups, etc. that are routed over a communication satellite system?

Question 7/IV — Maintenance of radio-relay links

(continuation of Question 7/IV studied in 1964-1968)

Joint study with the C.C.I.R. Recommendations drawn up in this connection will be sent to the C.C.I.R. for its approval.

Question 8/IV — Limits of impulsive noise for data transmission

(new question of interest to Study Group Special A)

For the purposes of planning the individual links making up a connection for data transmission, what impulse noise limits, if any, should be recommended in order to ensure that the overall limits laid down in Recommendation V.53 can be met?

Note. — Study Groups IV and Special A will need to collaborate in order to determine, if possible, what relationship exists between error rate under defined data system conditions (error correction, etc.) and defined impulsive noise conditions.

Question 9/IV — Automatic re-establishment of the service by wideband switching

(new question)

a) What functions hitherto carried out manually could usefully be performed automatically with the help of automatic wideband switching equipment?

b) If wideband switching facilities are employed for the automatic restoration of service of group etc. links or for similar purposes, what transmission performance limits should be met by such equipment?

Question 10/IV * — Measuring instrument specifications

(new wording of Question 10/IV studied in 1964-1968)

What types of transmission-measuring instruments used for transmission maintenance require to be specified by the C.C.I.T.T. and what should be the specifications?

Due account should be taken of the measurement accuracy required for the particular quantity being measured and the effect of human factors (see Annex 2 below).

Note. — A plan for the future study of this question, drawn up by Study Group IV in 1964-1968, is given in Annex 1.

ANNEX 1
(to Question 10/IV)

Plan for the future study of Question 10/IV

1. Study Group IV will appoint a rapporteur during the 1968-1972 study period to whom contributions will be sent directly, the rapporteur to be responsible for presenting a report and, finally, for drafting specifications for those instruments for which it has been shown that specifications are desirable and possible.

2. The rapporteur may wish to organize the study by re-examining the information already obtained during 1964-1968 and he may wish to obtain further information by asking administrations etc. to submit outline specifications for instruments that they consider could be usefully specified for international transmission maintenance purposes by Study Group IV.

3. The following is a list of some instruments that might be specified by Study Group IV. However, the need for such specifications must always be firmly established before any lengthy study is undertaken:

a) fixed-frequency, fixed-level, selective measuring instruments to measure reference pilots, line pilots, intersupergroup and other additional measurement frequencies;

(The accuracy could be of the order of 0.05 dB (0.6 cNp), the selectivity of the same order as that of the corresponding pilot selecting filter used in automatic regulators and pilot receivers etc., and the response time so arranged as to make the meter insensitive to impulsive noise and to interference from the multiplex traffic signal, for example, clicks.) It may prove useful to distinguish between absolute and relative accuracy. These concepts will require further study.

b) sweep-frequency versions of the general-purpose instruments specified in Vol. IV, *Blue Book*, Supplement 3, sections A and B;

(The accuracy of frequency of send level and of level-measurement would probably be somewhat less than that called for in Supplement 3.1 of Vol. IV of the *White Book*. The other parameters might well be the same. A method of synchronizing, and the sweep-periodicity would need to be specified.)

c) noise generators, including a conventional telephone signal generator (Recommendation G.227);

d) voltmeter portion of the psophometer with the view to so specifying it that, in addition to its established use in speech and sound-programme transmission, it may also be unambiguously used for other noise measurements, for example, flat or band-limited;

e) frequency-shift measurements;

f) non-linear distortion-measuring instruments for sound-programme circuits;

g) interruption counters;

h) Instruments for measuring group delay distortion.

ANNEX 2
(to Question 10/IV)

General comments on the accuracy obtainable from measuring equipment

A useful aim for the accuracy of measuring equipments and measuring techniques is that they should be (for example) an order better than the permitted tolerance in the magnitude of the quantity being measured.

There are two factors which bear upon this problem:

— the tolerances in the levels, losses, frequencies, etc. permitted in the international network;

— what can reasonably be achieved and demanded in the present state of the art of test instrument manufacture bearing in mind cost, robustness, and ease of instrument maintenance.

Tolerances in recommended limits (for levels or losses)

Some of the smallest tolerances recommended for various levels or losses are as follows:

— pilots (group, supergroup, line, etc.) $\pm$ 0.1 dB or $\pm$ 0.1 dNp

— signals at frequencies within the basic group or supergroup band $\pm$ 1 dB or $\pm$ 1 dNp

— signals at line frequencies of HF systems	± 2 dB or ± 2 dNp
— transmission loss of telephone circuits at reference frequency	± 0.3 dB or ± 0.4 dNp

Performance of measuring instruments

From Volume IV of the *Blue Book*, Supplement 3, sections A and B, it is apparent that the accuracy currently obtainable in direct-reading general purpose level-measuring instruments (not requiring a comparison operation by the operator) is 0.5 dB (0.6 dNp) and the send-level accuracy of signal generators (not requiring complicated calibrating procedures involving external sub-standard devices) is also 0.5 dB (0.6 dNp).

The first conclusion is that for some measurements comparison methods are necessary, perhaps, in some cases, in conjunction with a more or less complicated send-level calibration procedure.

The aim should be that the operations required for routine transmission measurements should be as simple and uncomplicated as possible.

It follows that the accuracy of test instruments has to be improved. To this end it should be noted that an enhanced accuracy can readily be obtained from fixed-frequency, fixed-level, selective-measuring techniques.

Question 11/IV * — Automatic transmission-measuring equipment

(continuation of Question 11/IV—1964-1968; new wording)
(in collaboration with Study Group XI)

Study Group IV has drawn up a specification for a limited number of automatic transmission-measuring equipments known as ATME No. 1 (see Supplement No. 3.5). This equipment has already been put into service and has shown that automatic equipment can be used to measure the transmission characteristics of an automatic telephone circuit.

Based on the experience gained with ATME No. 1:

1. What should be the basic clauses of a general specification for an automatic measuring equipment to be called ATME No. 2 suitable for future use on the worldwide telecommunication network, taking into account:

— the expected continued rapid extension of international (semi-) automatic operation on a worldwide basis;
— the introduction of C.C.I.T.T. signalling system No. 5 for international working, together with the use of TASI and non-TASI equipped circuits, and the use of both-way circuits;
— the work being done in connection with the specifications for the new C.C.I.T.T. signalling system No. 6.

2. Using this ATME No. 2:

a) would it be possible to make routine maintenance measurements at 800 Hz lese frequently or even to cease them and to make only the multi-frequency routins maintenance measurements at several frequencies, and if so, how often?

b) what should be the characteristics of automatic measuring arrangements for use in the international service?

c) what administrative methods should be considered in connection with the use of automatic measuring arrangements, particularly in the international service?

d) what universal codes should be adopted whereby access is obtained to automatic testing facilities at the distant end?

Note. — Some of the important considerations to be taken into account in the study of automatic measuring arrangements, particularly in the intercontinental service, are listed below.

a) The new measuring arrangement should be compatible with existing C.C.I.T.T. signalling systems and capable of functioning over circuits equipped with concentrators.

b) Consideration should be given to the development of a universal arrangement capable of overall signalling testing and transmission measurement.

c) To the extent possible, the new arrangement should be capable of working with national and international measuring and testing arrangements.

d) Consideration should be given to the method of transmission of information concerning the measurement data and results and the manner in which these data and results are to be made available to the directing responding equipment.

e) Speed of testing is an important consideration.

f) Consideration should be given to specifying variations as deviations from design net loss rather than from an absolute level value.

g) Consideration should be given to providing quantitative noise assessments rather than qualitative comparisons (" yes " or " no " test).

h) Universal access codes for tests and measurements should be established. The design should provide for flexible testing arrangements permitting the incorporation of new test and measurement circuits on a modular basis.

i) Consideration should be given to differentiating between tests or measurements over circuits assigned to various transmission media.

Question 12/IV * — Automatic noise measurement

(new question)

Considering :

a) that the noise measurement detector recommended by the C.C.I.T.T. utilizes a square-law detection which effectively doubles the measurement range (in dB) at its output;

b) that the resulting range (about 70 dB) is difficult to measure with an automatic measuring instrument without range switching;

c) that at least one administration has adopted a different form of detector which enables the entire noise measurement range to be measured automatically without range switching;

should a noise measurement detector other than one with a square-law characteristic be adopted for use in automatic noise measurements (and possibly in other applications)?

Note. — In the study of this question it should be admitted that:

1. true power measurements require an r.m.s. detector such as a thermocouple;

2. a square-law detector is one approximation to an r.m.s. detector; and

3. a quasi-r.m.s. detector (a detector which is a compromise between an average and a peak detector) may be a satisfactory approximation to an r.m.s. detector for use in automatic noise measurements and in other applications.

Information on a quasi-r.m.s. detector is found in the *Bell System Technical Journal*, July 1960, pages 925 to 931, in the appendix to an article by W. T. Cochran and D. A. Lewinski entitled "A new measuring set for message-circuit noise". In this article an analysis is given of the measurement results obtained using a quasi-r.m.s. detector to measure signals having various waveforms.

Question 13/IV * — Maintenance equipment for sound-programme circuits

(continuation of former Question 13/IV—1964-1968)

Can an arrangement consisting of an automatic device sending a series of consecutive measuring frequencies plus an appropriate measuring unit be used to facilitate measurements during the line-up period and also for routine maintenance measurements on sound-programme circuits? If so, what recommendations should be laid down for such equipment (basic clauses of a model specification)?

Note. — See, in the following Annex, a draft specification proposed by Study Group IV in 1964-1968 and which should be used as a basis for further studies under this question.

ANNEX

(to Question 13/IV)

Proposed draft of a specification for an automatic measuring equipment for sound-programme circuits

1. *General*

The C.C.I.T.T. automatic measuring equipment for sound-programme circuits is capable of rapidly measuring all relevant parameters necessary for checking the quality of such circuits. The measuring results are recorded by an analogue recorder. The diagrams of the measurements are suitable for subsequent documentation and not only permit an immediate decision by the staff in the field on whether the sound-programme circuit or sound-programme connection respectively can be used for service but they also provide the basis for later exact evaluation by the responsible transmission engineer.

The overall time for the measurements amounts to 133 seconds. It is thus short enough to check the quality also of international chains of sound-programme circuits interconnected on a short-term basis during the preparatory and lining-up period according to Recommendation N.4. Measurements for this purpose, made by the I.S.P.C.s involved in accordance with Recommendations N.12 and N.13, do not require any preceding agreement.

The measuring programme for sound-programme circuits may be extended, if needed, by an additional programme for testing a pair of sound-programme circuits with a view to their capability of carrying stereophonic signals. This measuring programme is to be specified at a later date.

2. *Quality criteria to be checked*

With the C.C.I.T.T. automatic measuring equipment for sound-programme circuits the following quality criteria can be checked:

— deviation of the 0.8-kHz lining-up level from the nominal value;

— weighted and unweighted noise level;

— non-linear distortion measured selectively as distortion factors of the 2nd and 3rd order and as a difference tone factor of the 3rd order;

— compandor functioning test;

— loss versus frequency.

3. *Specifications*

3.1 *Sending unit*

3.1.1. *Start, synchronization and time base*

By means of a locking press-button in the sending unit the measuring programme for single or permanent mode of operation can be started. Start and synchronization of the receiving unit are triggered by synchronizing pulses (1.3 kHz/—12 dBm0). The smallest time base that can be programmed is fixed at 1.33 second. The synchronizing frequency related to this time base gives 0.75 Hz and has to be kept within ±1%.

3.1.2 *Station coding*

The measuring programme is preceded by the code of the sending station using the Morse alphabet. For this end 19 timing pulses are provided which may be filled either by pulses, bars or intervals. According to the rhythm of a particular code a 0.8-kHz signal of —32 dBm0 is changed to the lining-up level. The duration of Morse dots and dashes shall be 25% or 50%, respectively, of one timing pulse.

3.1.3 *Sending level for lining up and for measurements at all frequencies*

According to the proposals made in contribution COM IV—No. 175 (1964-1968) to amend Recommendation N.21 the lining-up level (0.8 kHz) and the sending level for measurements at all frequencies should be as low as —12 dBm0. The measurements at all frequencies are to be carried out with the aid of a wobble generator comprising the frequency range from 0.03...16 kHz. Each octave—beginning at 0.05 kHz—is marked by short pulses. The speed of this sequence of operations (7.5 seconds/octave) corresponds to the indications given in Supplement No. 3, Vol. IV of the *Blue Book*, page 258.

3.1.4 *Sending level for non-linear distortion measurements* [1]

The sending levels of the test frequencies correspond to the maximum programme level (see note to Recommendation N.13), that is, the single tones for the non-linear distortion measure-

[1] It shall be possible for the signal sent for the measurement of non-linearity distortion to be included in or omitted from the test cycle at will (for example, under control of a switch). Whether or not the non-linearity distortion measurement is made must be determined for each circuit by users of the device, and in a manner ensuring that the prescriptions of Recommendation N.21 are respected.

ments lead to the same peak loading as the double tone for the difference tone factor measurements (single tone 2.2 $V_{r.m.s.} = 3.1\ V_{p0}$ and double tone $2 \times 1.1\ V_{r.m.s.} = 2 \times 1.55\ V_{p0} = 3.1\ V_{p0}$ referred to a zero relative level point). In order to avoid overload of carrier frequency transmission systems only frequencies below 2 kHz (with regard to circuits equipped with pre- and de-emphasis techniques) are applied and the duration of transmission is automatically reduced to the length of a single timing pulse[1]. The following test frequencies are used:

a) For the measurement of non-linear distortion in the lower audio-frequency range:

$$\left.\begin{array}{l}\text{0.09 kHz for the } k_2\text{-measurement}\\ \text{0.06 kHz for the } k_3\text{-measurement}\end{array}\right\}\ \text{using a 0.18 kHz filter}$$

b) For the measurement of non-linear distortion in the medium audio-frequency range:

$$\left.\begin{array}{l}\text{0.8 kHz for the } k_2\text{-measurement}\\ \text{0.533 kHz for the } k_3\text{-measurement}\end{array}\right\}\ \text{using a 1.6 kHz filter}$$

c) For the measurement of non-linear distortion in the carrier-frequency range of an f.d.m.-channel:

0.8 kHz + 1.42 kHz for the d_3-measurement using a 0.18-kHz filter
$= 2 \times 0.8$ kHz $- 1.42$ kHz

The measurement of the upper d_3-modulation product at 2.04 ($= 2 \times 1.42 - 0.8$) kHz is not made. To compensate for this the meter reading for the lower d_3-product at 0.18 kHz is doubled.

3.1.5 *Sending signal for compandor functioning test* [2]

In order to detect rapidly a non-complementary behaviour of regulating amplifiers in compandors a 0.8-kHz signal is injected, the level of which is switched between the values +6, −6, +6 dBm0 from one timing pulse to the following.

3.2 *Receiving unit*

3.2.1 *Level measurement*

All level measurements are expressed in terms of r.m.s. values. The dynamic properties of the rectifier circuitry for noise measurements meets the requirements of Recommendation P.53 (Volume V of the *Red Book*) [3].

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[1] The method of measurement described is intended for temporary use. A change may be necessary if after further study the C.C.I.T.T. recommends another method.

[2] This test is intended for temporary use. A change will be necessary if after further study the C.C.I.T.T. may issue recommendations for compandors and appropriate methods of their testing.

[3] It may be necessary to replace the weighting filter specified in this recommendation by a new one if, with regard to high-quality circuits, the C.C.I.T.T. recommends to use the weighting curve proposed in C.C.I.R. Doc. X/108.

Using a measuring device with a logarithmic characteristic, a linear level-measuring range of +10 dB referred to the respective centre-of-range is obtained.

For the particular measuring function the following centres-of-range are provided:

— lining-up level and level at all frequencies	−12 dBm0
— noise level weighted and unweighted (signal/noise ratio referred to +9 dBm0	−51 dBm0 60 dB)
— non-linear distortion level (ratio referred to +9 dBm0	−31 dBm0 40 dB)
— level step signal	0 dBm0

The weighting network for the noise level measurements meets the requirements of Recommendation P.53.

3.2.2 *Recording device*

The transient response time of the recording device should not exceed 200 ms.

Paper width and speed may be chosen according to national standards. The following values have proved to be practicable:

paper width	100 mm
paper speed	2 mm/s

The above-mentioned values yield (on the 20-dB level range) a level scale of 2 dB/10 mm.

In addition to the recording device it would be desirable to provide appropriate access points for the use of an oscilloscope.

3.3 *Sequence of operations*

The sequence of operations of the measuring programme and the associated time units is shown in the appendix.

3.4 *Permanent recordings of noise level*

The receiving unit can be used independently of the sending unit for the purpose of making permanent recordings of weighted noise after locking the automatic control mechanism. In this operational mode the level range can be modified manually by a further ± 10 dB.

3.5 *Matching characteristics*

According to the lining-up procedure for sound-programme circuits using the constant voltage method the following impedances are to be provided for:

— output impedance of the sending unit	< 10 ohms
— input impedance of the receiving unit	> 20 kilo-ohms

Both values may be changed by internal switching to 600 ohms if, for the lining up of the sound-programme circuit, the impedance matching method is applied following local practice. The sending and receiving units can be adjusted by means of a switch to the following relative levels:

−3 dBr = nominal value at the repeater stations of administrations;

−3 dBr = nominal value at the studios of broadcasting authorities.

3.6 *Accuracy of measurements*

Sending unit :

a) Individual generators

— level tolerance	± 0.2 dB
— frequency tolerance	< 1.0%
— harmonic distortion at 2 *f* and 3 *f*	< 0.1%

b) Sweep generator

— level tolerance at 0.8 kHz	± 0.2 dB
— level/frequency response referred to 0.8 kHz	± 0.2 dB

Receiving unit :

Tolerances, including recording device:

— mid-scale value −12 dBm0 and 0 dBm0	± 0.3 dB
— mid-scale value −51 dBm0 and −31 dBm0	± 1.0 dB

The required thermal stability must be obtained 15 minutes after switching on. As far as the details of the division of the tolerances are concerned, reference is made to the values given in contribution COM IV—No. 187 (1964-1968) on pages 61 to 65.

The tolerances may then be reduced by calibrating the sending and receiving units when interconnected on a loop basis.

APPENDIX (to Annex to Question 13/IV)

Sequence of operations

Time pulses	Sending unit		Receiving unit	
	Frequency kHz	Level dBm0	Measuring function	Centre of range dBm0
1	1.3	−12	start signal	—
1	—	—	pause	—
1	1.3	−12	start signal	—
1	—	—	pause	—
1	—	—	interval, reserved for stereophonic measurements	—
2	—	—	pause	—
19	0.8 Morse code rhythm	−32/−12	station coding using Morse-alphabet	−12
1	—	—	pause	—
4	0.8	−12	lining-up level	−12
2	—	—	pause	—
1	1.3	−12	start signal	—
2	—	—	pause	—
5	—	—	noise level weighted by psophometer filter	−51
5	—	—	noise level unweighted	−51
2	—	—	pause	—
1	0.09	+9	k_2-level with 0.18-kHz filter	−31
1	—	—	pause	—
1	0.06	+9	k_3-level with 0.18-kHz filter	−31
1	—	—	pause	—
1	0.8 1.42	+3 +3	d_3-level with 0.18-kHz filter	−31
2	—	—	pause	—
1	0.8	+9	k_2-level with 1.6-kHz filter	−31
1	—	—	pause	—
1	0.533	+9	k_3-level with 1.6-kHz filter	−31
2	—	—	pause	—
3	0.8	+6/−6/+6	step-level signal	0
2	—	—	pause	—
35	0.03...16 with frequency marks at each octave beginning at 0.05 kHz	−12	level/frequency response	−12
Total 100				

Overall time for the measuring programme: 100 timing pulses × 1.33 s/time pulse = *133 s*

Question 14/IV — Methods to be recommended in order to reach the noise and crosstalk objectives on circuits for sound-programme transmission

(former Question 9/XV, referred to Study Group IV)

The noise and crosstalk requirements for sound-programme circuits in Recommendations J.21 and J.31 *(White Book)* cannot generally be fully met, especially in the case of circuits of great complexity or length, when telephone equipment with ordinary characteristics (translating equipments, through-connection filters, symmetric pair cables, etc.) is used.

This situation is certain to be repeated, perhaps in more acute form, with the high-quality monophonic and the stereophonic sound-programme circuits at present under study by the C.M.T.T. (Study Programmes 5A/CMTT and 5B/CMTT).

In previous periods of study of this problem (see the following Remark), Study Group XV singled out three methods of improving the situation from the point of view of noise and crosstalk:

— careful choice of the frequency band to be used in the basic group;

— use of pre-emphasis;

— use of compandors.

For the first method, see *White Book* Recommendation J.22; for the second, Recommendation J.21. In the case of the third, the question is still under study (Question 7/XV).

In view of this, can general rules for the use of these methods be defined, with references to the more common individual cases?

To study the more significant individual cases, it is proposed to consider the four following circumstances:

a) What in practice is the number of sound-programme circuits established on the same telephone carrier system?

b) What is the probability of simultaneous transmission of different sound-programme signals on each of these circuits?

c) What is the probability of simultaneous transmission of identical sound-programmes on each of these circuits?

d) What is the probability of coincidence of the above-mentioned simultaneous transmissions with hours of heavy telephone traffic?

Note. — This question should be studied in close relation with the study of Questions 1/XV, 2/XV, 6/XV and 7/XV, and with Study Programmes 5A/CMTT and 5B/CMTT.

REMARK

History of the study of the question

This question was first set, for study by C.C.I.T.T. Subgroup 1/1, by the Ist C.C.I.T.T. Plenary Assembly, in 1956 (see Question 20 of Study Group 1 and the associated annexes, *Red Book*, Volume I, pages 159-161).

The study was continued by Study Group XV under Question 9/XV following the IInd Plenary Assembly (see *Red Book*, Volume III, pages 444-445).

After the IIIrd Plenary Assembly, study was continued under Question 9/XV with the following wording and annexes:

" Question 9/XV — Methods for meeting noise and crosstalk objectives on carrier programme circuits

(continuation of Question 9/XV studied in 1961-1964)

Since special arrangements have to be made in certain cases for programme circuits on carrier systems, to meet the noise and crosstalk requirements recommended by the C.C.I.T.T.,

and as these arrangements may consist of the use of one or more of the following methods: use of compandors, pre-emphasis, use of Position III for the band transmitted to line (see Recommendation J.22 and Question 8/XV),

can general rules for the use of these methods be defined in the light of the conditions that will be met in each special case?

Note 1. — The methods mentioned are dealt with in the following recommendations or questions:

Compandors: paragraph b) of the Note in Recommendation J.21, Questions 7/XV and 8/XV;

Pre-emphasis: paragraph a) of the Note in Recommendation J.21;

Use of Position III: Recommendation J.22 and Question 8/XV.

Note 2. — This question should be studied by Study Groups IV and XV.

Note 3. — Annexes 1 and 2 show the replies by the Administrations of the Federal Republic of Germany and of the United Kingdom in 1961-1964.

ANNEX I

(to Question 9/XV)

Reply to Question 9/XV (1961-1964) by the Administration of the Federal Republic of Germany

The starting-point for the question is the known fact that a programme channel set up on the hypothetical reference circuit for telephone systems (length: 2500 km, psophometric power: 10 000 pW, signal-to-crosstalk ratio corresponding to intelligible crosstalk: 58 dB) shows a psophometric power 11.6 dB too high and a crosstalk attenuation 16 dB too low unless special measures are taken to remedy the defect.

The following comment may be made on the various aspects of the question:

Limitation of the band transmitted to line

It may be possible in carrier circuits to find groups whose line noise is below 0.3 pW/km and whose far-end crosstalk ratio to adjoining systems is not below 74 dB (8.5 nepers). Such groups would be suitable for equipping programme channels. In view of the many transmission systems to be considered, however, the Federal German Administration believes that the choice of such circuits for the purpose of a C.C.I.T.T. Recommendation is not satisfactory.

Use of compandors

The use of compandors on each of the three audio sections of the reference circuit is the appropriate means of meeting the noise and crosstalk conditions for a programme circuit of 2500 km. This is still valid for crosstalk from a programme circuit to another programme circuit; the same applies when the two circuits are set up on the two directions of transmission of the same group. Clicks, which are not limited by C.C.I.T.T. recommendations, are also materially reduced by compandors.

In addition to the considerable diminution of crosstalk effect by dynamic compression, intelligible crosstalk, when carrier compandors are used, becomes very unintelligible owing to shift of the zero frequency.

Pre-emphasis and de-emphasis network

The improvement of 7 to 8 dB in the signal-to-noise ratio obtainable with one pre-emphasis and one de-emphasis is not sufficient for a programme circuit 2500 km in length. Further, crosstalk between circuits for programme transmissions is not thereby improved. The question of a possible reduction in crosstalk effect between telephone circuits and programme circuits has not yet been clarified (see Question 22/XII).

The combination of a compandor with a pre-emphasis and de-emphasis network might, on the other hand, produce some results. While, in order to avoid undue non-linear distortion at the lower frequencies, compandors which operate in the audio position always require some device which attenuates audio regulation at the lower frequencies, such as interposing a pre-emphasis network in front of them, such an arrangement is not necessary with compandors which operate in the carrier position.

It does, however, happen, though only in rare cases, in all compandors that circuit noise is not entirely masked by the programme, i.e. in cases where the programme consists entirely of isolated audio-frequency, wide-amplitude sinusoidal sounds. If a compandor is combined with a pre-emphasis network, improved results may then be obtained. However, it seems that the desirable pre-emphasis curve is not the one recommended by the C.C.I.T.T. (Remark of Recommendation J.21) but a pre-emphasis curve specially designed for the type of compandor considered. The Federal German Administration proposes that further study be given to this point under Question 7/XV.

Inverted frequency distribution

The use of a frequency position in the band transmitted by programme channels when the frequency is offset or inverted in relation to that of the band transmitted by telephone channels represents an advantage in that it enables the question of the effect of telephone circuit crosstalk on programme circuits to be more easily solved. Nevertheless, this measure alone is not sufficient, since it reduces neither the noise nor the effect of programme circuit crosstalk on programme circuits.

Crosstalk between the two directions of transmission

The conditions laid down for minimum intelligible crosstalk attenuation between two broadcast programmes transmitted over the go and return channels of a group link are the same as those for programmes transmitted in the same direction, so that, in accordance with Recommendation J.21, f), a crosstalk ratio of at least 74 decibels has to be maintained over the 2500-kilometre hypothetical reference circuit.

Whereas, for the other frequency bands in the same direction of transmission, the far-end crosstalk is the weakest point in cables with coaxial or multiple balanced pairs, the crosstalk problem, for frequency bands in the opposite direction, chiefly lies in the cabling within the racks used for the two directions, because the differences in level are considerable. There is also a problem with regard to couplings by the joint carrier-supply path.

On the other hand, the cables give rise to no near-end crosstalk problems, since the opposite direction is transmitted, either in separate cables, or in a separate band (with balanced pairs), or since, with multiple coaxial-pair cables, the near-end crosstalk attenuation is very considerable.

Hence, if we are to be sure of getting 74 decibels, we shall have to observe the following crosstalk ratios for the various stations in the hypothetical reference circuit (the 4-Mc/s system, for instance):

Station with	Per station	Number in the hypothetical reference circuit	Resulting figures
	db		db
Terminal equipment	87	6	79
Through supergroup equipment . . .	87	3	82
Through group equipment	84	3	79
Line amplifier.	105	270	81
Resulting figure for all stations			74

Note. — In the table, we have assumed minimum figures, and the resulting figures have been obtained by addition of power. The discrepancies between the crosstalk attenuation for the various kinds of station are attributable to the number and type of rack used therein.

These minima are not always reached in the Federal German carrier equipment. In measurements made on 43 different group links the average crosstalk attenuation discovered in the band from 84 to 96 kc/s was 82 decibels (9.5 nepers). The standard deviation for the figures measured was 6.5 decibels (0.75 neper). If a compandorized transmission system be used, these crosstalk figures improve so much that in almost every case it is possible to abide by Recommendation J.21, f).

ANNEX 2
(to Question 9/XV)

Comment on Question 9/XV by the United Kingdom Administration

The question of carrier programme transmission on circuits up to 1000 km in length has been covered in the Remark of Recommendation J.21. However, with 2500-km circuits when the line noise is 4 pW per km (white), the weighted noise in a normal programme band will be about 11 db higher than the C.C.I.T.T. figure for maximum permissible noise of —48 dbm0p. Assuming a 7- or 8-db noise, advantage can be obtained with the standard C.C.I.T.T. emphasis networks (see Recommendation cited above) there will still be some 3 or 4 db further noise suppression needed for the maximum circuit length.

Probably the most satisfactory solution for the suppression of noise as well as intelligible crosstalk is the use of compandors with emphasis networks and that is our approach to the problem. There are of course very practical advantages in using the one type of emphasis network for all purposes and, while questions of mean and peak loading with subjective distortion arising are under active study, our present tentative view is that the same networks should be used.

Further advantage may be gained by inverting the band with respect to its normal position—i.e. using a virtual carrier frequency of 84.5 kc/s; uncontrolled sources of crosstalk from telephone channels will then be unintelligible. Special precautions must be taken to guard against crosstalk from the upper sideband of channel 7 but this can be readily controlled by inserting a filter to suppress this sideband at a point in the transmission path before the injection of the programme. This special filter has of course to be removed from circuit when normal telephony operation of channels 4, 5 and 6 is required and it may prove difficult to perform this circuit change without interruption to channel 7. Thus part-time use of this arrangement to provide programme channels may have disadvantages which outweigh the advantages of improved crosstalk.

The use of compandors would remove the need for such marginal improvements in crosstalk and, in such cases, it would probably be unnecessary to adopt inversion as a general rule."

The suggestions in Notes 1 to 3 associated in 1964 with the above wording of the Question was followed by the following reply to Question 9/XV by Study Group XV in its preliminary reply to the IVth Plenary Assembly (AP IV/62, pp. 35-36).

"*Reply :*

Study Group XV considers that the study of this question should henceforth be entrusted to Study Group IV, which would be able to study the question taking the following information into consideration:

— on the one hand, existing recommendations or those being prepared by Study Group XV on the specification of compandors, pre-emphasis, the use of position III for the band transmitted to line (see Recommendation J.22 and Questions 7 and 8/XV);

— on the other hand, the results of studies which the C.M.T.T. has been requested to make—these will indicate the conditions to be met by circuits for programme transmissions.

The Swiss Administration has submitted two unnumbered documents concerning this question. The document entitled " Methods for obtaining low noise on programme circuits " will be forwarded to the C.M.T.T. in the context of part b) of Question E/CMTT (COM Sp.C—No. 58) (COM XV—No. 95, page 18). In addition, both documents will be forwarded to the Special Study Group C in connection with its studies on the loading of carrier systems.

Study of Question 9 will thus be concluded as far as Study Group XV is concerned. It is understood that, in the study of Question 7/XV, the possibility of the simultaneous presence of a pre-emphasis network and a compandor will be considered."

Following this reply in 1968, the IVth Plenary Assembly approved the wording of a question for Study Group IV (Question 14/IV—1964-1968) as shown above.

Question 15/IV — Application of quality control to maintenance measurements

(continuation of Question 15/IV—1964-1968)

Study of the application of quality control to the transmission performance of international circuits and groups and supergroups. Examination of the application of sequential control methods, especially on large groups of circuits.

Note. — Annex 1 gives a summary of studies made under this Question in 1961 to 1968. For a method using control charts, see Annex 2 below. See also Recommendation M.63.

ANNEX 1
(to Question 15/IV)

History of the study of Question 15/IV (1961-1968)

Question 15/IV was first set for study by Study Group IV following the IInd Plenary Assembly (New Delhi, 1960), at a time when administrations were showing some concern over the load placed on repeater stations by the necessity for making periodical routine measurements on an ever-increasing number of circuits, coupled with the special difficulties involved in measurements on international circuits (establishing co-operation, language difficulties, etc.). Parallel studies concerning the development of automatic transmission measurement equipment and the use of the " batch " method for circuit measurement have proceeded to a point where they already make a considerable contribution to easing the maintenance load and the study of quality control methods and their application to circuit measurement has perhaps tended to seem less urgent. Nevertheless, circuits continue to increase in number and such methods may well have to be applied in the future.

When the question was first put to Study Group IV, it was expressed with two aspects—namely, the use of control chart methods (particularly the Shewhart control chart) and the application of sequential control methods. In the course of time, Study Group IV has tended to the view that, while the use of control chart methods may usefully be applied to circuit maintenance, sequential control methods are of less interest in this connection.

The Danish Administration was one that showed considerable interest in control chart methods, and during the 1961-1964 C.C.I.T.T. Study Period a report was made to Study Group IV on the application of such methods to the Danish inland network. Further experience by the Danish Administration led to the publication of Supplement No. 26 in Volume IV of the C.C.I.T.T. *Blue Book.* During the 1964-1968 study period, the Danish Administration pursued its initiative and, in conjunction with the Administrations of Norway, Sweden and the Federal Republic of Germany, carried out a trial on an international basis of the methods that had been applied to the Danish Inland network. A report on this trial is given in Annex 2.

Based on their experience, the countries concerned have also drawn up a revised supplement (Supplement No. 1.4 to Volume IV of the *White Book*). This gives sufficient information to enable other administrations to apply the method used in the trial.

Other methods have been used on national networks, and Supplement No. 1.4 also describes methods in use by the N.T.T. on the Japanese network and in North America by the American Telephone & Telegraph Company. It is to be noted that the latter method deals rather with the quality of what are known in the C.C.I.T.T. as " connections ", that is, subscriber-to-subscriber connections, and which are not the direct concern of Study Group IV. The method, however, includes an assessment of circuit quality and is therefore of interest to Study Group IV.

ANNEX 2

(to Question 15/IV)

The application of quality control to maintenance measurements

(Report by the Administrations of Denmark, the Federal Republic of Germany, Norway and Sweden on the experimental application of the control chart technique to the maintenance of international telephone lines)

1. *Introduction*

This report is a continuation of the first report submitted to the C.C.I.T.T. on the subject by the Administrations of Denmark, the Federal Republic of Germany, and Sweden, published by the Secretariat as contribution COM IV—No. 160 (1964-1968). The first report was studied at a meeting of Working Party IV/5 (Geneva, 28 March-1 April 1966 reported in contribution COM IV—No. 65 (1964-1968), page 31), where it was tentatively concluded that statistical control methods could be applied to maintenance measurements, but that more information on the method would be desirable in order to reach a final decision. The administrations taking part in the experiment were requested, therefore, to carry on with the work, in which also the Norwegian Administration would henceforward take part.

In the present report a survey is made of the amount of measuring work that has been carried out, the state of the circuits (lines) is described and illustrated in the conventional manner, and by way of discussion an attempt is made to answer the questions raised during the study of the first report.

2. *Maintenance efforts and results*

The tables of this Annex contain a survey of the number of maintenance activities that have been actually carried out during the six months from 1 June to 30 November 1967, which lie immediately before the drafting of this report. A comparison is made with the number of measurements that would have had to be made under the present C.C.I.T.T. rules, and finally the quality level of the lines involved in the experiment is described by conventional statistics.

The following remarks serve to explain and to expand the information given in the tables.

i) *Column 1, Route; column 2, Number of circuits*

In accordance with the general rule, each terminal station was in control of its outgoing circuits, except in the case of the Hamburg-Stockholm route, where both directions of traffic were joined together for the purposes of the sampling. Only circuits routed on direct groups between the terminal stations were included in the experiment.

ii) *Column 3, Number of samples*

As explained in document COM IV—No. 60 (1964-1968), it was decided to measure each circuit three times a year on the average, by the sampling method. In principle the number of samples in each month is given by:

$$\frac{\text{Number of circuits} \times 3}{2 \times 12}$$

In practice the number may be different because of rounding-off. As regards the Hamburg-Stockholm route, however, the number of samples was determined on the basis that each circuit is measured twice a year on the average, giving a further reduction.

iii) *Column 4, Number of sample series*

The figure of this column indicates the number of times communication had to be established with the opposite terminal in order to make the measurements specified by the sampling. By way of comparison the number of communications to be set up in order to carry out conventional measurements according to M.61 would be at least of the order of three to five depending on the number of circuits.

iv) *Column 5, Number of investigations*

The number of investigations is a measure of the effort required beyond the mere measurements. An investigation was initiated by a point whose plot fell outside the control limits of the $\overline{X}/R$ chart and comprised such activities as:

— readjusting the group or channel gain setting,

— taking note of the fact that the group link was temporarily rerouted,

— finding the measuring equipment faulty,

— etc.

v) *Columns 6, 7 and 8, Number of measurements, etc.*

The number of measurements actually performed is, of course, the number of samples multiplied by two, as each sample comprises two circuits. The number of measurements according to M.61 is based on the number of circuits of the route multiplied by 2.5. This factor is arrived at in the following way: each circuit would be measured six times a year, once at several frequencies, and for the remainder at a single frequency. As the measurement at several frequencies was retained during the experiment, we are left with five single frequency measurements, half of which is related to a period of six months.

The figure termed " *reduction* " refers only to the difference in the number of measurements between columns 7 and 6, given as a percentage, and should not, in any way, be taken as a measure of a net saving in manpower. No substantial saving can reasonably be expected until the method is more widely adopted, so that administrative work in connection with the sample scheme and the production of sample forms becomes a routine operation, and also so that the maintenance officers become aware of the characteristics of the method, requiring them to establish communications with distant stations fairly frequently as compared with the batch-testing method, in order to carry out and evaluate comparatively few measurements in the course of each period of contact.

vi) *Columns 9, 10 and 11, Statistics*

All the measurement results collected by sampling in the course of the six months under review have been analysed statistically in the conventional way. It appears from the analysis that the circuits lie well within the limits specified in Recommendation M.16.

3. *General comment on the control chart method*

It is common practice, when we are trying to judge the performance of the international network, to prepare a statistical analysis of measurement results. The most recent example of such a compilation was the contribution by the rapporteur (M. G. Laguérie—France) appointed by Working Party IV/4 to carry out the analysis of results of routine measurements on a yearly basis. Such analyses are excellent, though they only become available after a considerable delay in relation to the state of the network at the time when the measurements were taken. It is possible to deduce from such analyses guiding principles of a more general nature in respect of methods and techniques to be adopted with a view to improving the performance of the network, and again, later analyses may show whether the improvements aimed at were achieved.

The adoption of the control chart technique, in the form designed by W. A. Shewhart, means that the procedure of statistically analysing measurement results as a preliminary to taking action, or rather, to deciding whether any action at all should be taken, is put directly in the hands of the staff making the actual measurements. The $\overline{X}/R$ control chart is designed in such a way that the maintenance staff are enabled to decide, with reference to a set standard and according to a simple rule, either that it is best to leave things as they are or that further action is necessary in order to find and remove assignable causes of variation. If such action is indicated, the small size of the sample, a characteristic of this method, makes it easy to locate the particular measurement result that caused a plot on the control chart to fall outside the limits, and from this fact the maintenance staff may proceed according to established practice.

4. *Comments on details of the control chart method*

4.1 *Sampling scheme*

The management of the sampling scheme, and, in this context, the production and distribution of sample forms, is an important element, and once the method has been introduced this part of the work may present a task that is not negligible, if it is to be handled manually on the lines set out in the first report (document COM IV—No. 60, 1964-1968). However, the work is readily adaptable for data processing, and this has been done with satisfactory results in the maintenance organization of the Danish inland network.

4.2 *Determination of control limits*

The aim of maintenance must be that the number of cases when a circuit is outside the tolerance specification is kept as low as possible. This aim implies that action should preferably be taken before circuits become faulty. Consequently the limits of the control charts should be set corresponding to a value of standard deviation that is less than the standard deviation of the tolerance specification. In the *Blue Book*, Volume IV, Recommendation M.16, section 1, it is said in respect of a 1000-km circuit that:

> " ... the standard deviation ... should not exceed ... 1.2 dNp ... It is desirable that the difference between the mean value of the transmission loss and the nominal value should not exceed ... 0.6 dNp."

For our purposes this may be taken to mean a range of variation to be centred at zero deviation with tolerance limits removed three standard deviations from the limits connected with the mean value, or in figures:

$$\pm 6 \pm (3 \times 12) = \pm 42 \text{ cNp}$$

corresponding to a standard deviation of 14 cNp. On this basis, control chart limits might be drawn corresponding to standard deviations of, say, 10, 7 or 5 cNp according to the capability (depending upon length, complexity, type of equipment, etc.) of the route concerned, in order to enable the maintenance staff to take corrective action if possible before shifts in transmission characteristics cause circuits to go outside tolerance limits.

5. *Answers to questions*

We do not feel ourselves in a position to give exhaustive answers to the questions raised by Working Party IV/5 in connection with the study of the first report (see COM IV—No. 65, 1964-1968, page 32). However, the following observations may give some guidance.

1) The deciding factors for the amount of maintenance needed, whatever the methods, are, firstly, the stability and reliability built into the network by design, production, installation and commissioning of the equipment used and, secondly, the quality level (tolerance limits) specified in respect of its performance.

2) The extent to which intervals between samples may be lengthened, with consequent saving in man-power because basic time spent on establishing communication between terminal stations is reduced, is dependent on the performance of the group link or links over which circuits are set up. We expect that, if satisfactory performance of the group links is ensured, intervals between samplings may be lengthened to such an extent that man-power requirements will be reduced substantially by comparison with the conventional method. When the ATMEs have been generally introduced, the preparation time becomes negligible.

3) A traffic route of the order of 12 outgoing circuits would be the minimum for any reduction of measurement work, on the assumption that at least one sample a month is considered desirable.

4) Statistical theory requires that samples should be drawn preferably from rational sub-groups. Since tolerance limits take no account of the actual routing, we find it most convenient, as was done in the course of the experimental application, to consider each traffic route as integral and to make subdivisions only for practical and economical purposes. It would, for example, be wasteful to try to maintain part of a large traffic route at a very high performance level, if only a modest, though satisfactory performance with reference to the tolerance specification could reasonably be expected, whether this be because of approaching obsolescence, complex routing or generally difficult conditions of operation. If a traffic route is composed of different line systems, it may be practical to make subdivisions and to take separate samples from each of them. Thereby it is possible to control the quality of these subdivisions in the most economical way.

The combining of results from both directions of transmission helps towards equalizing transmission characteristics.

5) Insufficient data are available for us to give a quantitative estimate, but our general feeling is that economies will be possible.

6. *Conclusion and recommendation*

The control chart method has been used experimentally for more than three years in the transmission maintenance of telephone circuits between major towns of our countries with good results. It appears from the preceding sections of this report that not all problems in connection with the control chart method have been fully cleared up, but we are of the opinion, nevertheless, that the method has proved itself so far that it may now be adopted by the C.C.I.T.T. as an alternative maintenance procedure. Accordingly, we propose that a recommendation to this effect be drawn up, inviting administrations which wish to explore the possibilities of the statistical methods dealt with in the present contribution to adopt such methods by bilateral agreements.

Period 1/6—30/11 1967

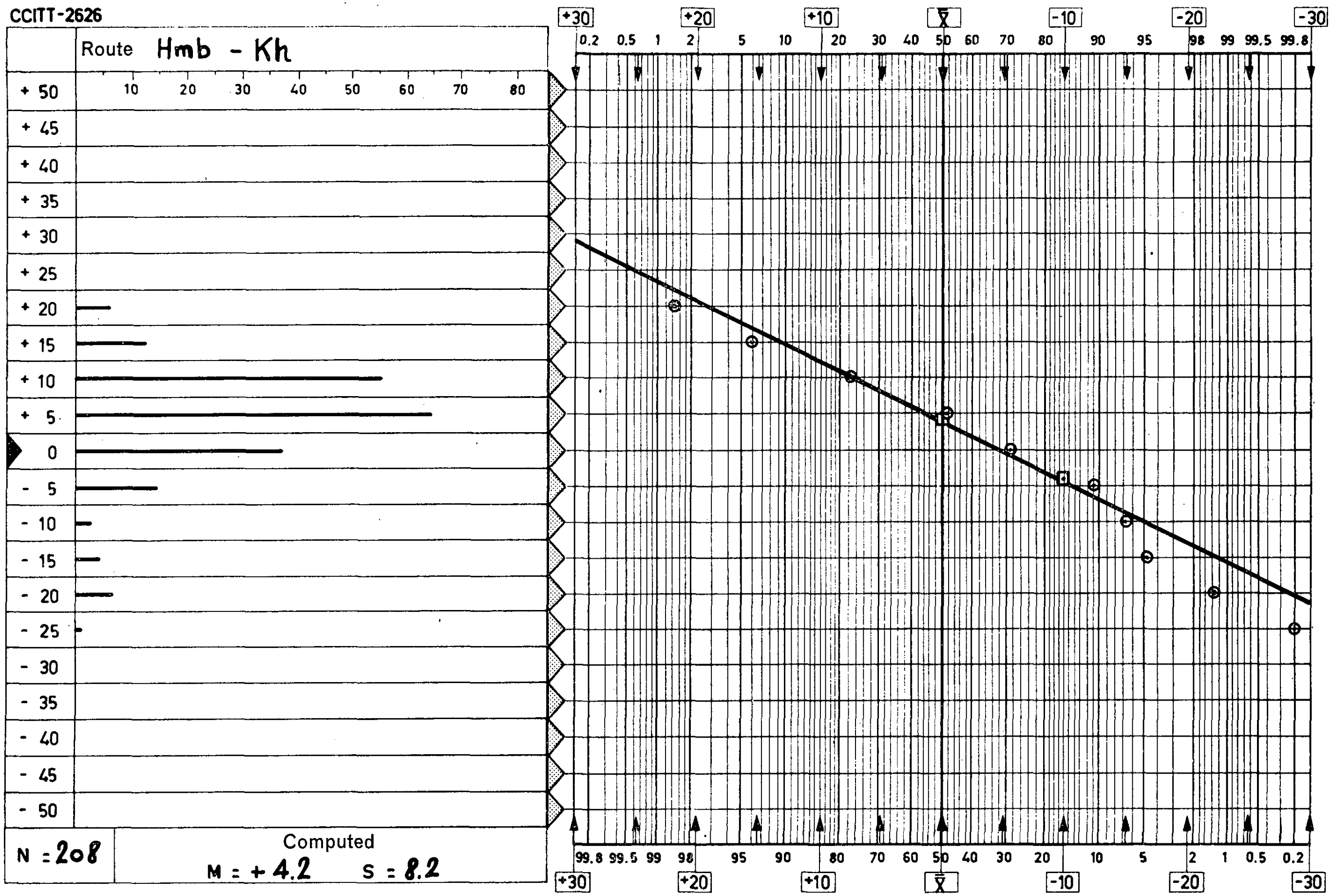
Experimental application of quality control methods to maintenance measurements
Summary of maintenance efforts and of results

Sheet 1

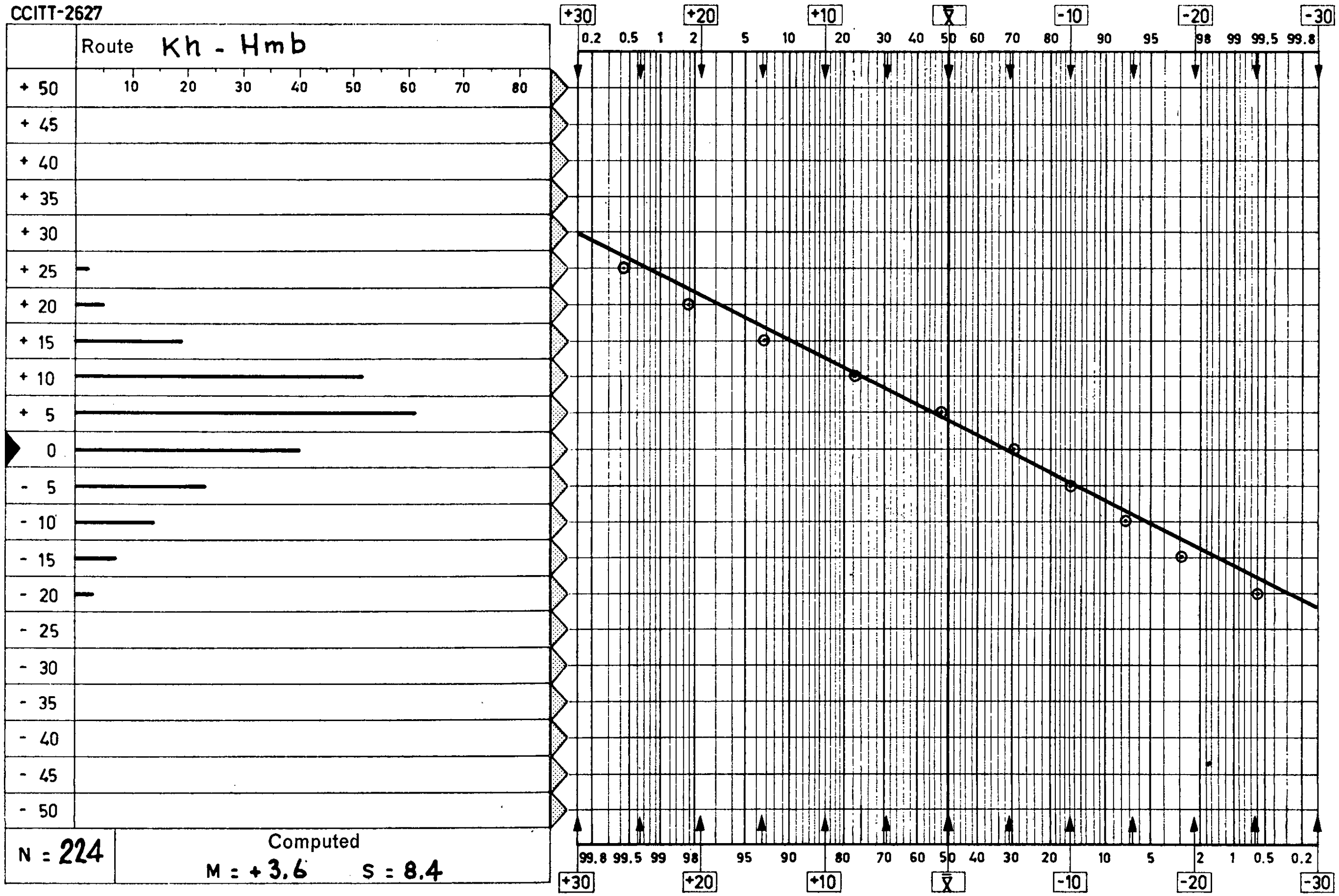
Route	Number of circuits	Number of samples	Number of sample series	Number of investigations	Number of measurements actually performed	Number of measurements according to Volume IV, M.64 (*Blue Book*)	Reduction in the number of single-frequency measurements in %	Deviations from nominal value: Mean cNp	Deviations from nominal value: Standard deviation cNp	Graphical representation: Sheet No.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Hmb-Kh	70	52	12	4	104	175	40	+4.2	8.2	2
Kh-Hmb (400 km)	70	56	12	5	112	175	36	+3.6	8.4	3
Kh-Mm	60	48	12	2	96	150	36	−4.4	7.9	4
Mm-Kh (35 km)	88	66	12	1	132	220	40	−3.0	8.7	5
Kh-Oslo (800 km)	52	43	12	7	86	130	34	0.0	12.2	6
Kh-Stkm	78	60	12	5	120	190	37	−1.5	9.3	7
Stkm-Kh (700 km)	72	53	12	5	106	180	41	+0.9	12.0	8
Hmb-Stkm and vice versa	82	42	12	1	76 [a]	205	63	+1.6	11.6	9

[a] By an error, the measurements indicated in respect of four samples were not carried out.

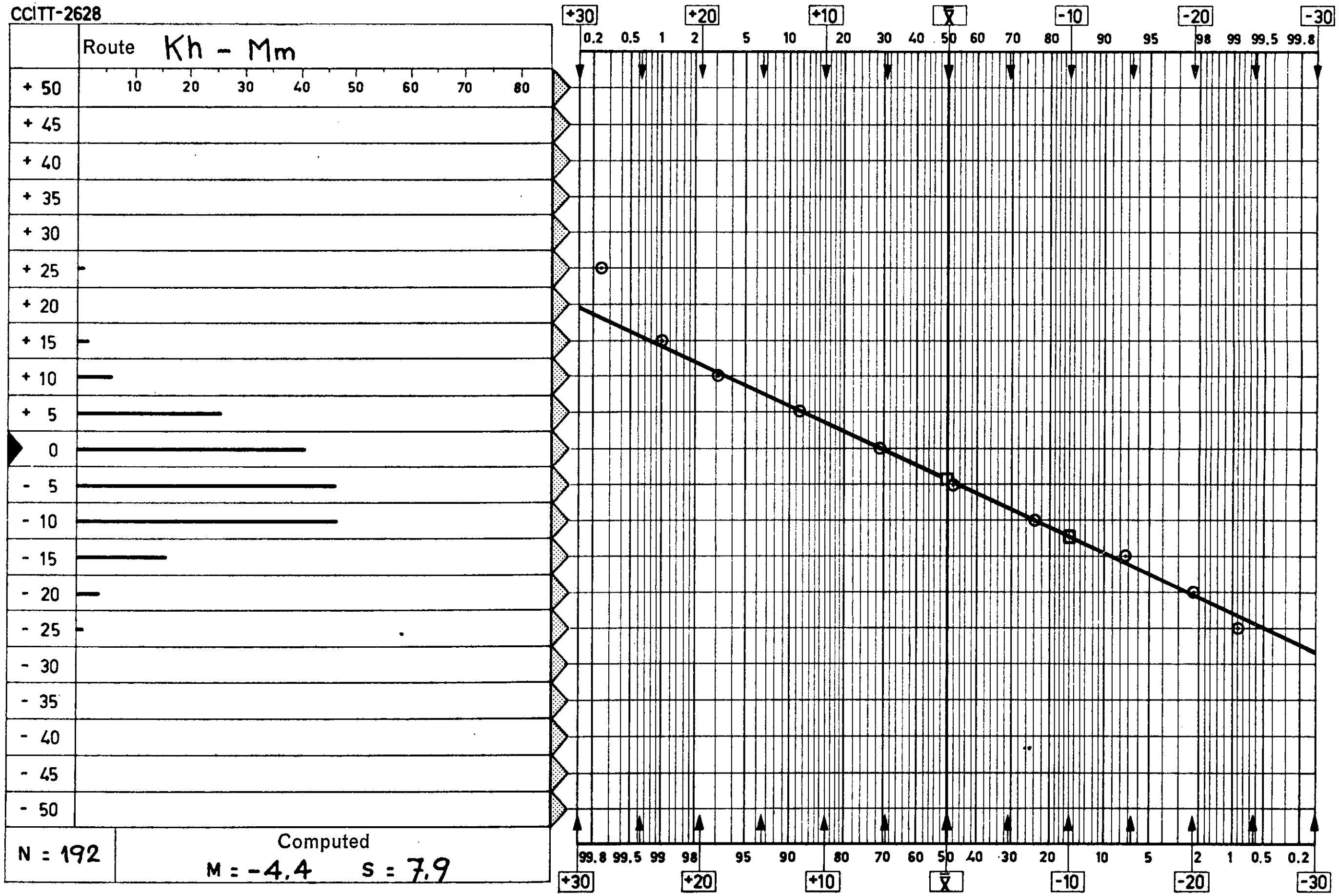
Period 1/6 – 30/11 1967 *Results of maintenance measurements obtained by sampling* Sheet 2



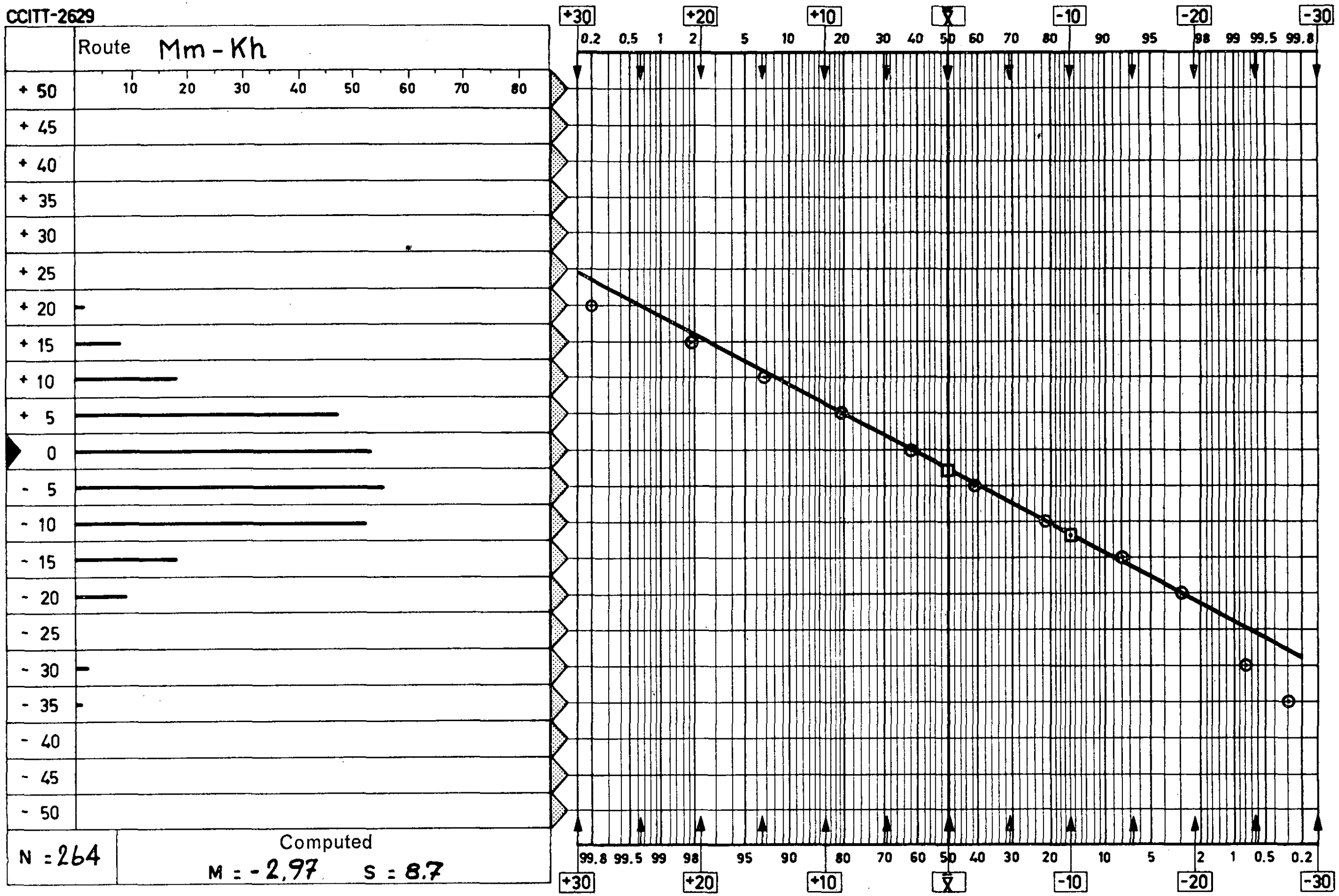
The straight line of the cumulative normal distribution is based on the computed values given below the histogram



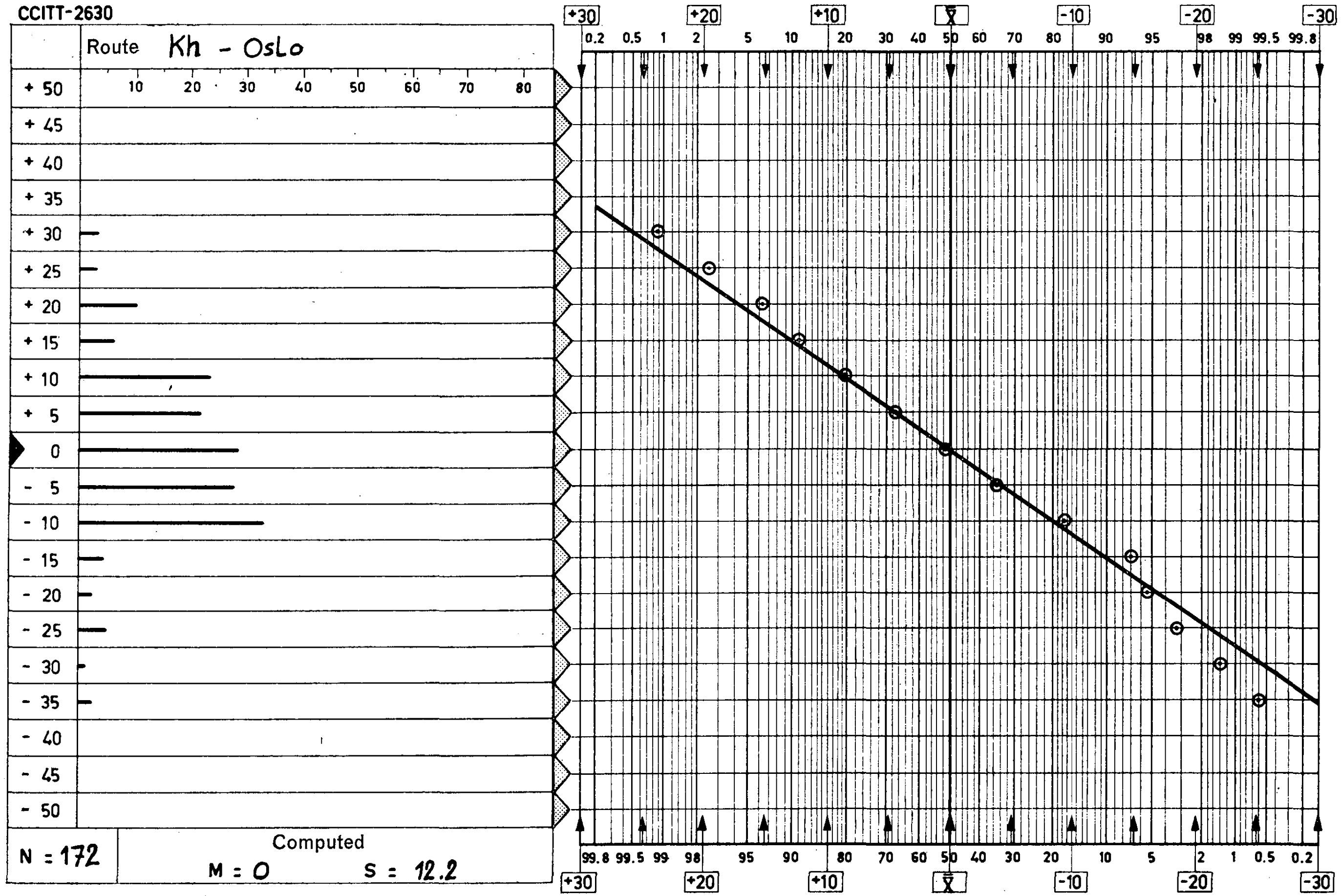
The straight line of the cumulative normal distribution is based on the computed values given below the histogram



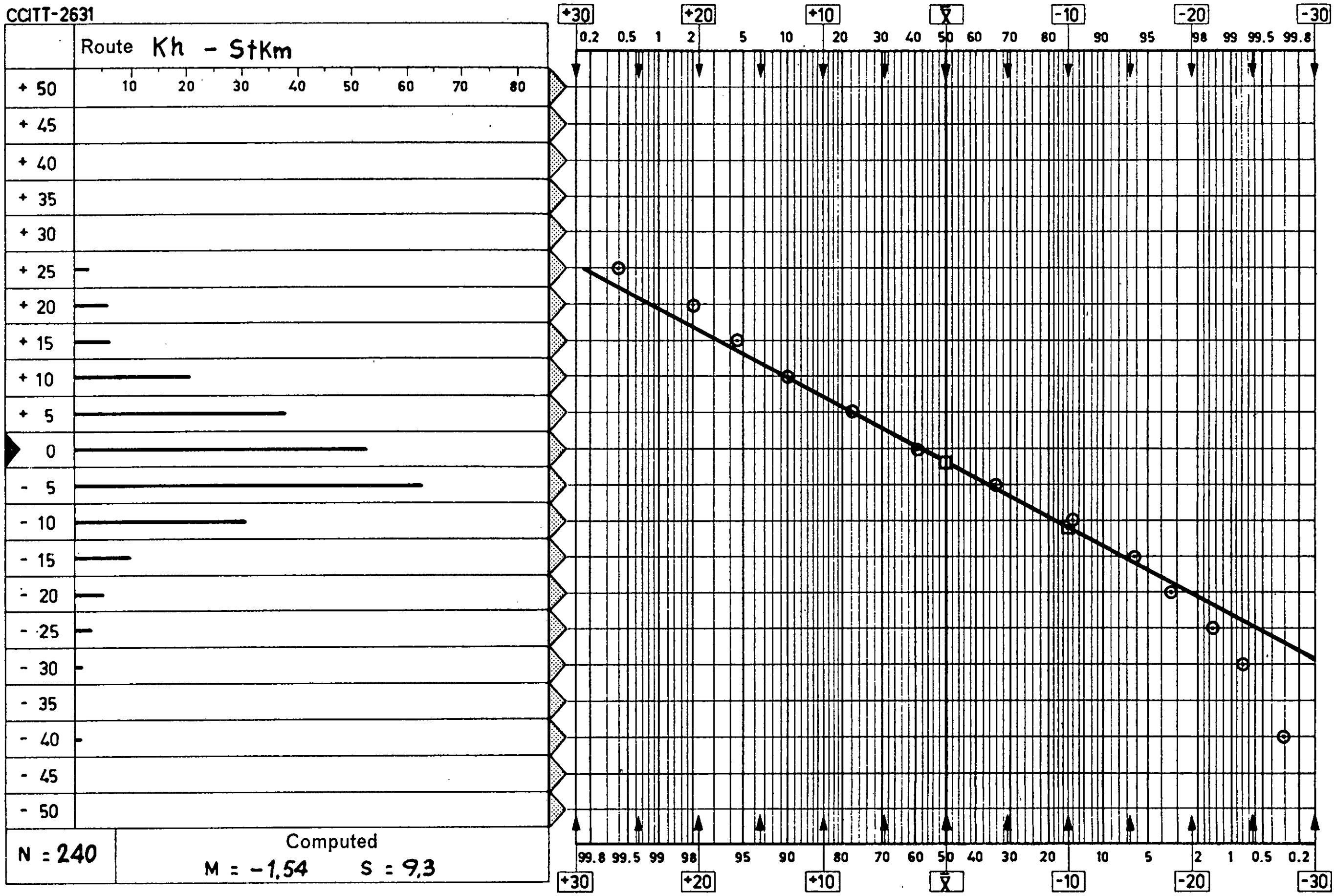
The straight line of the cumulative normal distribution is based on the computed values given below the histogram



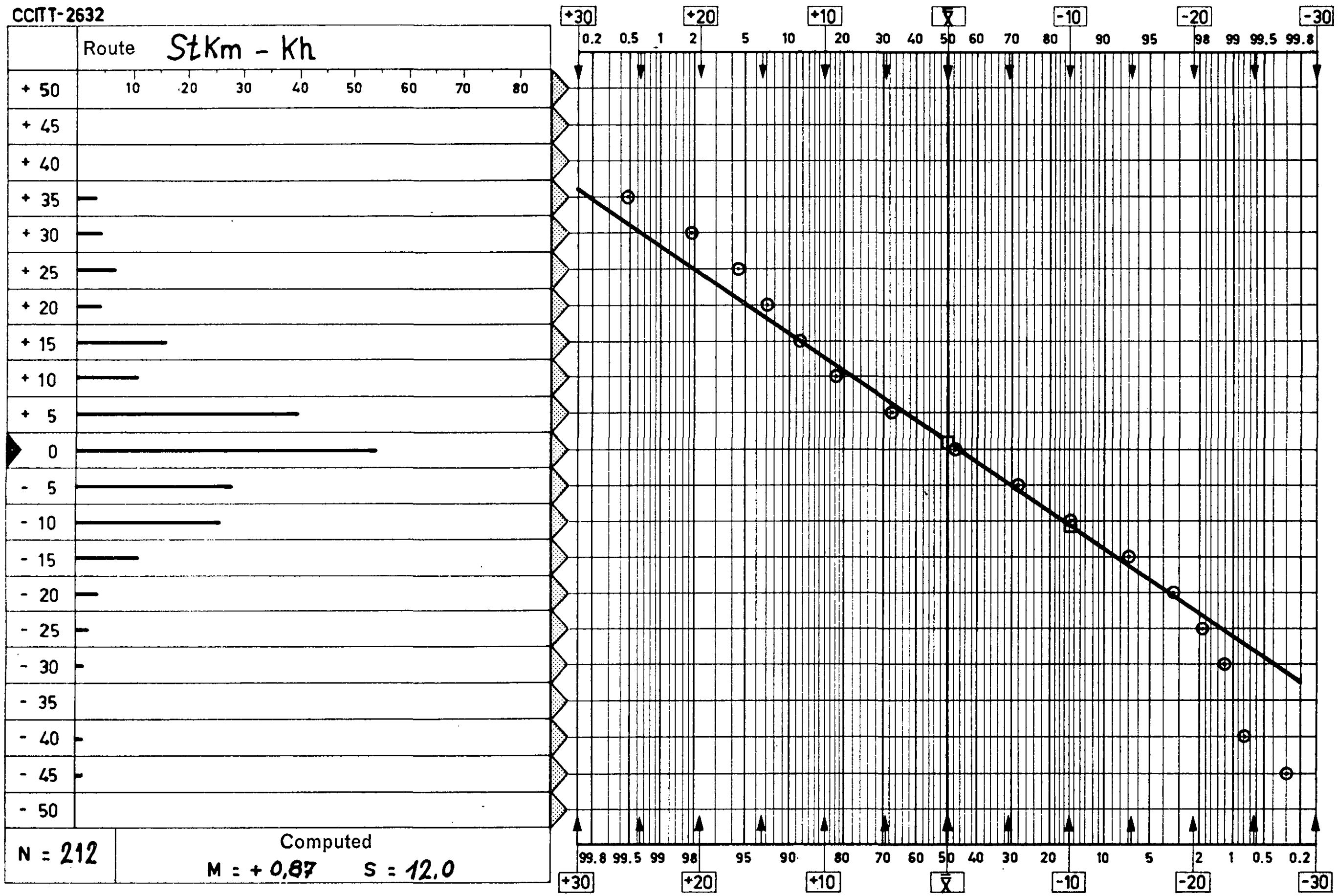
The straight line of the cumulative normal distribution is based on the computed values given below the histogram



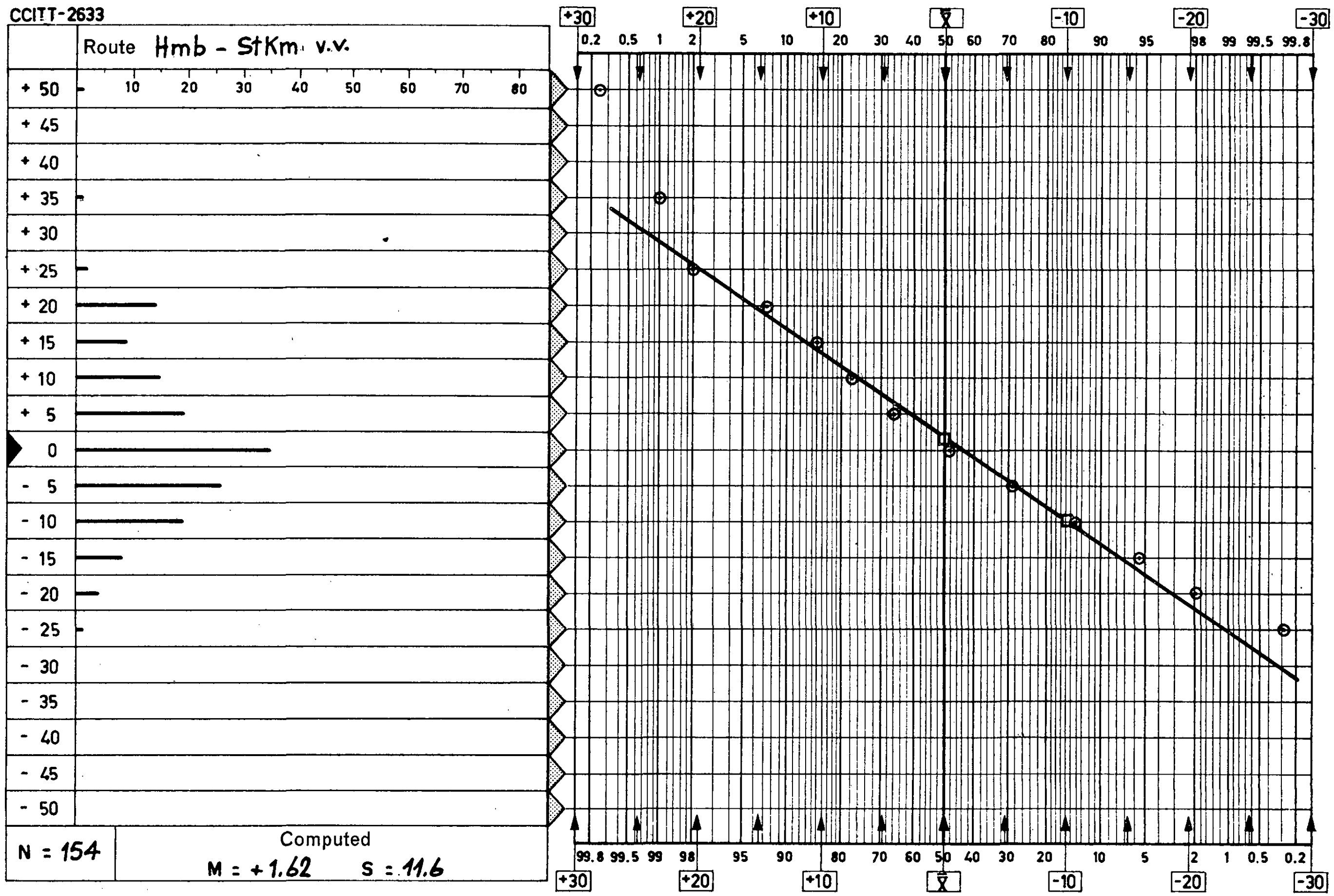
The straight line of the cumulative normal distribution is based on the computed values given below the histogram



The straight line of the cumulative normal distribution is based on the computed values given below the histogram



The straight line of the cumulative normal distribution is based on the computed values given below the histogram



The straight line of the cumulative normal distribution is based on the computed values given below the histogram

Question 16/IV — Maintenance of new systems specified by the C.C.I.T.T. and keeping Volume IV of the C.C.I.T.T. White Book up to date

(continuation of Question 16/IV—1964-1968; wording modified)

To keep the Maintenance Instructions established by Study Group IV always up to date, it is desirable to revise them and to include in them, as necessary, new instructions for systems and equipment newly specified by other study groups.

Specific points to be examined to ensure adequate maintenance instructions are:

a) programme circuits:

— use of compandors,

— use of pre-emphasis and de-emphasis networks,

b) data transmission over telephone circuits,

c) out-of-band signalling systems of a carrier telephone channel (how should it be ensured that the quality of the signalling channel is adequate?).

In order to keep the sections of Volume IV under continuous review, during the 1968-1972 period the delegates of the Administrations named below have undertaken to be responsible for advising Study Group IV of the detailed texts to amend the sections shown of Parts I and II of Volume IV of the *White Book*.

France	Part I, section 1
United Kingdom	Part I, sections 2 and 6
Netherlands	Part I, section 3
Switzerland	Part I, sections 4 and 5
Federal Republic of Germany	Part II, sections 1 and 2

Question 17/IV — Effect on maintenance of the introduction of new components and of modern equipment design

(new wording of Question 17/IV studied in 1964-1968)

How will the general introduction of new components and modern equipment like semi-conductor devices, printed and integrated circuits, and techniques replacing electro-mechanical devices such as relays, potentiometers, etc. by electronic means, affect existing maintenance methods and the reliability of modern equipment?

Some headings under which information could be given are as follows:

— training of staff (new maintenance philosophy);

— maintenance of modern transmission equipment (manual maintenance, automatic testing measuring and supervisory techniques);

— necessity for specialized apparatus for tests and measurements on modern transmission equipment;

— maintenance and repair methods for sub-assemblies of equipment. Special precautions in maintenance or repair work.

Question 18/IV — Maintenance of telephone type circuits

(new question; continuation of Question 14/IV, 1964-1968)

What modifications and additions should be made to the instructions for lining-up and maintenance applying to international telephone-type circuits?

The study must cover the needs for all lengths of international circuits including the longest possible circuits in the international network.

The following kinds of telephone-type circuits should be considered:

a) those used for public switched telephony (Part I, Section 3, of Volume IV, *White Book*);

b) those used for voice-frequency telegraphy or facsimile (Part I, Section 4, of Volume IV, *White Book*);

c) leased circuits (Part I, Section 5, of Volume IV, *White Book*);

d) service circuits (Recommendation M.10 of Volume IV, *White Book*).

Question 19/IV — Maintenance of sound-programme circuits

(continuation of former Questions 19/IV, 20/IV and 21/IV studied during 1964-1968)

What modifications and additions should be made to the instructions for lining-up and maintenance applying to international sound-programme transmission (Part II, Section 1, of Volume IV, *White Book*)?

Note 1. — A limitation on the level of test and measurement signals is essential on programme circuits equipped with pre-emphasis and de-emphasis networks, to avoid the risk of an unacceptable overload on carrier systems on which such circuits may be set up.

(See on page 364 of Volume III of the *Blue Book* the footnote to the Remark to Recommendation J.21.)

Note 2. — See in Part 2 of Volume IV of the *White Book* Recommendation N.13, which recommends:

— a maximum permissible level of 0 dBm0 for a period of the order of 30 seconds or a much lower level (not to exceed −12 dBm0) for a continuous tone;

— a maximum permissible level of −12 dBm0 at frequencies other than the reference frequency;

and Recommendation N.21, which specifies that no measurements of non-linearity distortion shall be made on circuits that include at least one carrier section.

Note 3. — The classification of sound-programme circuits according to bandwidth, etc., is being studied under Question 4/XV. Certain proposals originating with the Federal German Republic, and examined during 1964-1968 under former Question 19/IV are being reproduced in an annex to the wording of Question 4/XV. Leased sound-programme circuits are being studied under Question 3/III. Some questions concerning sound-programme circuits are also studied by the C.M.T.T.

Note 4. —

a) The C.C.I.T.T. Recommendation for the limits of the variation of level with frequency for an international programme circuit, type A, is given by the graph in Recommendation J.21, *Blue Book,* Volume III, page 360, Figure 110 and in paragraph a is also given the condition for the band of frequencies effectively transmitted. Corresponding maintenance information for type A and type B circuits will be found in the tables given in Recommendation N.10 of Volume IV of the *White Book.*

b) When a permanent programme *link* is provided between two broadcasting authorities the link is set up in such a way that the characteristic given in Recommendation N.10 is respected.

c) For programme *links* set up on a temporary basis, that is to say when administrations are asked to provide temporary programme *links* for a broadcast, the *link* is set up using permanent international programme *circuits* connected in tandem to form an international programme *line* together with the necessary local lines.

d) When the international line portion of an international programme *link* is set up for a broadcast, since each circuit composing the line can have the limits given above, it frequently happens that the limits are exceeded when the line is established.

e) During the line-up period, when Recommendation N.12 is applied, it frequently happens that before the circuit can be handed over to the broadcasting authorities, equalization is necessary in order that the limits given in Recommendation N.21 can be respected.

f) In many cases equalization is not possible, due either to lack of time or absence of suitable equalizers.

g) The question arises therefore as to whether the limits of level variation with frequency for programme *circuits* should not be considerably closer than those for a programme line or link.

Question 20/IV — Maintenance of television circuits

(continuation of Question 12/IV—1964-1968)

What modifications and additions should be made to the instructions for lining-up and maintenance applying to international television transmissions (Part II, Section 2, of Volume IV, *White Book*)?

Question 21/IV Measurements on switched connections

(new question)

(point 7 of Question 1/XVI—conclusions to be transmitted to Study Group XVI)

Note 1. — On a proposal by Study Group XVI, the IIIrd Plenary Assembly asked Study Group IV to undertake a series of measurements during 1964-1968 aimed at finding the actual transmission performance of switched connections, to help Study Group XVI in its study of the new transmission plan (Question 1/XVI, point 7, *Blue Book,* Volume III, p. 661).

After examination of the results of this series of measurements, Study Group XVI wished for further measurements to be undertaken. It was specified by the IVth Plenary Assembly that further series should be organized by Study Group IV under this present question, but that, in view of the amount of work that had to be carried out by administrations, such measurements should not be made more than once in the period between successive Plenary Assemblies.

There are three types of tests:

— measurements of the transmission quality of complete international connections between, and including, local exchanges;

— measurements of the portion of national networks used to establish international connections;

— measurements to ascertain if the international transmission plan is being correctly introduced. This will include measurements on international circuits or on chains of international circuits as well as measurements of international telephone exchanges.

Instructions on how these tests are to be made and of how the results are to be submitted are given in the following supplements of Volume IV of the *White Book*:

Supplement 4.5 — Transmission quality of complete connections.

Supplement 4.6 — Transmission quality of national extensions.

Supplement 4.7 — Transmission quality of international circuits, chains of circuits and international centres.

Note 2. — See the results of the previous series of measurements in Volume III of the *White Book* and in Supplement 4.4 of Volume IV of the *White Book*.

Question 22/IV — Measuring the reliability of international leased circuits

(new question)

1. How should the reliability of international leased circuits (as defined in Recommendation M.101, Volume IV of the *White Book*) be defined, and in what units should it be expressed?

2. How should the reliability be measured?

3. What is the present reliability (in the terms to be defined) of international leased circuits?

4. What is the expected reliability of various possible reserve arrangements?

For example:

a) a circuit for which there is a complete or partial nominated reserve;

b) a parallel arrangement of circuits;

c) a number of circuits with a common reserve.

Note 1. — Administrations and private operating agencies should consult the users of leased circuits to obtain details of their experience.

Note 2. — Study Group IV does not consider that it is responsible for laying down reliability requirements.

Note 3. — Question 12/C of Study Group Special C concerns definitions and general studies relating to reliability. Study Group XV is studying Questions 40/XV, 41/XV, 42/XV, 43/XV and 44/XV which relate respectively to the reliability of a system, of different services, of transmission systems, of the component parts of a system and of components.

Question 23/IV — Influence of human factors on reliability

(new question)

To what extent may human factors, such as methods of maintenance, operating errors, system operation, etc. influence system reliability?

SUPPLEMENTS TO SERIES M and N RECOMMENDATIONS

TABLE OF CONTENTS

SUPPLEMENT No. 1.1

PREFIXES USED IN THE DECIMAL SYSTEM

In the decimal system the multiples and sub-multiples of the fundamental units are indicated by the following prefixes:

Prefix	Symbol	Meaning	Prefix	Symbol	Meaning
téra	T	10^{12}	déci	d	10^{-1}
giga	G	10^{9}	centi	c	10^{-2}
méga	M	10^{6}	milli	m	10^{-3}
myria	ma	10^{4}	micro	µ	10^{-6}
kilo	k	10^{3}	nano	n	10^{-9}
hecto	h	10^{2}	pico	p	10^{-12}
deca	da	10			

SUPPLEMENT No. 1.2

TRANSMISSION MEASUREMENT CONVERSION TABLES [1]

A. *Conversion tables for transmission level measurements and noise measurements*

Notes concerning the tables:

1. The equivalence between transmission levels measured in terms of power relative to one milliwatt and those measured in terms of voltage relative to 0.775 volt is, strictly speaking, valid only when the measurements are made across an impedance of 600 ohms non-reactive (see Supplement No. 2.3).

2. The equivalence between noise measurements made using a C.C.I.T.T. psophometer (dBmp, dNmp, mVp, pWp) and noise measurements made in North America using a noise-measuring instrument having an F1A weighting characteristic or one having c-message weighting (dBa or dBrnC respectively) is explained in Supplement No. 3.2.

3. If noise on a telephone circuit has the character of white noise—that is, noise having a uniform spectral power density and a Gaussian probability distribution of amplitudes—the un-weighted noise-power level which would be measured on this circuit would be 2.5 dB above the psophometric noise-power level.

4. Psophometric emf will be twice the psophometric voltage given in the tables providing that measurements are made across an impedance of 600 ohms non-reactive. If noise measurements are made across an impedance other than 600 ohms the psophometric voltage is determined by applying a correction factor to the measurements, viz:

$$\text{psophometric voltage} = \text{noise voltage measured} \times \sqrt{\frac{600}{R}}$$

where R is the impedance across which measurements are made.

[1] These tables have no stated degree of accuracy. They are intended for approximate conversions only.

TABLE 1

Decibels to decinepers, voltage and power

Decibels (dBm)	Decinepers (dNm)	Voltage across 600 ohms (mV)	Pico-watts (pW)		
Psophometric noise measurements				North American noise measurements	
(dBmp)	(dNmp)	(mVp)	(pWp)	(dBrnC)	(dBa)
0	0	775	10^9	+90	+84
−1	−1.15	690	794×10^6	+89	+83
−2	−2.30	615	631×10^6	+88	+82
−3	−3.45	548	501×10^6	+87	+81
−4	−4.61	489	398×10^6	+86	+80
−5	−5.76	436	316×10^6	+85	+79
−6	−6.91	388	251×10^6	+84	+78
−7	−8.06	346	200×10^6	+83	+77
−8	−9.21	308	158×10^6	+82	+76
−9	−10.4	275	126×10^6	+81	+75
−10	−11.5	245	10^8	+80	+74
−11	−12.7	218	794×10^5	+79	+73
−12	−13.8	195	631×10^5	+78	+72
−13	−15.0	173	501×10^5	+77	+71
−14	−16.1	155	398×10^5	+76	+70
−15	−17.3	138	316×10^5	+75	+69
−16	−18.4	123	251×10^5	+74	+68
−17	−19.6	109	200×10^5	+73	+67
−18	−20.7	97.5	158×10^5	+72	+66
−19	−21.9	86.9	126×10^5	+71	+65
−20	−23.0	77.5	10^7	+70	+64
−21	−24.2	69.0	794×10^4	+69	+63
−22	−25.3	61.5	631×10^4	+68	+62
−23	−26.5	54.8	501×10^4	+67	+61
−24	−27.6	48.9	398×10^4	+66	+60
−25	−28.8	43.6	316×10^4	+65	+59
−26	−29.9	38.8	251×10^4	+64	+58
−27	−31.1	34.6	200×10^4	+63	+57
−28	−32.2	30.8	158×10^4	+62	+56
−29	−33.4	27.5	126×10^4	+61	+55
−30	−34.5	24.5	10^6	+60	+54
−31	−35.7	21.8	794×10^3	+59	+53
−32	−36.8	19.5	631×10^3	+58	+52
−33	−38.0	17.3	501×10^3	+57	+51
−34	−39.1	15.5	398×10^3	+56	+50
−35	−40.3	13.8	316×10^3	+55	+49
−36	−41.4	12.3	251×10^3	+54	+48
−37	−42.6	10.9	200×10^3	+53	+47
−38	−43.7	9.75	158×10^3	+52	+46
−39	−44.9	8.69	126×10^3	+51	+45
−40	−46.1	7.75	10^5	+50	+44
−41	−47.2	6.90	794×10^2	+49	+43
−42	−48.4	6.15	631×10^2	+48	+42
−43	−49.5	5.48	501×10^2	+47	+41
−44	−50.7	4.89	398×10^2	+46	+40

TABLE 1 *(cont.)*

Decibels (dBm)	Decinepers (dNm)	Voltage across 600 ohms (mV)	Pico-watts (pW)		
Psophometric noise measurements				North American noise measurements	
(dBmp)	(dNmp)	(mVp)	(pWp)	(dBrnC)	(dBa)
−45	−51.8	4.36	316 × 10^2	+45	+39
−46	−53.0	3.88	251 × 10^2	+44	+38
−47	−54.1	3.46	200 × 10^2	+43	+37
−48	−55.3	3.08	158 × 10^2	+42	+36
−49	−56.4	2.75	126 × 10^2	+41	+35
−50	−57.6	2.45	10^4	+40	+34
−51	−58.7	2.18	7940	+39	+33
−52	−59.9	1.95	6310	+38	+32
−53	−61.0	1.73	5010	+37	+31
−54	−62.2	1.55	3980	+36	+30
−55	−63.3	1.38	3160	+35	+29
−56	−64.5	1.23	2510	+34	+28
−57	−65.6	1.09	2000	+33	+27
−58	−66.8	0.975	1580	+32	+26
−59	−67.9	0.869	1260	+31	+25
−60	−69.1	0.775	10^3	+30	+24
−61	−70.2	0.690	794	+29	+23
−62	−71.4	0.615	631	+28	+22
−63	−72.5	0.548	501	+27	+21
−64	−73.7	0.489	398	+26	+20
−65	−74.8	0.436	316	+25	+19
−66	−76.0	0.388	251	+24	+18
−67	−77.1	0.346	200	+23	+17
−68	−78.3	0.308	158	+22	+16
−69	−79.4	0.275	126	+21	+15
−70	−80.6	0.245	10^2	+20	+14
−71	−81.7	0.218	79.4	+19	+13
−72	−82.9	0.195	63.1	+18	+12
−73	−84.0	0.173	50.1	+17	+11
−74	−85.2	0.155	39.8	+16	+10
−75	−86.3	0.138	31.6	+15	+9
−76	−87.5	0.123	25.1	+14	+8
−77	−88.7	0.109	20.0	+13	+7
−78	−89.8	0.098	15.8	+12	+6
−79	−91.0	0.087	12.6	+11	+5
−80	−92.1	0.077	10	+10	+4
−81	−93.3	0.069	7.94	+9	+3
−82	−94.4	0.062	6.31	+8	+2
−83	−95.6	0.055	5.01	+7	+1
−84	−96.7	0.049	3.98	+6	0
−85	−97.9	0.044	3.16	+5	−1
−86	−99.0	0.039	2.51	+4	−2
−87	−100	0.035	2.00	+3	−3
−88	−101	0.031	1.58	+2	−4
−89	−102	0.027	1.26	+1	−5
−90	−104	0.024	1	0	−6

TABLE 2

Decinepers to decibels, voltage and power

Decinepers (dNm)	Decibels (dBm)	Voltage across 600 ohms (mV)	Pico-watts (pW)		
Psophometric noise measurements				North American noise measurements	
(dNmp)	(dBmp)	(mVp)	(pWp)	(dBrnC)	(dBa)
0	0	975	10^9	+90	+84.0
−1	−0.869	698	813×10^6	+89.13	+83.1
−2	−1.74	637	676×10^6	+88.26	+82.3
−3	−2.61	574	550×10^6	+87.39	+81.4
−4	−3.47	518	447×10^6	+86.53	+80.5
−5	−4.34	472	372×10^6	+85.66	+79.7
−6	−5.21	426	302×10^6	+84.79	+78.8
−7	−6.08	384	246×10^6	+83.92	+77.9
−8	−6.95	346	200×10^6	+83.05	+77.1
−9	−7.81	316	166×10^6	+82.19	+76.2
−10	−8.69	284	135×10^6	+81.31	+75.3
−11	−9.55	256	110×10^6	+80.45	+74.5
−12	−10.4	234	912×10^5	+79.6	+73.6
−13	−11.3	211	741×10^5	+78.7	+72.7
−14	−12.2	190	603×10^5	+77.8	+71.8
−15	−13.0	173	501×10^5	+77.0	+71.0
−16	−13.9	156	407×10^5	+76.1	+70.1
−17	−14.8	141	331×10^5	+75.2	+69.2
−18	−15.6	129	275×10^5	+74.4	+68.4
−19	−16.5	116	224×10^5	+73.5	+67.5
−20	−17.4	104	182×10^5	+72.6	+66.6
−21	−18.2	95.3	151×10^5	+71.8	+65.8
−22	−19.1	85.9	123×10^5	+70.9	+64.9
−23	−20.0	77.5	100×10^5	+70.0	+64.0
−24	−21.0	69.8	794×10^4	+69.0	+63.0
−25	−21.7	63.7	676×10^4	+68.3	+62.3
−26	−22.6	57.4	550×10^4	+67.4	+61.4
−27	−23.5	51.8	447×10^4	+66.5	+60.5
−28	−24.3	47.2	372×10^4	+65.7	+59.7
−29	−25.2	42.6	302×10^4	+64.8	+58.8
−30	−26.1	38.4	246×10^4	+63.9	+57.9
−31	−26.9	35.0	204×10^4	+63.1	+57.1
−32	−27.8	31.6	166×10^4	+62.2	+56.2
−33	−28.7	28.4	135×10^4	+61.3	+55.3
−34	−29.5	25.9	112×10^4	+60.5	+54.5
−35	−30.4	23.4	912×10^3	+59.6	+53.6
−36	−31.3	21.1	741×10^3	+58.7	+52.7
−37	−32.1	19.2	617×10^3	+57.9	+51.9
−38	−33.0	17.3	501×10^3	+57.0	+51.0
−39	−33.9	15.6	407×10^3	+56.1	+50.1
−40	−34.7	14.3	339×10^3	+55.3	+49.3
−41	−35.6	12.9	275×10^3	+54.4	+48.4
−42	−36.5	11.6	224×10^3	+53.5	+47.5
−43	−37.3	10.6	186×10^3	+52.7	+46.7
−44	−38.2	9.53	151×10^3	+51.8	+45.8

TABLE 2 *(cont.)*

Decinepers (dNm)	Decibels (dBm)	Voltage across 600 ohms (mV)	Pico-watts (pW)		
Psophometric noise measurements				North American noise measurements	
(dNmp)	(dBmp)	(mVp)	(pWp)	(dBrnC)	(dBa)
−45	−39.1	8.59	123 × 10^3	+50.9	+46.9
−46	−40.0	7.75	100 × 10^3	+50	+44.0
−47	−40.8	7.06	813 × 10^2	+49.2	+43.2
−48	−41.7	6.37	676 × 10^2	+48.3	+42.3
−49	−42.6	5.74	550 × 10^2	+47.4	+41.4
−50	−43.4	5.24	447 × 10^2	+46.6	+40.6
−51	−44.3	4.72	372 × 10^2	+45.7	+39.7
−52	−45.2	4.26	302 × 10^2	+44.8	+38.8
−53	−46.0	3.88	251 × 10^2	+44.0	+38.0
−54	−46.9	3.5	204 × 10^2	+43.1	+37.1
−55	−47.8	3.16	166 × 10^2	+42.2	+36.2
−56	−48.6	2.88	138 × 10^2	+41.4	+35.4
−57	−49.5	2.59	112 × 10^2	+40.5	+34.5
−58	−50.4	2.34	9120	+39.6	+33.6
−59	−51.2	2.13	7410	+38.8	+32.8
−60	−52.1	1.92	6170	+37.9	+31.9
−61	−53.0	1.73	5010	+37.0	+31.0
−62	−53.9	1.56	4070	+36.1	+30.1
−63	−54.7	1.43	3390	+35.3	+29.3
−64	−55.6	1.29	2750	+34.4	+28.4
−65	−56.5	1.16	2240	+33.5	+27.5
−66	−57.3	1.06	1860	+32.7	+26.7
−67	−58.2	0.953	1510	+31.8	+25.8
−68	−59.1	0.859	1230	+30.9	+24.9
−69	−59.9	0.784	1020	+30.1	+24.1
−70	−60.8	0.706	813	+29.2	+23.2
−71	−61.7	0.637	676	+28.3	+22.3
−72	−62.5	0.581	562	+27.5	+21.5
−73	−63.4	0.524	457	+26.6	+20.6
−74	−64.3	0.472	372	+25.7	+19.7
−75	−65.1	0.431	309	+24.9	+18.9
−76	−66.0	0.388	251	+24.0	+18.0
−77	−66.9	0.350	204	+23.1	+17.1
−78	−67.8	0.316	166	+22.2	+16.2
−79	−68.6	0.288	138	+21.4	+15.4
−80	−69.5	0.259	112	+20.5	+14.5
−81	−70.4	0.234	91.2	+19.6	+13.6
−82	−71.2	0.213	75.9	+18.8	+12.8
−83	−72.1	0.192	61.7	+17.9	+11.9
−84	−73.0	0.173	50.1	+17.0	+11.0
−85	−73.8	0.158	41.7	+16.2	+10.2
−86	−74.7	0.143	33.9	+15.3	+ 9.3
−87	−75.6	0.129	27.5	+14.4	+ 8.4
−88	−76.4	0.117	22.9	+13.6	+ 7.6
−89	−77.3	0.106	18.6	+12.7	+ 6.7
−90	−78.2	0.095	15.1	+11.8	+ 5.8

TABLE 3

Table showing corresponding values of power ratio and decibels

Power ratio	Decibels	Power ratio	Decibels
1.0233	0.1	19.953	13.0
1.0471	0.2	25.119	14.0
1.0715	0.3	31.623	15.0
1.0965	0.4	39.811	16.0
1.1220	0.5	50.119	17.0
1.1482	0.6	63.096	18.0
1.1749	0.7	79.433	19.0
1.2023	0.8	100.000	20.0
1.2303	0.9	158.49	22.0
1.2589	1.0	251.19	24.0
1.3183	1.2	398.11	26.0
1.3804	1.4	630.96	28.0
1.4454	1.6	1000.0	30.0
1.5136	1.8	1584.9	32.0
1.5849	2.0	2511.9	34.0
1.6595	2.2	3981.1	36.0
1.7378	2.4	6309.6	38.0
1.8197	2.6	10^4	40.0
1.9055	2.8	$10^4 \times 1.5849$	42.0
1.9953	3.0	$10^4 \times 2.5119$	44.0
2.2387	3.5	$10^4 \times 3.9811$	46.0
2.5119	4.0	$10^4 \times 6.3096$	48.0
2.8184	4.5	10^5	50.0
3.1623	5.0	$10^5 \times 1.5849$	52.0
3.5481	5.5	$10^5 \times 2.5119$	54.0
3.9811	6.0	$10^5 \times 3.9811$	56.0
5.0119	7.0	$10^5 \times 6.3096$	58.0
6.3096	8.0	10^6	60.0
7.9433	9.0	10^7	70.0
10.0000	10.0	10^8	80.0
12.589	11.0	10^9	90.0
15.849	12.0	10^{10}	100.0

TABLE 4

Table showing corresponding values of power ratio and decinepers

Power ratio	Decinepers	Power ratio	Decinepers
1.020	0.1	13.46	13.0
1.041	0.2	16.45	14.0
1.062	0.3	20.09	15.0
1.083	0.4	24.53	16.0
1.105	0.5	29.96	17.0
1.127	0.6	36.60	18.0
1.150	0.7	44.70	19.0
1.174	0.8	54.60	20.0
1.197	0.9	81.45	22.0
1.221	1.0	121.5	24.0
1.271	1.2	181.3	26.0
1.323	1.4	270.4	28.0
1.377	1.6	403.4	30.0
1.433	1.8	601.9	32.0
1.492	2.0	897.9	34.0
1.553	2.2	1339	36.0
1.616	2.4	1998	38.0
1.682	2.6	2981	40.0
1.751	2.8	4447	42.0
1.822	3.0	6634	44.0
2.014	3.5	9897	46.0
2.226	4.0	$10^4 \times 1.476$	48.0
2.460	4.5	$10^4 \times 2.203$	50.0
2.718	5.0	$10^4 \times 3.286$	52.0
3.004	5.5	$10^4 \times 4.902$	54.0
3.320	6.0	$10^4 \times 7.313$	56.0
4.055	7.0	$10^5 \times 1.091$	58.0
4.953	8.0	$10^5 \times 1.628$	60.0
6.050	9.0	$10^6 \times 1.203$	70.0
7.389	10.0	$10^6 \times 8.886$	80.0
9.025	11.0	$10^7 \times 6.566$	90.0
11.02	12.0	$10^8 \times 4.852$	100.0

SUPPLEMENT No. 1.3

THE NORMAL (OR LAPLACE-GAUSS) DISTRIBUTION

One statistical distribution which finds considerable application is the normal (or Gaussian) distribution. This distribution, which under certain conditions is used as an approximation to other frequently encountered distributions, has certain properties that make it easy to manipulate. Figure 1 is a representation of an example of such a distribution. Two parameters, the mean, designated by the symbol M, and the standard deviation, symbol S, fully define the distribution. One standard deviation from each side of the mean includes 68.3% of the area under the curve, two standard deviations include 95.4% of the area and three standard deviations 99.7%. In the example of Figure 1 the distribution is of deviations of transmission loss from the nominal, and it is seen that these are distributed normally with $M = 0$ dB and $S = 1$ dB. The area under the curve in this instance represents the number of measurements made. In Figure 2 another example is shown with $M = +0.3$ dB and $S = 1.6$ dB. It is worth noting that in this instance the areas each side of the value of nominal loss, 0 dB, are not equal. Consequently, more of the circuits measured had excess loss than excess gain.

In practice it is often necessary, given the mean value and standard deviation of a population normally distributed, to determine the percentage of the population lying in various parts of the distribution, for which purpose Table 1 has been constructed. In order to use the table, the particular value of interest of the deviation from the mean is divided by the standard deviation to give the variable k (termed the normal deviate) for which the table is constructed.

As an example of the use of this table, consider the case of a signal receiver designed to operate satisfactorily when the losses of the circuits on a particular route are within ±4 dB of 0 dB, the assumed nominal value. If, however, the losses of the circuits are in fact distributed with a mean −0.4 dB and standard deviation 2 dB then the percentage of the signal receivers likely to operate satisfactorily is obtained as follows:

+4 dB deviation from nominal is 4.4 dB from mean.

−4 dB deviation from nominal is 3.6 dB from mean.

Hence the appropriate k values are obtained as follows:

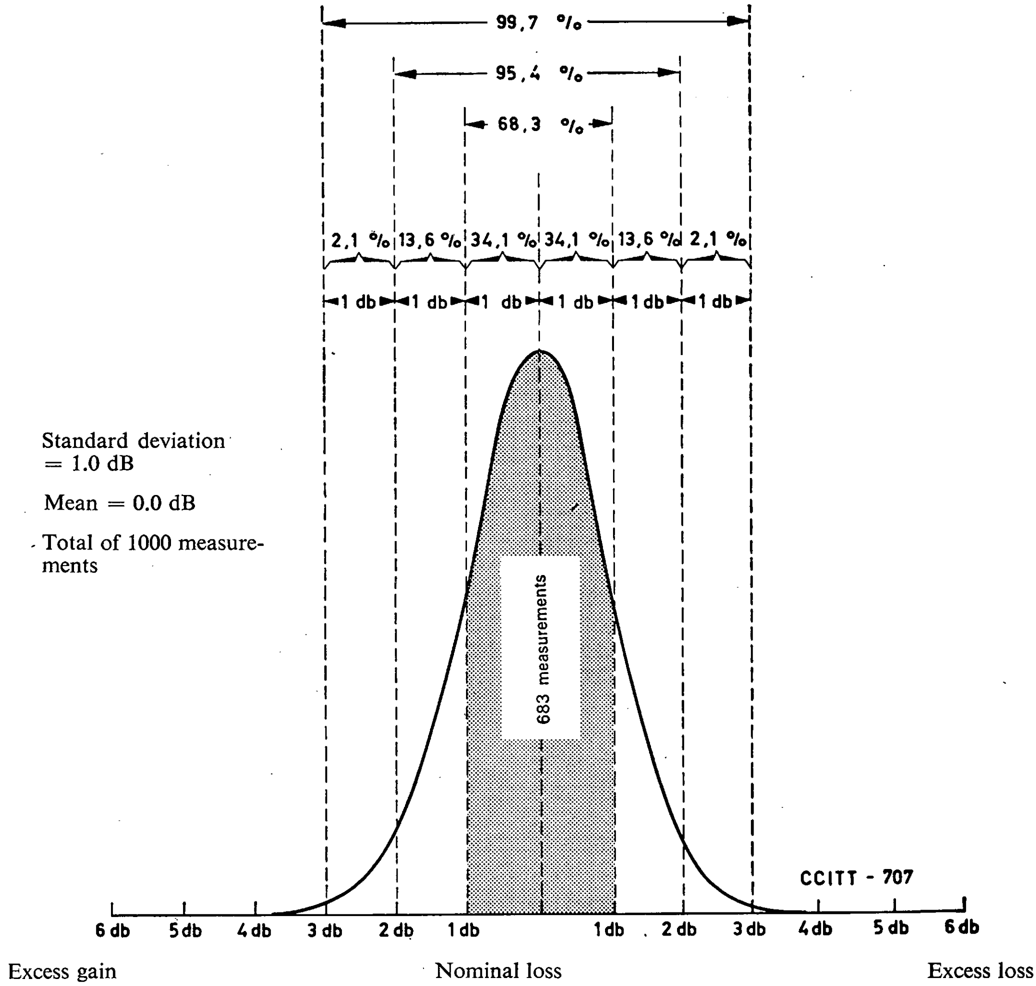
4.4 dB is $4.4/2.0 = 2.2$ standard deviation from mean.

3.6 dB is $3.6/2.0 = 1.8$ standard deviation from mean.

From Table 1, column 3,

$k = 2.2$ gives 1.39%.

$k = 1.8$ gives 3.59%.



683 measurements in range of 1 dB excess gain and 1 dB excess loss

954 measurements in range of 2 dB excess gain and 2 dB excess loss

997 measurements in range of 3 dB excess gain and 3 dB excess loss

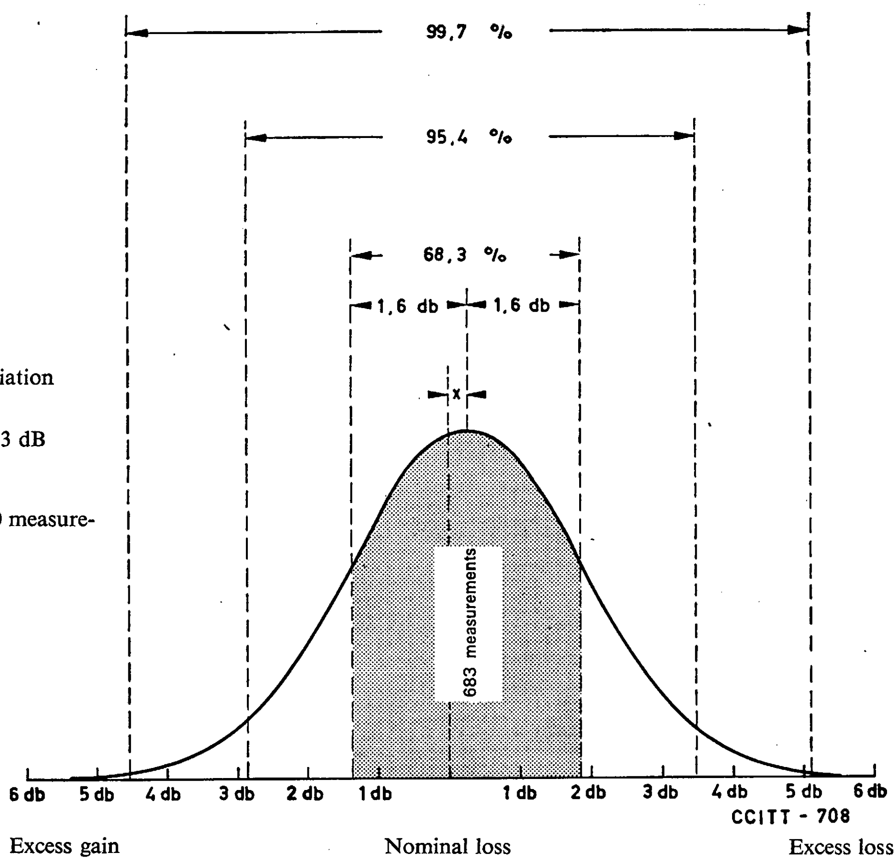
FIGURE 1. — **Chart showing distribution with zero mean**

Standard deviation = 1.6 dB

Mean = +0.3 dB

× = 0.3 dB

Total of 1000 measurements



683 measurements in range of 1.3 dB excess gain and 1.9 dB excess loss

954 measurements in range of 2.9 dB excess gain and 3.5 dB excess loss

997 measurements in range of 4.5 dB excess gain and 5.1 dB excess loss

FIGURE 2. — **Chart showing distribution with mean of +0.3 dB**

TABLE 1

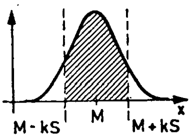
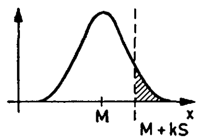
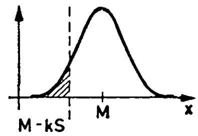
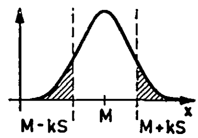
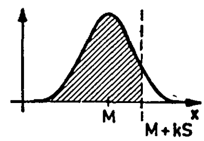
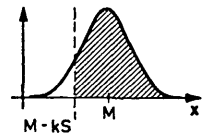
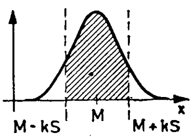
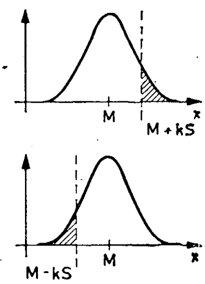
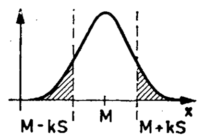
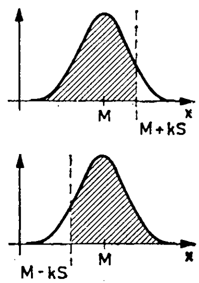
	Percentage of population			
k (1)	Between $M \pm kS$ (2)	Above $M + kS$ or below $M - kS$ (3)	Outside limits $M + kS$ (4)	$< M + kS$ or $> M - kS$ (5)
		 		 
0.0	0	50.000000	100.00000	50.00000
0.1	7.96556	46.01722	92.03444	53.98278
0.2	15.85194	42.07403	84.14806	57.92597
0.3	23.58228	38.20886	76.41772	61.79114
0.4	31.08434	34.45783	68.91566	65.54217
0.5	38.29250	30.85375	61.70750	69.14625
0.6	45.14938	27.42531	54.85062	72.57469
0.6745	50.00000	25.00000	50.00000	75.00000
0.7	51.60726	24.19637	48.39274	75.80363
0.8	57.62892	21.18554	42.37108	78.81446
0.9	63.18798	18.40601	36.81202	81.59399
1.0	68.26894	15.86553	31.73106	84.13447
1.1	72.86678	13.56661	27.13322	86.43339
1.2	76.98606	11.50697	23.01394	88.49303
1.2816	80.00000	10.00000	20.00000	90.00000
1.3	80.63990	9.68005	19.36010	90.31995
1.4	83.84866	8.07567	16.15134	91.92433
1.5	86.63856	6.68072	13.36144	93.31928
1.6	89.02014	5.48993	10.97986	94.52007
1.6449	90.00000	5.00000	10.00000	95.00000
1.7	91.08690	4.45655	8.91310	95.54345
1.8	92.81394	3.59303	7.18606	96.40697
1.9	94.25668	2.87166	5.74332	97.12834
1.9600	95.00000	2.50000	5.00000	97.50000
2.0	95.44998	2.27501	4.55002	97.72499
2.1	96.42712	1.78644	3.57288	98.21356
2.2	97.21932	1.39034	2.78068	98.60966
2.3	97.85518	1.07241	2.14482	98.92759
2.3263	98.00000	1.00000	2.00000	99.00000
2.4	98.36050	0.81975	1.63950	99.18025
2.5	98.75806	0.62097	1.24194	99.37903
2.5758	99.00000	0.50000	1.00000	99.50000
2.6	99.06776	0.46612	0.93224	99.53388
2.7	99.30660	0.34670	0.69340	99.65330
2.8	99.48898	0.25551	0.51102	99.74449
2.9	99.62684	0.18658	0.37316	99.81342

TABLE 1 *(cont.)*

	Percentage of population			
k (1)	Between $M \pm kS$ (2)	Above $M + kS$ or below $M - kS$ (3)	Outside limits $M+kS$ (4)	$< M + kS$ or $> M - kS$ (5)
				
3.0	99.73002	0.13499	0.26998	99.86501
3.0902	99.80000	0.10000	0.20000	99.90000
3.1	99.80648	0.09676	0.19352	99.90324
3.2	99.86258	0.06871	0.13742	99.93129
3.3	99.90332	0.04834	0.09668	99.95166
3.4	99.93262	0.03369	0.06738	99.96631
3.5	99.95348	0.02326	0.04652	99.97674
3.6	99.96818	0.01591	0.03182	99.98409
3.7	99.97844	0.01078	0.02156	99.98922
3.8	99.98544	0.00723	0.01446	99.99277
3.9	99.99038	0.00481	0.00962	99.99519
4.0	99.99366	0.00317	0.00634	99.99683

Therefore, 4.98 % of the receivers can be expected not to operate satisfactorily.

It is worth noting that when the mean deviation from the nominal value is zero, then the distribution is symmetrical about this value and $k = 2.0$. Entering the table at $k = 2.0$, column (2) gives 95.45 %, the percentage of circuits for which the receiver can be expected to operate satisfactorily, and column (4) gives 4.55 %, the expected percentage of failures.

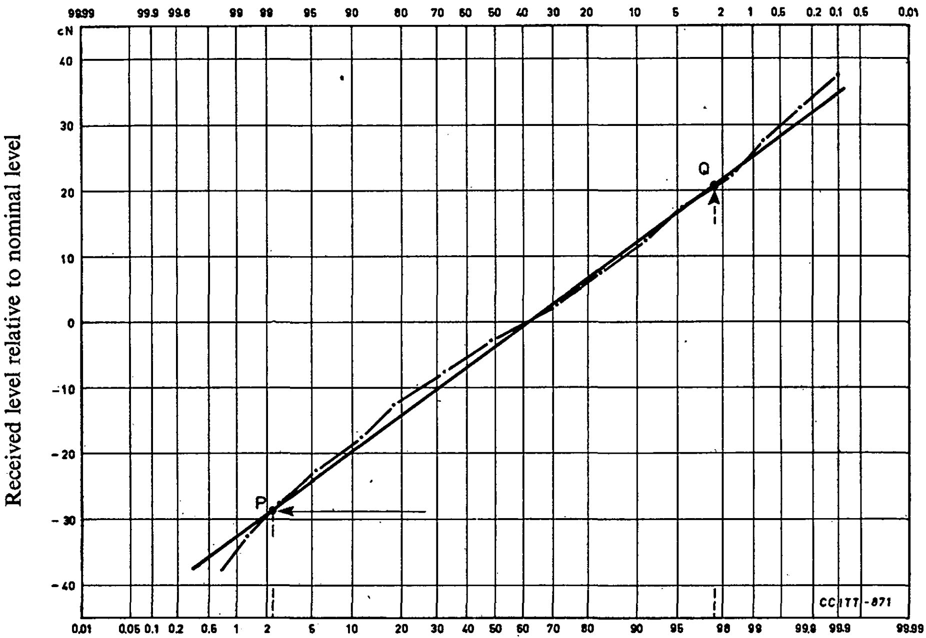
Numerical method—Use of a form

As an aid to computing the parameters of a sample of a distribution it is often convenient to use a form. Figure 3 illustrates such a form which in this example is one that was constructed specifically for calculating the mean and standard deviation of the samples of the distribution of circuit losses. The class intervals used on the form are those used in the study of Question 1/IV (see the Appendix to the Annex to Question 1/IV). These class intervals are defined in terms of centinepers, and appropriate decibel equivalents are given in column (2) of the form.

Interval in cNp or dB		Stroke record of the value of the difference between the measured value and the nominal value eg. measured = −2 dB, nominal = −3 dB, then difference = −2−(−3) = +1 dB																				Total number of strokes in each interval	Number of the interval	Product of columns (4) and (5)	Product of columns (5) and (6)
(1)	(2)	(3)																				(4)	(5)	(6)	(7)
cNp	dB	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100:				
above +62.5	above +5.43													Sum of this row only $X = 0$											
+62.5 to +57.6	+5.43 to +5.00																					0	12	0	0
+57.5 +52.6	+4.99 +4.57	//																				2	11	22	242
+52.5 +47.6	+4.56 +4.14																					0	10	0	0
+47.5 +42.6	+4.13 +3.70	///																				3	9	27	243
+42.5 +37.6	+3.69 +3.27	////																				4	8	32	256
+37.5 +32.6	+3.26 +2.83	𝍸																				5	7	35	245
+32.5 +27.6	+2.82 +2.40	///																				3	6	18	108
+27.5 +22.6	+2.39 +1.96	𝍸	𝍸	//																		12	5	60	300
+22.5 +17.6	+1.95 +1.53	𝍸	/																			6	4	24	96
+17.5 +12.6	+1.52 +1.10	𝍸	𝍸	𝍸	//																	17	3	51	153
+12.5 + 7.6	+1.09 +0.66	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	/														31	2	62	124
+ 7.5 + 2.6	+0.65 +0.23	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	///											48	1	48	48
+ 2.5 − 2.4	+0.22 −0.21	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	////											49	0	Total $P = 379$	0
− 2.5 − 7.4	−0.22 −0.64	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	///			88	1	88	88
− 7.5 −12.4	−0.65 −1.08	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	//										52	2	104	208
−12.5 −17.4	−1.09 −1.51	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	//						72	3	216	648
−17.5 −22.4	−1.52 −1.94	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	//														32	4	128	512
−22.5 −27.4	−1.95 −2.38	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	///													38	5	190	950
−27.5 −32.4	−2.39 −2.81	𝍸	𝍸	/																		11	6	66	396
−32.5 −37.4	−2.82 −3.25	𝍸	𝍸	𝍸																		15	7	105	735
−37.5 −42.4	−3.26 −3.68	𝍸	𝍸																			9	8	72	576
−42.5 −47.4	−3.69 −4.12	𝍸																				5	9	45	405
−47.5 −52.4	−4.13 −4.55	///																				3	10	30	300
−52.5 −57.4	−4.56 −4.98	𝍸																				5	11	55	605
−57.5 −62.4	−4.99 −5.42	//																				2	12	24	288
below −62.4	below −5.42	//												Sum of this row only $Y = 2$								Total $N = 512$		Total $Q = 1123$	Total $B = 7526$

Total of rows in column (4)	Total of first and last rows in column (3)	Difference between totals P and Q in column (6)	Total of rows in column (7)	Mean deviation	Mean of squared deviations	Variance	Standard deviation	% of sample falling outside range
$N = 512$	$E = X + Y$ $= 2$	$A = P - Q$ $= -744$	$B = 7526$	$M = \frac{A}{N} = -1.45$ In transmission units $M \times 5 = -7.25$ cNp $M \times 0.43 = -0.62$ dB	$R = \frac{B}{N} = 14.7$	$V = R - (M)^2$ $= 12.6$	$S = \sqrt{V} = 3.55$ In transmission units $S \times 5 = 17.75$ cNp $S \times 0.43 = 1.53$ dB	range $= \frac{100E}{E + N}$ $= 3.9$

FIGURE 3. — **Record of results of routine (Batch) transmission measurements**

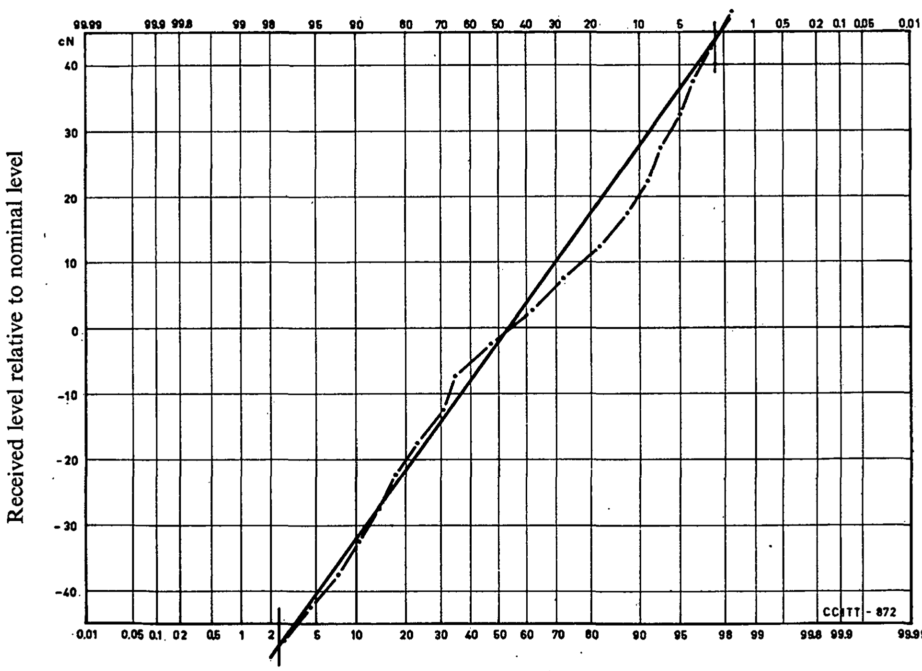


Percentage of measurements less than the ordinate

By numerical method $M = -3.5$ cNp $= -0.3$ dB; $S = 12.6$ cNp $= 1.1$ dB

By graphical method $M = -3.8$ cNp $= -0.3$ dB; $S = 12.4$ cNp $= 1.1$ dB

FIGURE 4. — **Numerical and graphical methods yield statistics that are similar**



Percentage of measurements less than the ordinate

By numerical method $M = -3.5$ cNp $= -0.3$ dB; $S = 21.1$ cNp $= 1.8$ dB

By graphical method $M = -2$ cNp $= -0.2$ dB; $S = 23$ cNp $= 2$ dB

FIGURE 5. — **Numerical and graphical methods yield statistics that are dissimilar**

The form is used as follows. A stroke is entered in column (3) against the interval value in columns (1) and (2)—class intervals in either centinepers or decibels—corresponding to the value of the deviation measured. This procedure is repeated until the set of measurements is completed. The total number of strokes in each interval is then added and entered in column (4). The calculation then proceeds as shown in the form, to give the mean deviation M, and the standard deviation S and the percentage of the measurements falling outside the tabulated range.

Graphical method—Use of arithmetic probability paper

As an alternative to calculating the mean value and standard deviation of a distribution by the numerical computation method described above, it is possible to estimate it graphically. This can be done by plotting the cumulative percentages on arithmetic probability paper. The ordinates corresponding to 97.7% and 2.3% are noted, and one quarter of their difference is approximately equal to the standard deviation of the actual distribution. If the 97.7% and the 2.3% points on the curve are joined with a straight line, the mean value of the actual distribution is approximately equal to the ordinate value corresponding to 50% on the straight line[1].

Figure 4 shows a plot of cumulative percentage of a particular distribution, points P and Q being the 2.3% and 97.7% points. The difference in their ordinates is $Q - P = 21 - (-28.5) = 49.5$ cNp, whence the standard deviation is $1/4\ (49.5) = 12.4$ cNp. (This should be compared with the value 12.6 cNp arrived at by a numerical computation similar to that described above.)

The mean value of the straight line joining P and Q is seen to be -3.8 cNp which may be compared to the calculated value, -3.5 cNp.

The advantages claimed for this method of estimating mean values and standard deviations are as follows:

a) the numerical computation work is less;

b) by confining attention to the middle 95% (approximately) of the data, marginal results which are most likely due to faults are excluded from the statistics;

c) by plotting the distribution, it can immediately be seen whether it is normal or not. If the distribution is not normal in the middle portion then causes other than random are at work, e.g. faults, etc.

When the distribution is normal or near normal, the graphical method gives sufficiently accurate values for M and S as in Figure 4.

However, when the distribution is not normal the graphical method gives values which are not equal to the mean and standard deviation of the distribution. See, for example, Figure 5, in which the value of the mean numerically computed from the original data and the value computed graphically differ by 1.5 cNp. Similarly, the values of the standard deviation differ by 1.9 cNp. It may be thought that these are errors. However, when the distribution is not normal, the mean and standard deviation lose their simplicity. For example, it is no longer true that the mean $\pm$ one standard deviation embraces 68.3%

[1] In practice there will be no great error in using the values of 2% and 98%, which are usually marked on arithmetic probability paper.

of the distribution. In the particular case of Figure 5 for example, -3.5 ± 21.1 cNp embraces 77%. It is equally misleading, of course, to cite the values -2 cNp and 23 cNp, but in this case:

a) it is known that the distribution is not normal;

b) not too much time has been spent in the computation.

SUPPLEMENT No. 1.4

METHODS OF QUALITY CONTROL

I. The application of the control chart method to telephone maintenance measurements

(Joint Note by the Administrations of Denmark, Federal Republic of Germany, Norway, and Sweden)

1. *Introduction*

This is a description of an adaptation of the Shewhart control chart method for use with maintenance measurements of international telephone circuits, based on experience gained during a trial period of more than three years. The use of control charts is combined with a random sampling procedure for circuits with a view to achieving an adequate survey of the performance of the network with the least possible effort as regards the number of measurements. The sampling procedure is applied in respect of *single-frequency* measurements, where it replaces the measurements with fixed intervals specified in Recommendation M.61. The measurements at *several frequencies* are carried out in accordance with M.61 on the days indicated in the Routine Maintenance Programme for International Circuits. As far as the maintenance of international group and supergroup links is concerned, the control chart method is applied to the daily or weekly readings of reference pilot levels.

In the following sections a brief outline is given of the theory of small samples and their evaluation by means of control charts, the lay-out of a sampling schedule and its use is described, and guidance is given for the design of a suitable control chart form and for the determination of control chart limits.

2. *An outline of statistical sample theory*

For ease of reference the normal distribution curve is shown as Figure 1. The normal distribution curve is a representation of the theoretical probability distribution of a variable quantity x that tends towards a standardized or central value, the mean value, being influenced by a large number of independent factors, each of which is of small effect. Probability is represented by the area under the curve and will take a value between zero and unity, the total being unity or 100%. The probability that x may take a value in the interval between x_a and x_b is represented by that part of the area that is vertically delimited by the ordinates having their origins at these values, as shown in Figure 1 by shading.

The normal distribution curve is completely described by two quantities or parameters, χ and σ, symbolizing the mean value and the standard deviation, respectively, of x. (It is customary to use Greek letters for theoretical quantities; χ and σ correspond to the symbols $\bar{x}$ (x bar) and s which are commonly used to denote mean value and standard deviation of an empirical distribution). The area of the normal distribution falls symmetrically on both sides of the mean value, with 68.2% between values of $-\sigma$ and $+\sigma$,

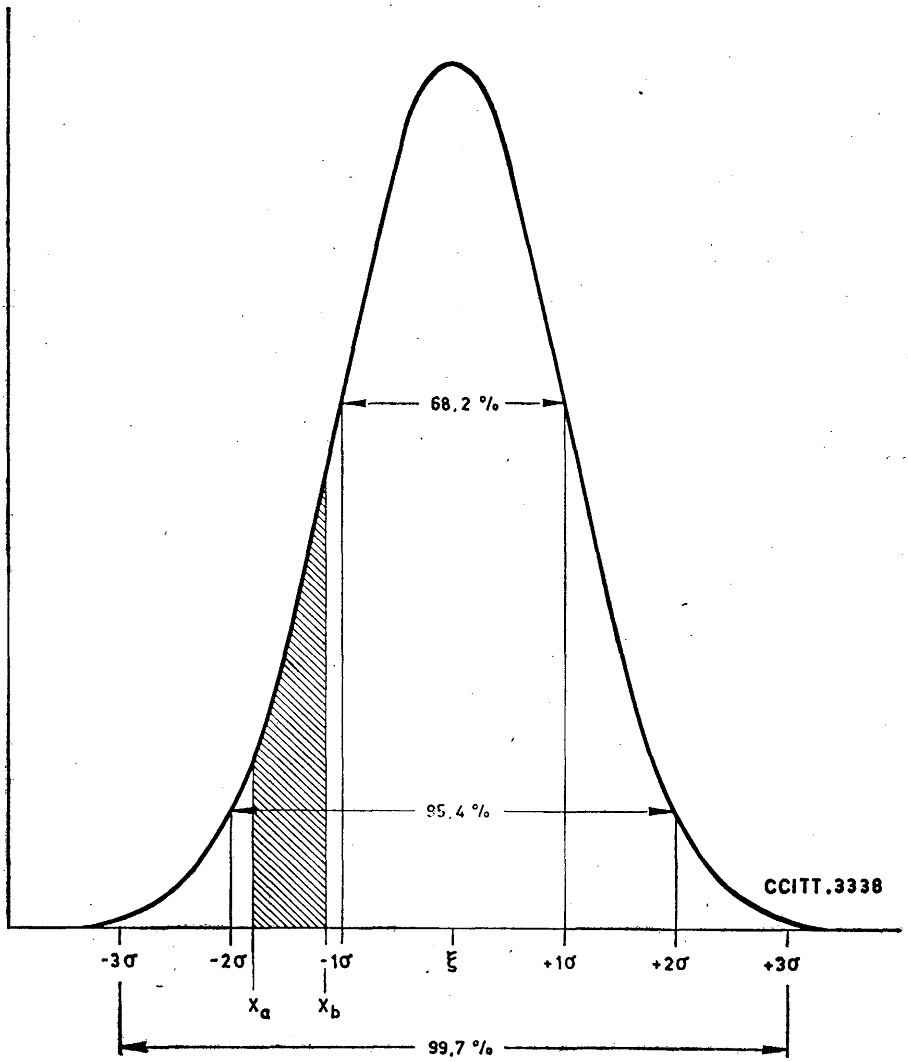


FIGURE 1. — **The normal distribution**

or one standard deviation on either side of the mean, 95.4% within two standard deviations, and 99.7% or, for practical purposes, nearly the whole of the area, within three standard deviations on either side of the mean.

2.2 *Controlling a process by small samples*

The bar diagram of Figure 2 is constructed on the basis of the normal distribution and shows a large number of loss values with a standard deviation of 5 cNp around a mean value of 0 cNp. From this theoretical population 25 samples have been drawn by random selection, each sample consisting of four observations $x_1 - x_4$. From each sample the mean value $\bar{X}$ and the difference between the largest and the smallest observation, which is called the range and denoted by R, have been computed. The results of the sampling appear from Table 1.

TABLE 1

Results of 25 random samples

Sample No.	x_1	x_2	x_3	x_4	$\bar{X}$	R
1	−5	1	0	6	0.5	11
2	−11	7	0	8	1.0	19
3	5	−2	2	7	3.0	9
4	−4	3	5	−3	0.3	9
5	0	−2	−2	−2	−1.5	2
6	4	−4	−7	1	−1.5	11
7	−3	−1	−3	6	−0.3	9
8	−1	−2	−2	−10	−3.8	9
9	−3	3	4	−3	0.3	7
10	0	−1	3	−5	−0.8	8
11	2	2	−4	−1	−0.3	6
12	2	0	0	9	2.8	9
13	0	−3	3	−3	−0.8	6
14	−7	3	14	4	3.5	21
15	−9	2	6	0	−0.3	15
16	−3	3	3	−1	−1.0	6
17	−3	8	2	7	3.5	11
18	−9	−3	−5	−3	−5.0	6
19	5	−3	−8	−1	−1.8	13
20	3	−4	−1	−2	−1.0	7
21	−6	−2	3	−1	−1.5	9
22	2	0	13	−1	3.5	14
23	−2	9	−7	8	2.0	16
24	−7	12	−1	−5	−0.3	19
25	3	−1	5	−6	0.3	11

If attention is confined in the first instance to the sample mean values, it is seen that the sample means are different, but that they cluster around the true mean value $\bar{x}$, which is zero. It is not possible on the basis of one particular sample to obtain any accurate information concerning the population from which the sample was drawn. This, of course,

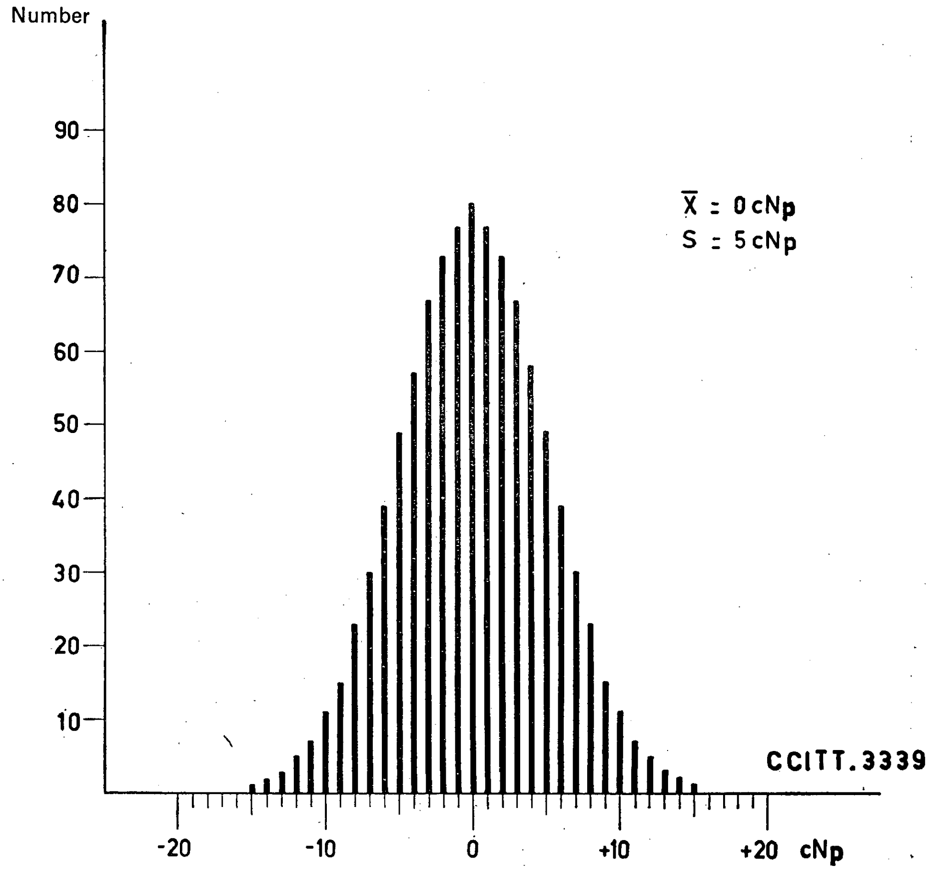


FIGURE 2. — A theoretical distribution of loss values

is true of any sample comprising only a small number of observations. However, the variation between samples in succession is subject to a certain regularity, since it may be shown that the mean values of random samples from a normally distributed population with parameters ($\bar{x}$, s) are themselves normally distributed with parameters ($\bar{x}$, $s/\sqrt{n}$), where n is the sample size. This fact is illustrated in Figure 3, which shows the probability distributions of the mean values of different sample sizes, compared with the distribution of the population from which the samples were drawn.

The sample mean values, therefore, with a probability of 99.7% will fall within limits given by the relation $\bar{x} \pm \frac{3s}{\sqrt{n}}$, as long as no changes take place in the population from which the samples were drawn. A sample mean falling outside these limits is almost certainly a sign that a change has occurred, since the theoretical probability of such a value is only 0.3% or three in a thousand samples.

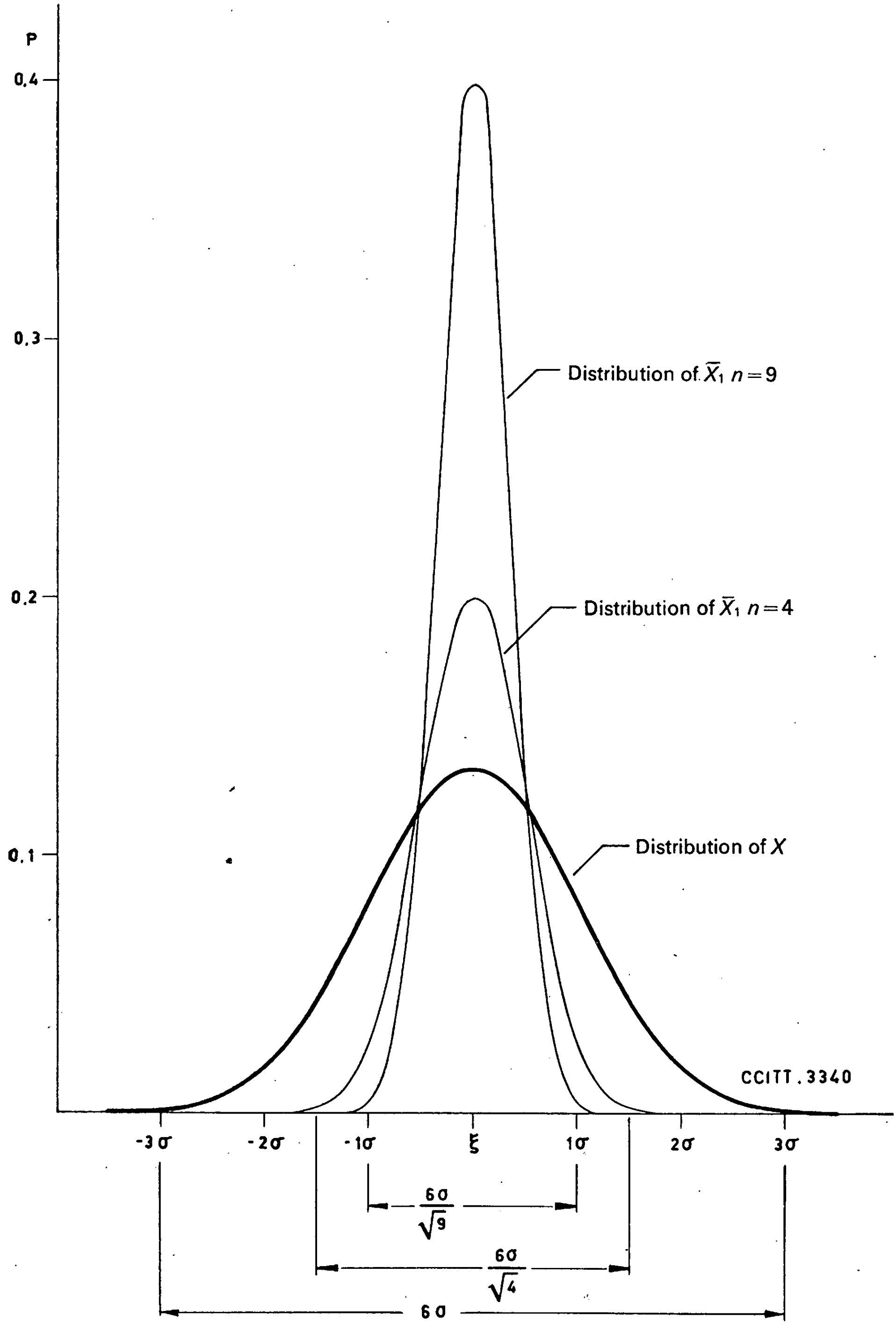


FIGURE 3. — Distribution of individual observations (heavy line)
Distribution of mean values (thin lines)

Control station: ________

____

(Route)

Object: *Circuit loss*

	Control limits ($\sigma = 1$)		*Central line*
	$\overline{X}$-chart	*R*-chart	*R*-chart
n	UCL/LCL	UCL	
2	±2.1	3.7	1.1
3	±1.7	4.4	1.7
4	±1.5	4.7	2.1
5	±1.3	4.9	2.3
6	±1.2	5.1	2.5

Sample size $n = 4$

Standard deviation objective $\sigma \leqslant 5\,\text{cNp}$

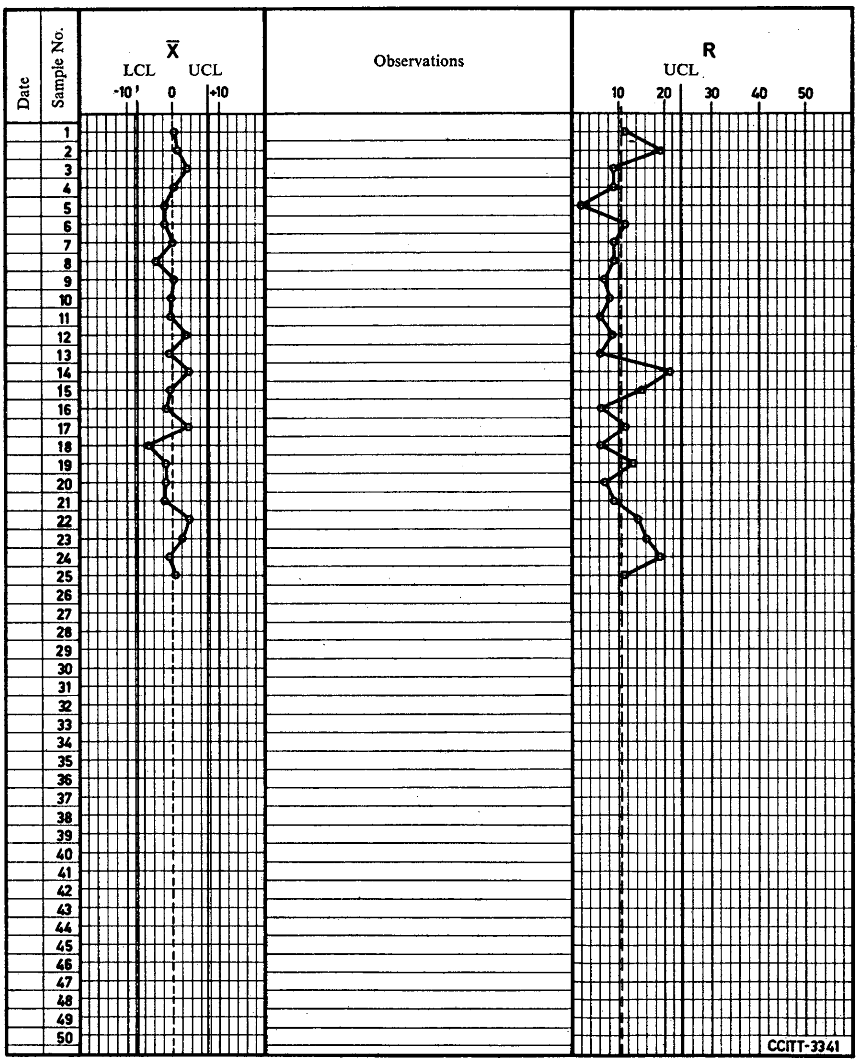


FIGURE 4. — $\overline{X}$ and R control chart

If a process is to be controlled with respect to product mean value by means of small samples, an $\bar{X}$ *control chart* as shown in Figure 4 may be used for the evaluation of the samples. This control chart was drawn up for the control of the transmission loss of a batch of circuits on the basis of a standard deviation of 5 cNp around zero deviation from the nominal loss. The lines marked UCL and LCL on the left-hand part of the form denote *upper control limit* and *lower control limit*, respectively. They are drawn at distances corresponding to $\pm 3 \frac{5}{\sqrt{4}} = \pm 7.5$ cNp (as the sample size $n = 4$) away from a central line, representing the expected mean. The sample means of Table 1 have been entered on this control chart. They will be seen to fall with approximately equal numbers on either side of the central line, with frequent shifts of direction of the lines connecting the plots. This general appearance of the control chart may be expected to go on as long as the process being controlled continues without any change. In these circumstances, the process is said to be in a state of statistical control.

In addition to the chart for mean values it is usually required to have another chart for controlling the spread (standard deviation) about the mean. The computation of the standard deviation, even of so small a sample as four observations, is very laborious, and for this reason it is the usual practice to use the sample range, R, instead of the sample standard deviation. So the chart becomes an *R control chart*, with control limits drawn on the basis of the theoretical distribution of the sample range.

The right-hand part of Figure 4 shows an R control chart combined with the $\bar{X}$ control chart. All the coefficients required for determining control limits are listed in the topmost part of the form. The coefficients in respect of control limits correspond to the factors usually denoted by A and D_2 in the tables incorporated with most books on statistical quality control. In addition to the control limit factors a coefficient conventionally denoted by d_2 is included which enables the user to set up a central line on the R chart.

For an R control chart laid out for a standard deviation of 5 cNp, with $n = 4$, the position of the upper control limit will be at $5 \times 4.7 = 23.5$ cNp, and of the central line at $5 \times 2.1 = 10.5$ cNp. On the R control chart of Figure 4 the sample ranges of Table 1 have been plotted in the same order as the corresponding sample means, and the remarks in respect of the $\bar{X}$ chart on the general appearance apply equally well here.

3. *A practical application of the sampling and control chart techniques to the maintenance of international circuits*

3.1 *Sampling schedule and sample form*

In this description of a practical method of managing the sampling procedure, the general rules are:

1. The number of measurements to build a sample is four. This sample size is achieved by selecting two circuits at a time and combining the four loss values, two from each direction of transmission.

Sampling schedule
Route: København-Hamburg

Control station: København
Direct groups

Circuits to be measured in average (times a year) : 3

Number of circuits in a sample : 2

Total number of circuits : 72

Number of samples each month $\frac{72\times 3}{2\times 12} = 9$

Sample allocation

Day / Week	M	Tu	W	Th	F
1		4			
2					
3		5			
4					

List of circuits

Serial No.	Circuit No.	Serial No.	Circuit No.	Serial No.	Circuit No.	Serial No.	Circuit No.
01	Z 46	26	Z 68	51	Z 94	76	
02	38	27	70	52	96	77	
03	48	28	110	53	98	78	
04	26	29	112	54	100	79	
05	50	30	114	55	102	80	
06	34	31	116	56	104	81	
07	36	32	30	57	106	82	
08	40	33	72	58	108	83	
09	42	34	6	59	M 2	84	
10	44	35	32	60	Z 118	85	
11	28	36	74	61	120	86	
12	2	37	52	62	122	87	
13	4	38	54	63	124	88	
14	8	39	56	64	126	89	
15	10	40	58	65	128	90	
16	12	41	60	66	130	91	
17	14	42	76	67	132	92	
18	16	43	78	68	134	93	
19	18	44	80	69	136	94	
20	20	45	82	70	138	95	
21	22	46	84	71	140	96	
22	24	47	86	72	142	97	
23	62	48	88	73		98	
24	64	49	90	74		99	
25	66	50	92	75		00	

FIGURE 5. — **Sampling schedule**

2. The sampling shall be made in a random manner—i.e. all circuits should have equal chances of being measured.

3. The number of samples is determined by stipulating that each circuit shall be measured in average a certain number of times, say, three a year.

4. The sample measurements shall be taken with regular intervals.

In order that the samples may be specified in a convenient manner, a sampling schedule as shown in Figure 5 may be used. On this schedule the circuits are listed in any preferred order, each circuit being allotted a serial number for the purpose of the selecting process. Batches of more than a hundred circuits may be accommodated by using two or more forms for the listing of circuits, numbering the circuits on the second form from 101 upwards, and so on. The number of samples is computed and a suitable distribution is determined on a monthly basis. The samples may now be prepared by reading off, from a table, random numbers in pairs and recording the corresponding circuit designations.

An extract of a table of random sampling numbers is given in Table 2. The digits of such tables are usually arranged in rows and columns of two or four digits. They may be read row by row or column by column, taking one, two, or more digits at a time according to requirements. On the basis of Table 2, reading the digits column by column and

TABLE 2

Random sampling numbers

0597	0344	9649	8713	0169
7807	8948	2297	6814	6988
2408	1832	5417	1047	6205
0262	5696	6158	4050	7094
6585	7169	3100	0329	9617

discarding, in our example, numbers higher than 72, the nine samples required for one month by the sampling schedule of Figure 5 will be composed as follows:

Sample No.	Random numbers	Circuits
1	05	Kh-Hmb Z 50
	24	Kh-Hmb Z 64
2	02	Kh-Hmb Z 38
	65	Kh-Hmb Z 128
3	07	Kh-Hmb Z 36
	08	Kh-Hmb Z 40
4	62	Kh-Hmb Z 122
	03	Kh-Hmb Z 48
5	18	Kh-Hmb Z 16
	56	Kh-Hmb Z 104
6	71	Kh-Hmb Z 140
	44	Kh-Hmb Z 80
7	48	Kh-Hmb Z 88
	32	Kh-Hmb Z 30
8	69	Kh-Hmb Z 136
	22	Kh-Hmb Z 24
9	54	Kh-Hmb Z 100
	61	Kh-Hmb Z 120

Control station: København

Sample form
international circuits

Date / 196. .

Route: København-Hamburg

Random digits	Circuit designation	Deviation from nominal loss Rec.	Far end
05	Kh-Hmb Z50		
24	Kh-Hmb Z64		

Sum	
Mean ($\overline{X}$)	
Range ($\underline{R}$)	

FIGURE 6. — **Sample form**

The preparation stage is completed by entering the selected circuits on sample forms as illustrated in Figure 6.

The sampling schedule should include, in respect of each traffic route, circuits of uniform constitution according to a broad division into the following categories:

— circuits on direct groups,

— other circuits.

It may be found practical to subdivide further according to, for example, whether or not automatic group regulation is provided, and also, in the case of large traffic groups according to different line systems, such as cable systems and radio-relay systems.

The sampling schedule should be kept up to date in conformity with any changes in the provision of circuits on the traffic route concerned.

When the measurements specified on a sample form are due, the four values of transmission loss, expressed as deviations from the nominal value, are recorded on the sample form, and a computation is made of the mean deviation ($\overline{X}$) and the range (R).

3.2 *The control chart*

The results of sample measurements should be entered on combined $\overline{X}/R$ control charts of the Shewhart type, a suitable form of which was shown in Figure 4. If the sample mean and the sample range both fall within or on the control limits, no further action is taken. If either of the values, or both, fall outside a control limit it is almost certain that an assignable cause is making its influence felt, and this assignable cause should be found and removed.

The position of the *control limits* of the control chart should be so that corrective action is taken as far as possible before the circuits of the traffic group in question go outside the *tolerance limits*. Consequently the control limits should be set to correspond to a value of standard deviation that is less than the standard deviation of the tolerance specification. The present requirements in respect of the transmission loss of international circuits are found in Recommendation M.16, section 1, which is worded as follows:

"1. *Variation of overall circuit loss with time*

1.1 *For all circuits*, the difference between the mean value of the transmission loss and the nominal value should not exceed 0.5 dB or 0.6 dNp.

1.2 *For category A circuits*, which, for some time, will continue to use older-type equipment, the objectives should be as follows:

a) For a circuit routed over a single channel of a group the standard deviation of the variation of overall loss between the circuit test access points for that circuit should not exceed 1.0 dB or 1.15 dNp.

b) For a circuit routed over channels of two or more groups in tandem, the standard deviation of the variation of overall loss between the circuit test access points for that circuit should not exceed 1.5 dB or 1.73 dNp.

1.3 *For all long circuits using modern-type equipment* and in general for category B circuits, the objective is that the standard deviation of the variations of overall loss should not exceed 1.0 dB or 1.15 dNp.

The method for achieving the above objective values is left to the discretion of administrations (better maintenance, fitting of automatic regulators, etc.)."

This must be interpreted to mean, for the purposes of determining control limits, that the transmission loss of international circuits should be within a range of variation which is centred at zero deviation with tolerance limits removed three standard deviations from the limits specified for the mean transmission loss, or in figures

$$\pm 0.6 \pm (3 \times 1.15) = \pm 4.05 \text{ dNp, and}$$
$$\pm 0.6 \pm (3 \times 1.73) = \pm 5.79 \text{ dNp,}$$

corresponding to standard deviations of 1.35 and 1.93 dNp, respectively. On this basis control chart limits should be drawn corresponding to standard deviations of, say, 1.4, 1.0, 0.7, or 0.5 dNp, according to the capability (depending upon length, complexity, type of equipment, etc.) of the route concerned, in order to enable the maintenance staff to take corrective action if possible before changes in transmission characteristics, if any, become of such magnitude that they cause the circuits to go outside tolerance limits.

4. *Application of the control chart method to reference pilot measurements*

In the supervision of group and supergroup links the control chart method is used in a way analogous to that described in the preceding sections, in order to control that the required stability of the links, as specified in Recommendation M.18, is maintained, or if automatic regulation equipment is provided, that the regulation process is satisfactory.

As the reference pilots are measured with fixed intervals, no sampling is necessary, and the following procedure could be applied:

1. Reference pilots are grouped in suitable combinations. For example, the five group reference pilots deriving from one supergroup would be an obvious combination.

2. From the readings taken with regular intervals of the reference pilot levels, mean and range are computed and entered on $\overline{X}/R$ control charts, which are kept separately for each combination. Control limits are set up according to the specifications of Recommendation M.18 or with reference to the specified performance of the regulation equipment, according to actual circumstances. On the basis of the control chart, corrective action is initiated in respect of level values that cause a plot outside the control limits.

5. *References*

The introduction and adaptation by our administrations of the control chart method for telephone transmission maintenance was inspired and assisted to a large extent by the following articles and books:

1. J. B. Pringle and G. Gaudet: A statistical approach to telephone transmission maintenance. *Communication and Electronics*, No. 33, November 1957.
2. A.-M. Gervaise: La gestion de la qualité. *Cables and transmission*, No. 1, January 1959.
3. H. J. Josephs and R. A. Hastie: Operational research in the Post Office, Part 1 — Sampling by random numbers; *The Post Office Electrical Engineers' Journal*, No. 1, April 1957.
4. M. J. Moroney: *Facts from figures*: Penguin Books, London, 1953.
5. A. Hald: *Statistical theory with engineering applications*; John Wiley & Sons, New York, 1960.
6. W. Uhlmann: *Statistische Qualitätskontrolle*; B. G. Teubner Verlagsgesellschaft, Stuttgart, 1966.

II. Methods for the evaluation of the transmission performance of telephone message circuits and connections

(Note by the American Telephone and Telegraph Company)

1. *General*

For several years, the American Telephone and Telegraph Company has had in operation a method for evaluating the transmission performance of circuits in its national network. This method, which has been described in Supplement No. 27 of Volume IV of the *Blue Book*, is based upon a statistical analysis of the measured deviations from the designed or expected 1000 Hz loss of the circuits. Application of this method and the associated corrective programmes have resulted in a continuous improvement in performance of the circuits such that the results for the Bell System were better than the objective of 1.0 dB standard deviation.

Analysis of the results, however, indicated that, while the standard deviation had been achieved, there was a significant number of circuits whose deviations were excessive and it was evident that the edges of the distribution still needed improvement. In other words, the distribution was not normal. Also, the statistical computations required in connection with the above method are complex and time-consuming for the people involved and our experience has indicated that they have considerable difficulty with this method.

In addition, it is recognized that evaluating the deviations from designed loss of circuits alone does not completely define the transmission performance of connections experienced by the subscribers. In view of these considerations, the American Telephone and Telegraph Company has embarked on the establishment of a comprehensive method for evaluating the transmission performance of connections encountered by subscribers. This new plan, when wholly implemented, will not only evaluate the transmission performance of circuits, but also of the subscriber lines as well as the transmission performance of circuits connected together (connections). It also will include an evaluation of the adequacy of the transmission design of circuits as well as their maintenance and will take into account the measured noise on both the circuits and subscriber lines.

The results of the overall plan will be expressed as a number known as the transmission performance index. This index will be derived from several component indexes, to indicate the individual performance achieved by the different factors which go to make up the overall index. Some of the components are already in operation while others are under development, or planned for the future.

The various component indexes are as follows:

1. Connection appraisal index,
2. Subscriber plant transmission index,
3. Trunk transmission design index,
4. Trunk transmission maintenance index.

The trunk transmission maintenance index replaces the method described in Supplement No. 27, Part III, Volume IV of the *Blue Book*.

A brief description of each of these component indexes is as follows:

1.1 *Connection appraisal index*

Connection appraisals are made by means of transmission measurements on sample calls. Since these calls include all of the components of plant used in a telephone call except subscriber lines and stations, they are good indicators of transmission performance of circuits in connections.

The sample calls on which the appraisals are based are made from a short line in the local exchange being appraised to test numbers in distant local exchanges reached by direct dialling as well as via operators. The distant local exchanges and type of calls are selected in accordance with user calling patterns. Fifty 1-kHz loss observations and fifty noise observations are obtained from the calls.

Each local exchange centre (wire centre) is appraised annually, except for small local exchange centres (wire centres under 2000 main stations) which are appraised once in every two years. The results of the appraisals are combined on a weighted basis to obtain an index for each administrative area.

1.2 *Subscriber plant transmission index*

The subscriber plant transmission index is now under development. When completed, it is expected to consist of two components, one measuring conformity with resistance design rules, and one measuring conformity with noise requirements.

The method of measurement of conformance to resistance design rules is under study. Conformance to noise requirements will be determined by sampling measurements taken in each local exchange centre once a year. The measurements will be taken at the local exchange end of the selected cable pairs with the station instruments in the on-hook condition. These measurements will be summarized and evaluated by a formula to obtain an estimate of the number of pairs with high noise. It is planned to place this index in effect during 1968.

1.3 *Trunk transmission design index*

The basis for the trunk transmission design index is under development. When completed, it is expected to give a measure of the performance of the circuits in meeting design loss, noise and balance requirements from measurements made at the time the circuits are placed in service.

1.4 *Trunk transmission maintenance index*

This index is to be based on three components described below of which two have already been put into effect. It is planned to place the third component in effect during 1968.

1.4.1 *Loss maintenance component*

This part of the index is for control of loss deviations and is itself subdivided into two parts:

a) Circuits without gain and those with negative impedance repeaters;

b) Circuits on carrier and those with other types of repeaters.

Measurements of 1-kHz loss are made on each circuit at a routine interval determined by the type of system over which the trunk is routed. The measurements are compared with design values, and the deviations show whether corrective action is required. The deviations before correction are summarized to provide the loss component of the trunk transmission maintenance index.

1.4.2 *Noise maintenance component*

The part of the trunk transmission maintenance index that is for control of noise deviations requires that every circuit be measured at least once a year.

A maintenance limit for noise values is established for each circuit depending upon its length and composition. The measurements are compared with the maintenance limits to see whether corrective action is required. The number of measurements exceeding the maintenance limits is summarized to provide the noise component of the trunk transmission maintenance index.

1.4.3 *Balance maintenance component*

This component of the trunk transmission maintenance index has recently been developed to determine whether balance conditions are being maintained in two-wire long-distance switching exchanges.

2. *Method of summarizing results*

When transmission measurements are summarized, they form a distribution which can be defined either statistically or graphically. A new plan using graphical methods has been adopted. It is believed to be effective in defining the adequacy of the transmission maintenance work on circuits. The new method is illustrated below in its application to the trunk transmission maintenance index. In practice, the curve is not actually drawn. Points on the curve are defined by counting the number of deviations which exceed specified reference values.

Figure 1 represents a normal distribution of loss deviations resulting from measurements on negative impedance repeatered and non-gain circuits. With the reference value R set at ± 0.7 dB, the percentage of deviations greater than 0.7 dB provides a measure

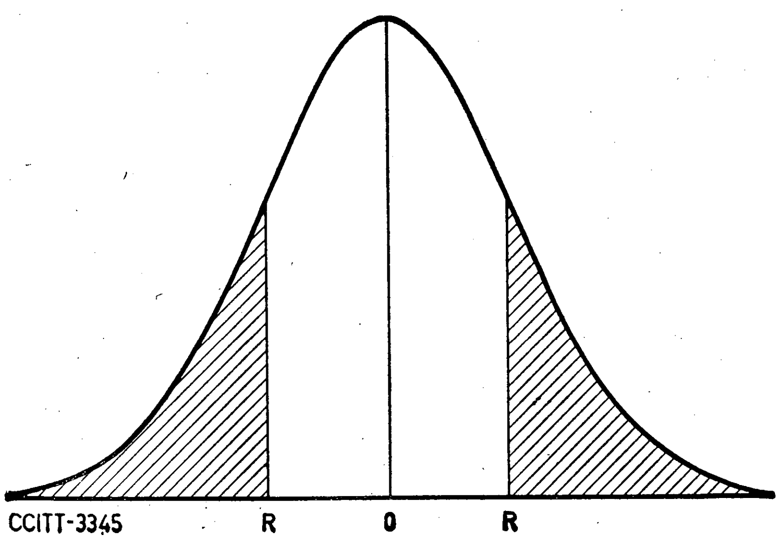


FIGURE 1. — **Distribution of loss deviations — Trunks without gain or with negative impedance repeaters**

of the distribution. If the standard deviation is abnormally high, the percentage of deviations exceeding 0.7 dB will be higher than normal. If the mean value of the deviations becomes significant, the percentage of deviations greater than 0.7 dB will increase.

Figure 2 represents a normal distribution of loss deviations resulting from measurements on carrier and repeatered trunks other than those of the negative impedance type. Since the deviations of the losses of these circuits tend to have a greater spread, two reference values, $R1$ and $R2$, have been selected, ± 0.7 dB and ± 1.7 dB, to give a better measure of the distribution.

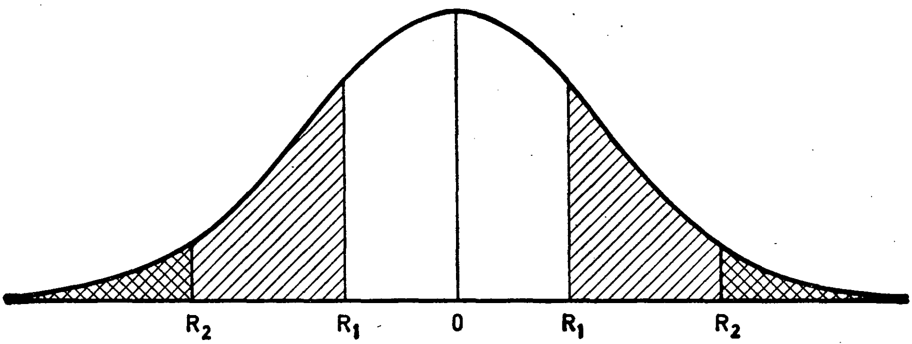


FIGURE 2. — **Distribution of loss deviations — Trunks on carrier and other types of repeaters**

Figure 3 shows a typical distribution of the deviations of measured noise from the maintenance limits on the various types of circuits, taking into account transmissions system and length. The shaded area represents the measurements which exceed mainte-

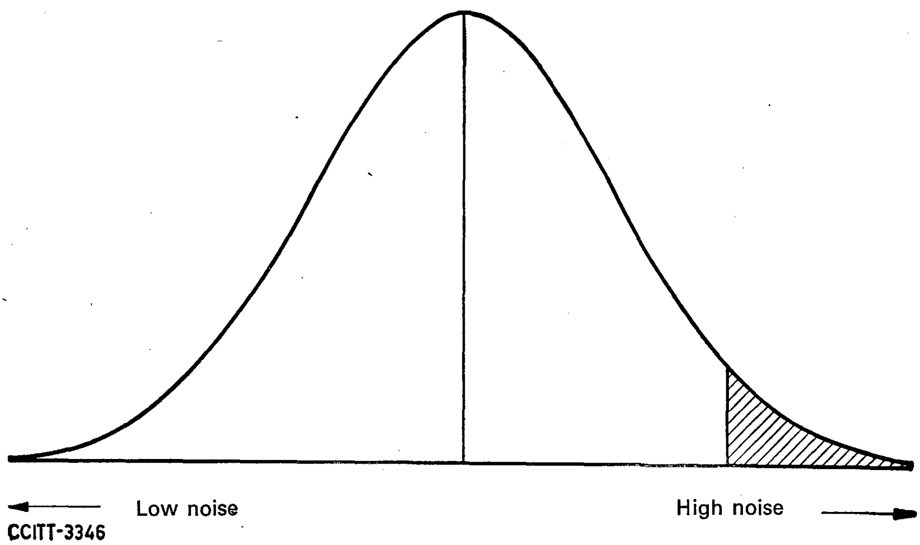


FIGURE 3. — **Distribution of noise deviations**

nance limits, the remainder of the curve illustrates how the rest of the measurements are distributed, in comparison to their maintenance limits.

In each case, for index purposes, the percentages of measurements exceeding the reference values are converted directly into indices using index tables arranged on a scale of 100.

III. Trunk quality control method using automatic trunk test and transmission measuring equipment

(Note by N. T. T., Japan)

The establishment of our trunk quality control method has been essential for controlling and improving transmission performance and the stability of connections. This paper describes the outline and practice of our trunk quality control method using our automatic trunk test and transmission measuring equipment [1] (ATTM). The basic principle of this method is the application of statistical quality control techniques to transmission quality control. Its object is the reduction of the manpower required for measuring circuit performance and for taking corrective action while maintaining the trunk quality at the desired level. At the same time, the method is expected to be adaptable to trunk quality standards that might improve in the future.

In Japan, the routine test method was adopted for the control of circuit quality long before the ATTM was developed. Tests and measurements were carried out manually on a sampling basis. Experience showed that difficulties arose in achieving stable transmission through such a control method. Investigation showed that the standard deviation of overall circuit loss variations for all circuits was 1.6 to 1.8 dB or about 0.2 Np on the average and on links, even those with supergroup automatic gain control devices, was 1.3 to 1.5 dB or about 0.16 Np.

On the other hand, as the nation-wide direct dialling network rapidly developed, the number of direct dialling circuits has increased enormously. Moreover, an operator check before the trunks are handed over to subscriber use has also become impracticable as a quality control in the case of most toll circuits. At the end of 1967, the total number of direct dialling circuits amounted to about 370 000 circuits and the ratio of no-delay service reached 85.1% for the whole country.

Under these circumstances, the maintenance of circuit quality to C.C.I.T.T. recommendations required more frequent and precise measurement over a large number of trunks, besides having to take appropriate action as needed. To base trunk quality control on manual measurement is, therefore, evidently impracticable and inefficient in cost and

[1] An outline description of our ATTM is given in the Annex to this paper.

manpower. This led eventually to development of our ATTM and its introduction into the trunk quality control system. A field trial on the links between Tokyo and Osaka confirmed that the ATTM was capable of frequent measurement over a large number of circuits with accuracy, high speed and at small expense. Also, the utilization of the ATTM in our quality control system since 1964 gave successful results. In other words, the standard deviation of overall loss variations decreased to below 1.0 dB the above-mentioned 1.7 dB in the sections using the ATTM. In addition, the manpower required for actual measurement was reduced to 1/100 (in man-hours) as compared with conventional manual measurement.

Our ATTM is devised so as to perform connection tests as well as transmission measurements and connection faults over an entire route, including switching equipment, may easily be found before they give trouble to a subscriber. This is an additional ATTM feature which greatly helps towards providing favourable service.

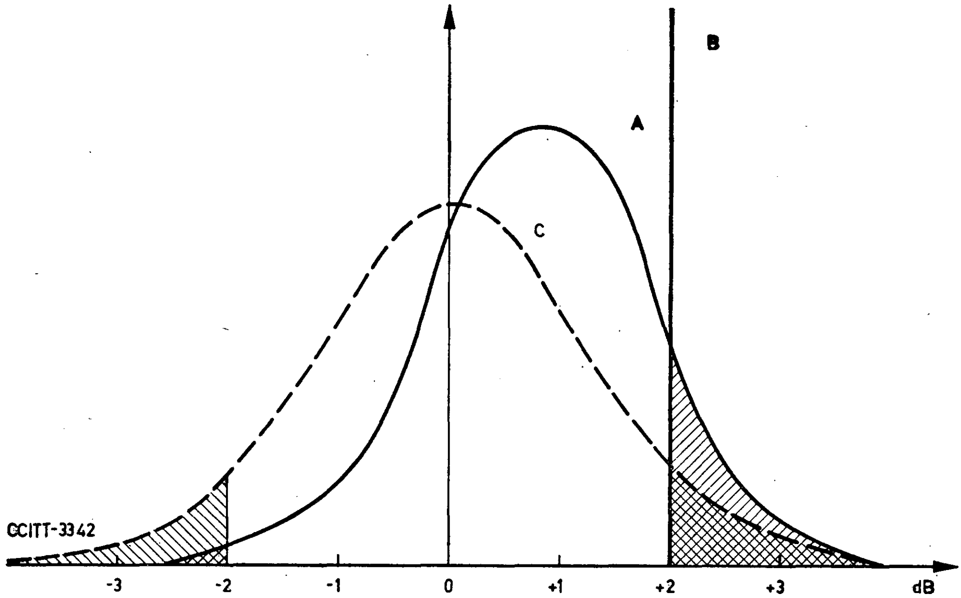
1. *General trunk quality control*

Trunk performance, in general, should be appraised from two aspects. One is transmission performance, and the other is connection stability. Transmission performance is specified in terms of loss variation and noise level. From the viewpoint of statistics, the variations of overall trunk loss can be dealt with on the basis of the mean value (m) and the standard deviation (σ), since they are distributed normally. The control limits in Japan are now defined to be below $m = 0.8$ dB and below $\sigma = 1.0$ dB this being regarded as a step towards meeting the value recommended by the C.C.I.T.T. With this critical distribution, the ratio of circuits exceeding ± 2 dB (the specified value) to the total circuits (hereafter called the inferiority rate at ± 2 dB) is about 10% as shown in Figure 1A. Hence, the distribution of $m = 2.0$ dB, $\sigma = 0$ dB or $m = 0$ dB, $\sigma = 1.2$ dB, as shown in Figure 1B or 1C, is considered to be statistically equivalent to the distribution of Figure 1A, because each inferiority rate is 10%. The relation of m and σ at a constant inferiority rate is as shown in Figure 2, where points A, B and C correspond to distributions A, B and C in Figure 1, respectively.

This idea produced a simplified control method, using inferiority rate as a control measure, to be taken, in operation, prior to the control method using only m and σ. The inferiority rate is given by:

$$\text{Inferiority rate} = \frac{\Sigma\ (\text{number of circuits exceeding specified value})}{\Sigma\ (\text{total number of measured circuits})} \times 100$$

where Σ denotes the total sum of each group of circuits during an appraisal period. The simplified control method is expected to be more effective for reduction of manpower, for no action is required to be taken on the shaded area in Figure 2.



Shaded area indicates inferior quality circuits Deviation (dB)

A: $m = 0.8$ dB $\sigma = 1$ dB
B: $m = 2$ dB $\sigma = 0$ dB
C: $m = 0$ dB $\sigma = 1.2$ dB

FIGURE 1. — **Normal distribution curve and rate of inferior quality circuits**

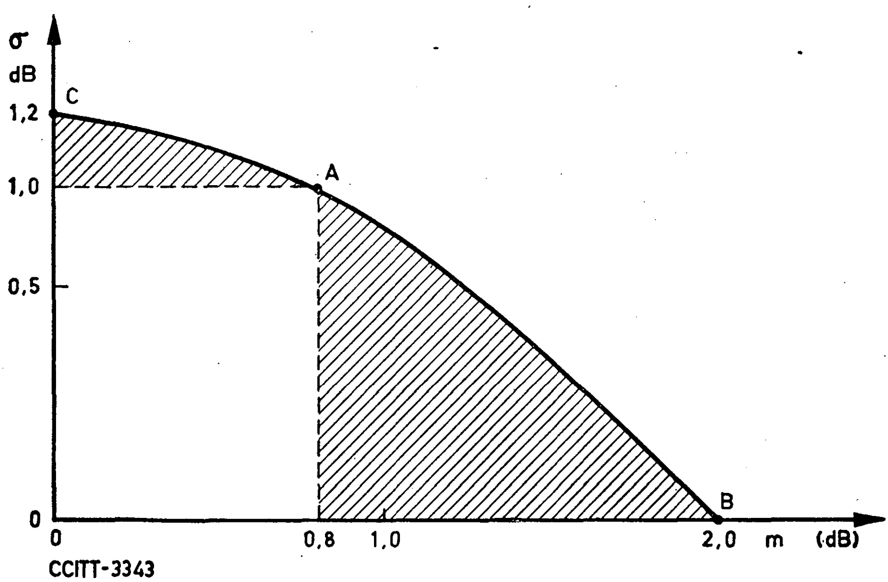


FIGURE 2. — **Relation between m and σ at a constant inferiority rate of 10%**

2. *Loss variation control method*

2.1 *Control limit*

The control limits in terms of m and σ are shown in Table 1 for the variation of overall loss on a group of trunks having the same conditions. The " conditions " mentioned here mean the transmission system used (microwave or coaxial cable, etc.), and the composition and direction of trunks.

TABLE 1

Control limits of transmission loss variations

Kind of trunk	Mean value (m)	Standard deviation (σ)
Transit trunk	0.8 dB	1.0 dB
Direct trunk	1.2 dB	1.5 dB

The variation includes here the variation with time and that due to differences in the circuits. The control limits are defined as being satisfied for 95% of total circuits.

2.2 *Practical procedure*

2.2.1 *Quarterly control*

This control is suitable for the variation of trunk loss extending over a long period of time. Action is taken only when the deviation of variations is shown to be definitive. In practice, there are two procedure steps in this control method.

a) *Inferiority rate control (1st step)*

The inferiority rate is obtained from a three-months summation of data from measurement made twice a month. The specified values are ± 2 dB for a transit trunk and ± 3 dB for a direct trunk. When the inferiority rate is less than 10% (the control limit in this step), the trunk quality is judged to be good in transmission quality over a group of trunks, and no action need be taken at all.

b) *m and σ control (2nd step)*

When the inferiority rate found from the control of the first step mentioned above is over 10%, m and σ are calculated [1] from the latest measurement data. Then, the variance and the deviation from the nominal value are corrected by suitable action until the m and σ obtained are less than the limits in Table 1.

[1] The ATTM output is able to give the results of calculation automatically.

2.2.2 *Daily control*

The daily control composed of L- and U-control is used for obtaining an estimate of overall loss variations on links during a shorter time, from daily measurement data. The purpose of this control is finally to satisfy the control limits listed in Table 1 for overall loss. Table 2 shows the daily control limits.

TABLE 2

Daily control limits

Kind of trunk	Loss-deviation (L-control)	Inferiority rate (U-control)
Transit trunk	± 4 dB	20% at ± 2 dB
Direct trunk	± 6 dB	20% at ± 3 dB

a) *L-control*

The L-control for individual trunk quality is carried out to find a circuit having an unsatisfactory level. If the deviation of loss from the nominal value exceeds the L-control limit, it is decided that irregularities are involved in the associated circuit. Each trunk is then adjusted so as to approach the mean value of its group.

b) *U-control*

This method is utilized for the control of overall loss variations in a short period of time. The limits of U-control are given by an inferiority rate in the same way as in the first step quarterly control. The limits, however, are set twice as large as the quarterly control limits, in view of the effect of random loss variations. When the inferiority rate exceeds the U-control limit twice in succession, the level of the supergroup or of the group is checked and adjusted to the nominal value as necessary.

3. *Noise control*

The circuit noise level is evaluated by comparison with the limit set; this is a signal-to-noise ratio of 48 dB weighted. The period of measurement is twice a month. Circuits with high noise are checked carefully and corrective action is taken.

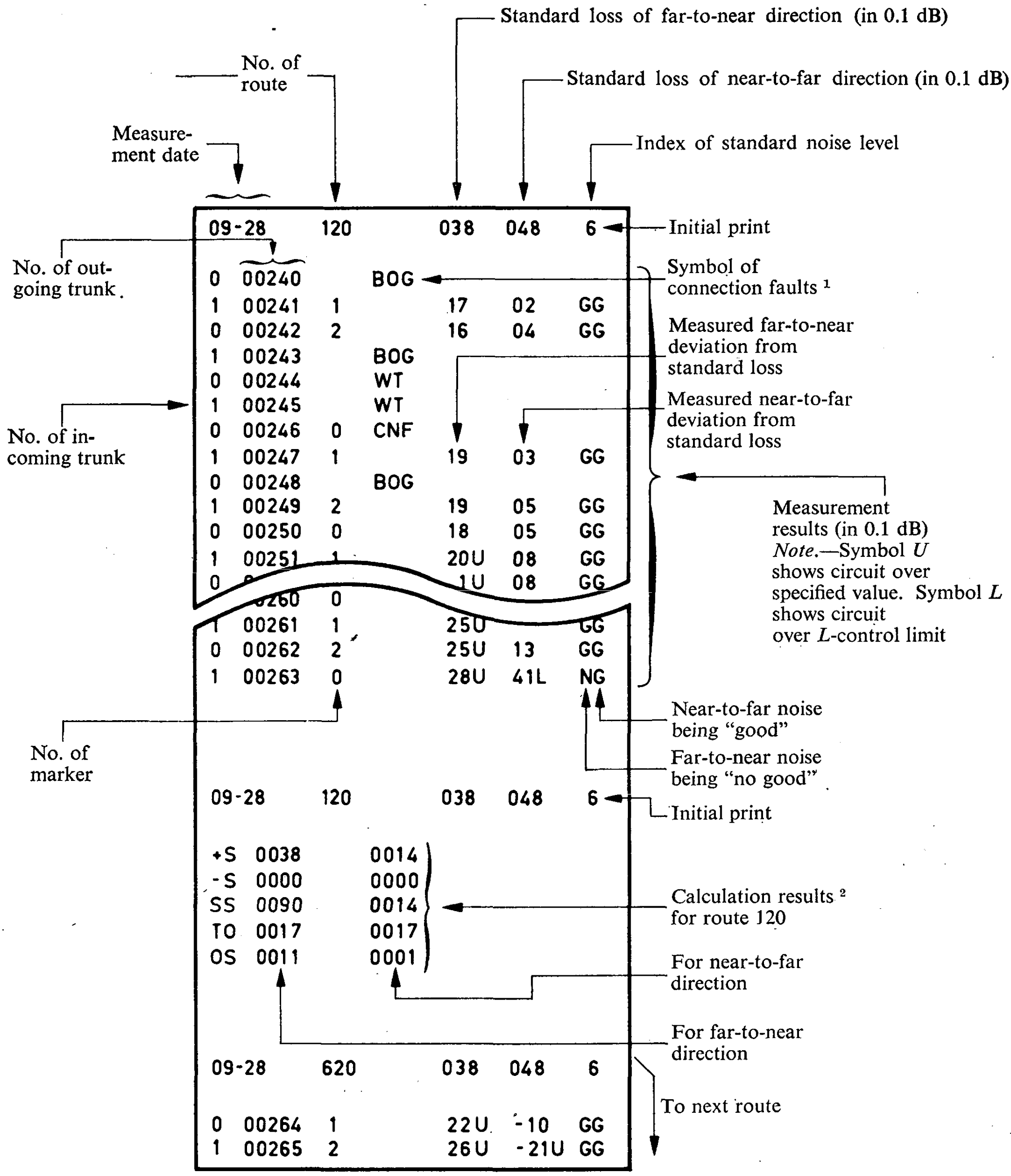
4. *Connection stability control*

In order to improve the connection stability of a network, prompt action should be taken after finding the location and the nature of faults. For this control, fault data must be collected, summarized and analysed, especially for faults whose causes are uncertain or difficult to detect. A vigilant survey is conducted to judge faults resulting from common causes, when the summation record for each group of trunks with the same conditions exceeds a certain specified value. Also, an unstable fault is traced from the fault data accumulated for each trunk during the three-months period.

ANNEX

Outline of the ATTM

The ATTM can carry out automatically connection tests on switching equipment and measurement of overall loss and noise level on circuits from the originating exchange through the interconnection of lines to the exchange. It also has a simple computer device. Consequently, all the information needed for tests and measurements is stored in its memory device and the mean value and the standard deviation of transmission loss on an assigned group of trunks are calculated and printed out. Figure 3 represents an example of the print-out form. It takes an hour for 120 to 140 trunks to be put through all the tests and measurements.



CCITT-3344

[1] BOG: outgoing trunk busy
CNF: continuity test failure
OS: number of *U* or *L* signed circuits
WT: work timing

[2] S: summation of deviations
SS: sum of squares of deviations
TO: total sum of measured circuits

FIGURE 3. — **Example of ATTM print-out form**

SUPPLEMENT No. 1.5

MATHEMATICAL PROCESSING OF THE MEASUREMENT RESULTS OF THE VARIATIONS OF THE OVERALL LOSS OF TELEPHONE CIRCUITS

(Note by the Administration of the U.S.S.R.)

The results of the measurements of the stability of equivalent provide a number of numerical values of equivalent, measured at different times.

To arrive at a characteristic magnitude giving the stability of the equivalent, it is necessary to treat the results by mathematical statistical processes.

This processing consists of obtaining the standard deviation of a distribution and assessing its limiting values. The standard deviation of the distribution is a characteristic magnitude representing the stability of equivalent.

As an example, we give a description of the statistical processing of the results of measuring the stability of the equivalent of a B 12 system channel over a period of one year (we have processed the actual values of the equivalent).

The table for example No. 1 given below shows the statistical treatment of these data. Let us consider how the various columns in this table are filled in.

In the *first column* we show the ranges of limiting values for all the measurement results. Results coinciding with the limiting values of a range are carried into either the higher or lower range, but in a uniform manner for the whole series. In the case mentioned, the value of the equivalent fell between the limits 1.50 Np and 2.60 Np (with a nominal value of 2 Np).

In the *second column* we show the frequency w_i (repetition), i.e. the number of values of the equivalent falling in the range considered.

If values different from zero appear at the edges of the distribution following two or three zero values for the frequency in the preceding ranges, it is advisable not to include them in the statistical processing since they are random excess values which are not typical for the particular distribution.

From the addition of all the values in the second column, the values in the *third column*, representing relative frequencies $\left(\frac{w_i}{n}\right)$, can be obtained by dividing the frequency for the range concerned by the total number of measurements.

From the values in the third column we can obtain an empirical differential distribution curve (histogram). For finding the integral distribution curve, we show in the *fourth column* of the table the relative cumulative frequencies $\left(\Sigma\frac{w_i}{n}\right)$. The sum of $\frac{w_1}{n}+\frac{w_2}{n}+\ldots+\frac{w_i}{n}$ tends towards 1 and, for the last term in the column, it is equal to 1 if the calculations are made to a sufficient degree of accuracy.

For the subsequent calculations, and for finding the mean value and the standard deviation, it is better, so as to make the work easier, to use a procedure which consists of choosing a conditional reference point A, which is a median value of any given interval. In general, any value in the series can be taken as the conditional reference point. Nevertheless, in choosing the conditional reference point, it is necessary to try to give it a value as close as possible to the mean value to be subsequently determined with greater accuracy. As a result of this operation, the numerical values in columns 6 and 7 will be very small and the calculations will therefore be easier.

For the choice of the conditional reference point we use the following method:

The test series has 3539 observations. By adding the frequencies (column 2) from top to bottom or bottom to top, we shall, at a certain stage in the addition, reach a number near to $\frac{n}{2}$

$$\frac{n}{2} = \frac{3539}{2} = 1769.$$

The addition of the numbers in the first 11 ranges gives the number

$$2 + 7 + 13 + 48 + 28 + 68 + 136 + 206 + 278 + 387 + 330 = 1503$$

which is obviously smaller than $\frac{n}{2} = 1769$.

By adding the frequency for the following range we find a number which exceeds $\frac{n}{2}$, for $1503 + 408 = 1911$.

Hence, for the conditional reference point, it is suitable to take the middle of the range 2.05 and 2.10.

Having chosen the conditional reference point, we fill in the *fifth column*, representing the deviations of the centres of the ranges (x') from the conditional reference point (A).

The values in the fifth column are evaluated by the following formula:

$$x' = \frac{x - {}_{,}A}{K} \tag{1}$$

where A is the conditional reference point,
x is the centre of any range,
K is the value of the range.

Values calculated from this formula will always be represented by a series of consecutive numbers:

$$-n, -(n-1), \ldots -4, -3, -2, -1, 0 \quad 1, 2, 3 \ldots +(m-1), +m.$$

To fill in the *sixth column*, the values in the second column have to be multiplied by the corresponding values in the fifth column ($w \cdot x'$). From the sum of the values in the sixth column it is possible to check more accurately whether the division of the sum of the values of the sixth column by the total number of measurements must remain within the limits:

$$-0.5 < \frac{\sum w_i \cdot x'}{n} < +0.5 \tag{2}$$

In the case mentioned

$$\frac{\sum w_i \cdot x'_i}{n} = \frac{668}{3539} = 0.18$$

If the inequality (2) is not satisfied, it is advisable to take as the conditional reference point the middle of the next higher or lower range, and to make a further check.

The mean value of the random value in tests is determined by the formula:

$$\bar{x} = A + \frac{\sum w_i \cdot x'_i}{n} \cdot K \tag{3}$$

where A is the conditional reference point and
K is the value of the range.

Hence, the results in the case of example No. 1 are:

$$\bar{x} = 2.075 + \frac{668}{3539} \cdot 0.05 = 2.084 \text{ Np.}$$

To obtain the values in the *seventh column* we multiply the squares of the deviations of the centres of the ranges from the conditional reference point (values in the fifth column squared) by the corresponding frequencies (values in the second column): $(w \cdot x'^2)$. The values in the seventh column can be obtained by multiplying the values in the sixth column by the corresponding values in the fifth.

From the sum of the values in the seventh column, it is possible to define the standard deviation by the formula:

$$\sigma = K \sqrt{\frac{\sum x'^2_i \cdot w_i}{n} - \left(\frac{\sum x'_i \cdot w_i}{n}\right)^2} \tag{4}$$

where K is the value of the range.

Hence, the results in the case of example No. 1 are:

$$\sigma = 0.05 \sqrt{\frac{43\,130}{3539} - \left(\frac{668}{3539}\right)^2} = 0.17 \text{ Np.}$$

Sometimes we can stop the processing of the results of the measurements at this point, so long as $\bar{x}$ and σ characterize, to a certain degree, the random value in tests.

* * *

To determine the limiting values, i.e. the maximum admissible deviations, we can use the integration function of the empirical series for the distribution (values in the fourth column). For the given distribution series, for example, the probability of not exceeding the value 2.50 Np would be 0.9913.

Nevertheless, since the number of measurements is limited, the certainty of this estimate of limiting values is always less than 1.

To determine the limiting values with complete certainty we use, not the empirical distribution curve, but the Kolmogoroff standard.

For this purpose, alongside the empirical integral distribution curve we make a graph of the confidence limits which are determined from the following inequality:

$$F(t) - \frac{\lambda_q}{\sqrt{n}} < \bar{F}(t) < F(t) + \frac{\lambda_q}{\sqrt{n}}$$

where

$F(t)$ is the distribution function of the given selection,
λ_q is the argument of the function $K(\lambda)$ in the table,
n is the number of measurements (in the selection),
$\bar{F}(t)$ is the distribution function of the whole.

According to the number of measurements made (n), it is advisable to take different appropriate values for the confidence range (see Table 1).

The certainty of the estimate will then conform to the maximum value of the series.

TABLE 1

Number of measurements (n)	< to 100	100 to 200	200 to 5000	5000 to 10 000	10 000 to 100 000
Confidence range $1 - K(\lambda)$ ($q\%$)	5	3	1	0.2	0.01
Argument λ of the function $K(\lambda)$ . . .	1.358	1.450	1.680	1.680	2.230

Where $n = 3539$, we take $q = 1\%$ and $\lambda = 1.627$.

With λ which is known, we determine the values of the *tenth column* representing the results of adding together the values in the fourth column and a constant value $d = \frac{\lambda}{\sqrt{n}}\cdot$ In our case,

$$d = \frac{1.627}{\sqrt{3539}} = 0.0273$$

$F_n(x) + \frac{\lambda}{\sqrt{n}}$ is the lower limit of the confidence range from which the lower limiting value of the distribution series is determined.

The *eleventh column* is filled in by taking the results of subtracting the constant value $d = \frac{\lambda}{\sqrt{n}}$ from the values in the fourth column, and represents the values of the function of the upper-limit curve of the confidence range $F_n(x) - \frac{\lambda}{\sqrt{n}}$.

By means of this curve we determine the upper limiting value of the distribution series. The probability of not exceeding a value of 2.60 Np for the equivalent or the insertion gain (see table for example No. 1) is 0.97.

The lower-limit curve serves to determine the lower limiting value of the series. In our case, with a probability of variation of equivalent (or of insertion gain) 0.97 or (1 —0.03) it will reach 1.55 Np, i.e. the reduction in the equivalent in relation to the nominal value of 2 Np will, with this probability of 0.97, be less than 0.45 Np.

With a probability of 0.94 or (1 — 0.03 — 0.03) the equivalent (the insertion gain) remains within the limits 1.55 Np to 2.60 Np (with a nominal value of 2 Np).

The *reliability* of this estimate is 0.99 ($q = 1.0\%$).

Figures 1 and 2 represent the integral distribution curves for the example concerned.

As can be seen in Figure 1, we plot the random values as abscissae and the probabilities as ordinates. The scales of the two axes are linear.

Figure 2 is shown plotted on a " probability " scale. The ordinates show the random values on a linear scale. The abscissae show the probability values according to the special scale of probabilities (scale corresponding to the representation of the probability integral function, in the form of a straight line).

In the table for example No. 2, we give the processing of the results for the stability during one hour of the B 12 system during a measurement period of one year.

(The processing of the deviations of equivalent in relation to the origin, during one hour of measurements, was made by the same method as that of example No. 1.)

Figure 3 shows the integral distribution curve for example No. 2 with a probability scale.

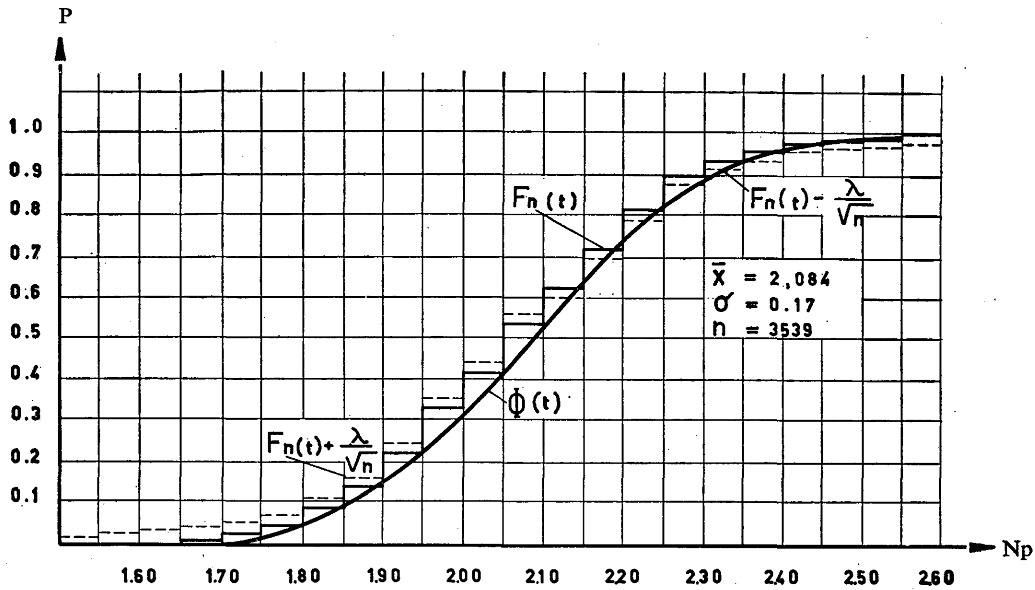


FIGURE 1. — **Integral distribution curve of the results of the development of example No. 1** (see Table 1)

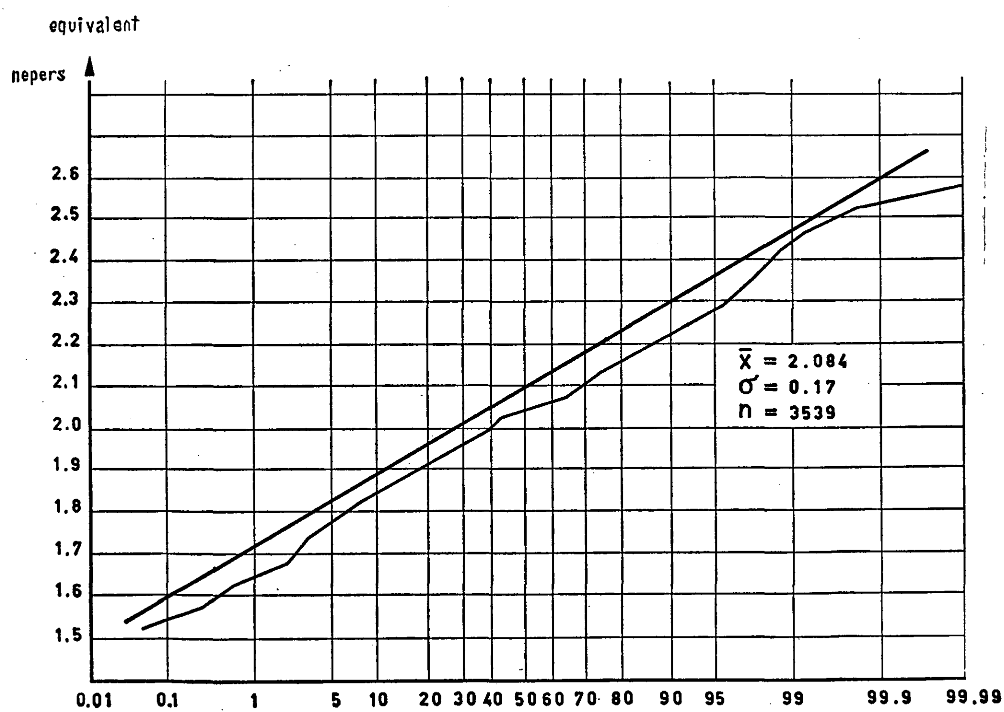


FIGURE 2. — **Integral distribution curve of the results of the development of example No. 1** (probability scale) (see Table 1)

TABLE FOR EXAMPLE No. 1

Processing of the results of measurements of stability of overall loss on one channel of a B 12 system (measurements made over a period of one year)

$n = 3539$ $A = 2.075$ $K = 0.05$ $\overline{x'} = 0.18$ $\overline{x} = 2.084$ $\sigma = +0.17$

n = number of measurements
A = conditional reference point (mean value of a range, arbitrarily chosen as the origin)
K = range value

Interval	w	$\frac{w}{n}$	$\sum \frac{w}{n}$	x'	$x'w$	x'^2w	$t = \frac{x-\overline{x}}{\sigma}$	$\Phi(t)$*	$F_n(t)+\frac{\lambda}{\sqrt{n}}$	$F_n(t)-\frac{\lambda}{\sqrt{n}}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1.50-1.55	2	0.0005	0.0005	−11	−22	242	−3.28	0.0005	0.0278	
1.55-1.60	7	0.0020	0.0025	−10	−70	700	−2.99	0.0014	0.0298	
1.60-1.65	13	0.0036	0.0061	−9	−117	1053	−2.70	0.0035	0.0334	
1.65-1.70	48	0.0137	0.0198	−8	−384	3072	−2.40	0.0082	0.0471	
1.70-1.75	28	0.0079	0.0277	−7	−196	1372	−2.11	0.0174	0.0550	
1.75-1.80	68	0.0192	0.0469	−6	−408	2448	−1.81	0.0351	0.0742	
1.80-1.85	136	0.0384	0.0853	−5	−680	3400	−1.52	0.0643	0.1126	
1.85-1.90	206	0.0582	0.1435	−4	−824	3296	−1.22	0.1112		
1.90-1.95	278	0.0786	0.2221	−3	−834	2502	−0.93	0.1762		
1.95-2.00	387	0.1094	0.3315	−2	−774	1548	−0.64	0.2611		
2.00-2.05	330	0.0932	0.4247	−1	−330	330	−0.34	0.3669		
2.05-2.10	408	0.1153	0.5400	0	0	0	−0.05	0.4801		
2.10-2.15	309	0.0873	0.6273	1	309	309	+0.24	0.5948		
2.15-2.20	346	0.0978	0.7251	2	692	1384	+0.53	0.7019		
2.20-2.25	335	0.0947	0.8198	3	1005	3015	+0.82	0.7938		
2.25-2.30	293	0.0828	0.9026	4	1172	4688	+1.12	0.8686		0.8753
2.30-2.35	150	0.0424	0.9450	5	750	3750	+1.41	0.9207		0.9177
2.35-2.40	79	0.0223	0.9673	6	474	2844	+1.71	0.9563		0.9400
2.40-2.45	63	0.0178	0.9851	7	441	3087	+2.00	0.9772		0.9578
2.45-2.50	22	0.0062	0.9913	8	176	1408	+2.30	0.9892		0.9640
2.50-2.55	22	0.0062	0.9975	9	198	1782	+2.59	0.9952		0.9696
2.55-2.60	9	0.0025	1.0000	10	90	900	+2.89	0.9980		0.9727
					668	43130				

* $\Phi(t)$ = from table of values of probability integral (normal distribution).

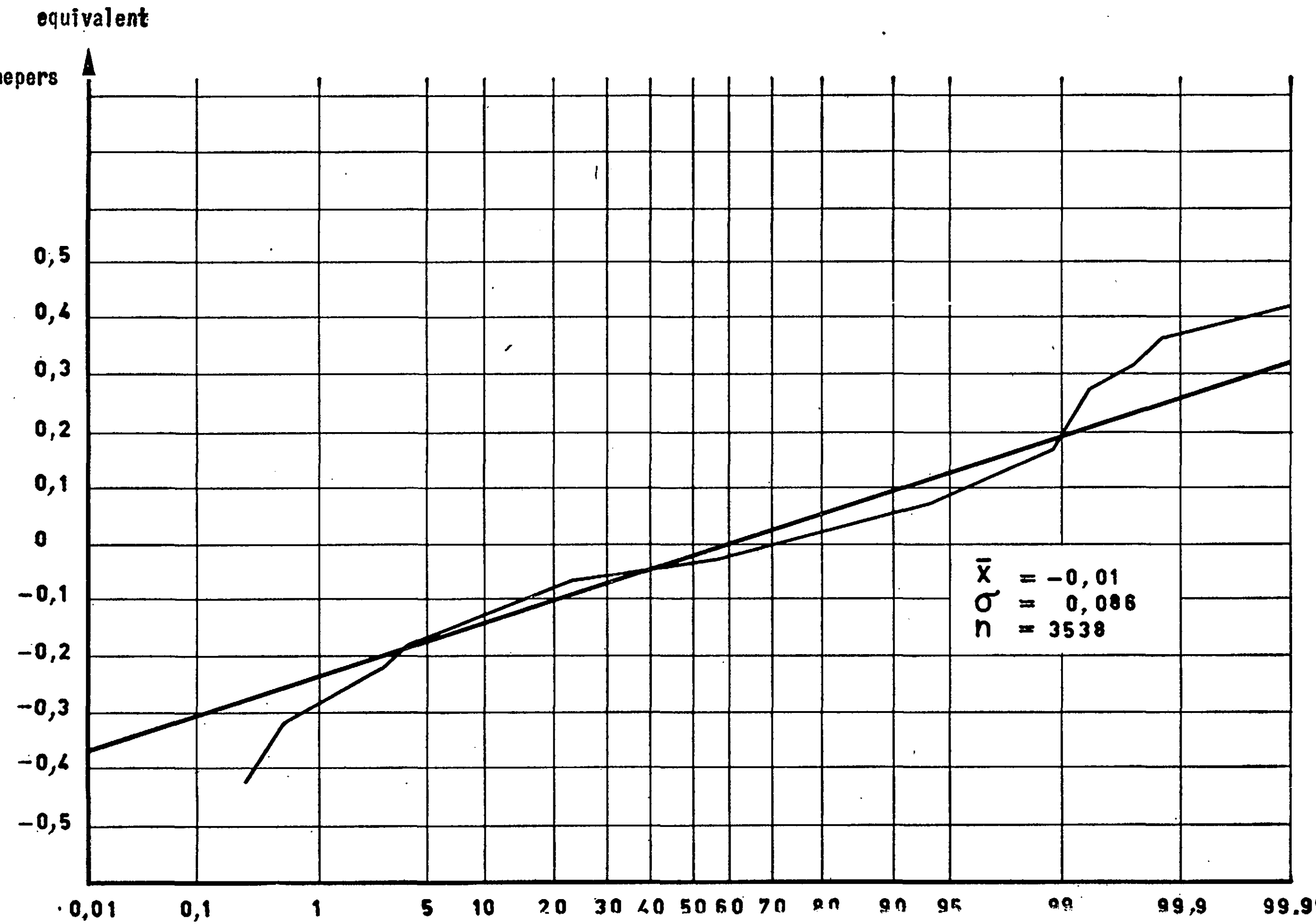


FIGURE 3. — **Integral distribution curve of the results of the development of example No. 2**
(probability scale)

TABLE FOR EXAMPLE No. 2

Processing of the results of measurements of stability of overall loss on one channel of a B 12 system (measurements made over a period of one year)

$n = 3537 \quad A = 0.025 \quad K = 0.05 \quad x' = 0.31 \quad \bar{x} = 0.01 \quad \sigma = \pm 0.086$

Interval	w	$\frac{w}{n}$	$\sum \frac{w}{n}$	x'	$x'w$	x'^2w	$t = \frac{x-\bar{x}}{\sigma}$	$\Phi(t)$*	$F_n(t)+\frac{\lambda}{\sqrt{n}}$	$F_n(t)-\frac{\lambda}{\sqrt{n}}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
−0.45 −0.40	12	0.0034	0.0034	− 8	− 96	768	−4.82	0.0000	0.0307	
−0.40 −0.35	4	0.0011	0.0045	− 7	− 26	196	−4.24	0.0000	0.0318	
−0.35 −0.30	6	0.0017	0.0062	− 6	− 36	216	−3.66	0.0001	0.0335	
−0.30 −0.25	23	0.0065	0.0127	− 5	−115	525	−3.08	0.0011	0.0400	
−0.25 −0.20	50	0.0141	0.0268	− 4	−200	800	−2.50	0.0063	0.0541	
−0.20 −0.15	71	0.0201	0.0469	− 3	−213	639	−1.91	0.0281	0.0742	
−0.15 −0.10	218	0.0616	0.1085	− 2	−436	872	−1.33	0.0918	0.1258	
−0.10 −0.05	415	0.1173	0.2258	− 1	−415	415	−0.75	0.2265		
−0.05 0	1230	0.3478	0.5736	0	0	0	−0.17	0.4325		
0-0.05	829	0.2344	0.8080	1	829	829	+0.40	0.6554		
0.05-0.10	426	0.1204	0.9284	2	852	1704	+0.98	0.8364		0.9011
0.10-0.15	144	0.0407	0.9691	3	432	1296	+1.56	0.9406		0.9418
0.15-0.20	58	0.0164	0.9855	4	232	928	+2.15	0.9842		0.9552
0.20-0.25	26	0.0074	0.9929	5	130	650	+2.73	0.9968		0.9656
0.25-0.30	15	0.0042	0.9971	6	90	540	+3.31	0.9995		0.9698
0.30-0.35	5	0.0014	0.9985	7	35	245	+3.89	0.9999		0.9712
0.35-0.40	5	0.0014	0.9999	8	40	320	+4.47	0.9999		0.9726
					1101	10943				

* $\Phi(t)$ = from table of values of probability integral (normal distribution).

SUPPLEMENT No. 2.1

SOME GENERAL OBSERVATIONS CONCERNING MEASURING INSTRUMENTS AND MEASURING TECHNIQUES

1. *Accuracy of measurements*

The measurement techniques used in measuring the various operating parameters of transmission systems should be devised to reduce to a minimum the number of errors which collectively contribute to the final accuracy of measurement. More than one acceptable method may be available for measurement of a particular parameter, in which case the method involving the least number of errors would naturally be chosen where possible. For example, insertion loss measurements could be made by either the direct method, using a level-stable calibrated signal source and a calibrated level-measuring set, or by the comparison method, using similar equipment in conjunction with an accurate reference attenuator network. In the direct method all the inaccuracies inherent in the equipment form part of the overall accuracy of the measurement procedure while in the comparison method measurement error can be reduced to that of the attenuator only and could therefore be restricted to quite low orders of magnitude. Furthermore, when measurements are made by the comparison method the level-measuring set need not necessarily be a calibrated device.

Attention must be paid to matching the sending and receiving impedances of the testing equipment to the input and output impedances respectively of the system or network under test (see Supplement No. 2.5).

Operating errors can, even in the case of relatively sophisticated measuring instruments, contribute to a large error in the final measurements. For example, using a direct-reading selective level-measuring instrument to make measurements over a range of signal levels and signal frequencies, errors could accumulate in the following typical manner:

Level indication/frequency characteristic:	$\pm$0.2 dB (0.23 dNp)
Meter calibration error:	$\pm$ 0.1 dB (0.12 dNp) to $\pm$ 0.25 dB (0.29 dNp), according to the type of instrument indication
Temperature variation:	$\pm$0.2 dB (0.23 dNp)
Attenuator (range switch) error:	$\pm$0.15 dB (0.17 dNp) high frequency; $\pm$1 dB (0.12 dNp) low frequency (assuming a heterodyne type level-measuring set)

If a built-in calibrating oscillator is included in the selective level-measuring set, then the above errors would be relative to the accuracy of the oscillator output level which itself could be susceptible to the following errors:

Setting errors:	$\pm$ 0.05 dB (0.06 dNp)
Level variation with temperature:	$\pm$ 0.1 dB (0.12 dNp)

Summating the above errors, the " most probable " error of level measurement at any frequency and at signal levels within the design capabilities of the measuring set would, for this equipment, be about 0.4 dB (0.46 dNp).

In examining the areas where possible improvements in the overall accuracy might be effected one could use an indicating instrument in the level-measuring set which possessed shaped pole-pieces and mechanical suppression of the electrical zero. Suitable proportioning of these properties can result in an instrument which possesses an almost linear decibel (neper) scale over its full scale length. Typical end-to-end current ratios which might be incorporated into such instruments can result in linear scales with ranges of the order of 6, 12, 20, or even 30 dB (7, 14, 25, or 35 dNp). The 12-dB (14-dNp) shaped-pole instrument would be particularly useful when used with a 10-dB (10-dNp) step attenuator (range switch) on the level-measuring set. The calibration error over the whole range of such an instrument would be of the order of $\pm$ 0.1 dB (0.12 dNp), compared with the maximum errors of $\pm$ 0.25 dB (0.29 dNp) cited in the above example.

Greater temperature stability and an improved level indication/frequency characteristic could be built into the measuring equipment but at a probable increase in cost. Even if it were possible to effect a 50 per cent improvement in temperature stability and frequency response, and even if an accurate linear-decibel (neper) scaled meter were used in the receiving equipment, the " most probable " error in level measurement would still be of the order of 0.25 dB (0.29 dNp).

In the special case of continuous monitoring of the level of a single frequency test tone or pilot frequency, the measuring equipment can be simplified to a very stable level-measuring set of constant sensitivity. Deviations from nominal in the level of the signal can be displayed directly on the scale of the indicating instrument of the level-measuring set. If the instrument is of the shaped-pole suppressed-zero type with a current ratio giving a scale range of 6 dB (7 dNp) then the calibration accuracy of the latter would be of the order of 0.05 dB (0.06 dNp). The " most probable " error in level measurements using such an instrument would be of the order of 0.15 dB (0.17 dNp).

In addition to the measuring set errors discussed above " human factor " errors amounting to as much as 0.5 dB can be introduced under adverse measuring conditions. The use of automatic measuring techniques and level-measuring sets with digital presentation and recording would help to reduce this source of error. However, although measuring sets could possibly be produced having the same order of measuring accuracy as those discussed above, instability in level sensing circuits would limit the optimum resolution to about 0.1 dB.

2. *Use of digital displays*

(*Note.* — A distinction should be drawn between instruments which display a digital representation of a continuously variable quantity (e.g. a digital decibelmeter) and instruments which are essentially event-counters and thus naturally lend themselves to a digital display (for example, error-rate counters of p.c.m. systems). These latter are *not* the subject of this section).

In general it is considered that the use of digital displays is desirable for some (but not all) transmission measurements. The quantity being measured should preferably be steady for a digital display since it is more difficult to form an estimate of the rate and extent of fluctuations of a varying quantity with this form of presentation than with a conventional scale-and-pointer display.

Digital displays would be suitable for non-specialized staff, but economic considerations, technical complexity and the possible physical size of portable equipment might limit their extensive use.

Digital display instruments can be used for measurements requiring the highest accuracy. Human errors are reduced and (for a given cost) it is often easier to make a digital display instrument more accurate than an analogue display-instrument in that the least-significant-figure error can often readily be made less than the scale-error of a conventional meter.

In general, a digital display takes less time to read than a scale indication and hence digital displays would be superior to analogue-displays for making measurements in quick succession. The facility for a printed or punched output might usefully be provided by the instrument for this purpose.

A digital display is not considered to be suitable if the quantity being measured is varying continuously (as for example, when the level of a signal is being adjusted with a potentiometer) and for this type of measurement a conventional pointer and meter display is to be preferred. However, if the adjustment is made in steps then a digital display would be satisfactory.

Digital display instruments are, in general, not considered quite so suitable for localizing sources of trouble giving rise to variations in level as analogue displays although they might be used for such a purpose if there was facility for a printed output. They are not considered suitable for studies of intermittent faults.

Digital display instruments have been used or could be used for the following purposes:

— automatic recording of measured results particularly with a view to subsequent evaluation by a computer,

— in conjunction with automatic loss and level measuring equipments.

3. *Direct-reading methods versus null or comparison methods*

(It should be noted that many types of digital display instruments are inherently comparison or null systems, the accuracy of which depends on the long-term stability of some internal reference device, for example, a zener diode. However, this section refers to comparison or null methods performed manually and hence digital display instruments are here regarded as direct-reading instruments).

In general, comparison or null methods which require the operator to manually adjust a control should be used only for measurements requiring the highest accuracy. Many administrations confine such methods to repair centres, laboratories or selected important centres.

Comparison or null methods are used for:

— calibrating reference power sources,

— checking line amplifiers, attenuators and other items of transmission equipment,

— measuring crosstalk ratios, noise levels, harmonic margin.

In the United States this method is used for measuring the level of group pilots. Portable instruments could use this method with advantage in that the stability is, in principle, vested in comparatively robust components such as attenuators, rather than in a meter.

In general, direct-reading techniques are considered suitable for most other types of measurements, particularly when cost or time must be conserved.

Some measuring sets capable of precise measurements combine manually-operated controls with a direct-reading instrument. These are the so-called " level lens " or " off-set zero " instruments in which for example the input level being measured is set equal to within say $\pm$ 0.5 dB of the reference signal by means of switched attenuators, the least step of which is in this case 1 dB, and the residual difference between the measured signal and reference signal is displayed on a centre-zero decibelmeter which indicates the sign as well as the magnitude of the difference. The level measured is given by the sum of the attenuator setting and the meter reading. The meter can readily be engraved to permit easy interpolation.

4. *Use of selective measuring sets*

Selective measuring sets are necessary when the wanted signal is accompanied by other signals or noise at relatively high levels, for example, crosstalk levels. Selective measuring sets may be either fixed-frequency or continuously variable. Fixed-frequency selective measuring sets are in general accurate and fast and tend to reduce human errors. However, they are restricted in use and it would be costly to provide a great variety of them.

On the other hand continuously variable selective measuring sets require more skill to use and sometimes, and for some applications, they are not so accurate or so fast.

Fixed-frequency selective measuring sets are used for measuring the levels of

— group and supergroup reference pilots,

— additional measurement frequencies for HF line systems,

— line-regulating pilots,

— intersupergroup pilots (although these can also be, and in some cases are, measured with continuously variable selective measuring sets),

— harmonic margin on sound-programme circuits (in conjunction with particular test signals at fixed frequencies),

— noise in the monitoring sets of wideband systems,

— interchannel measurements on 12-, 60- and 120-channel systems.

Some administrations have fixed-frequency selective measuring sets which enable lower order pilots to be measured, for example the five-group reference pilots at the frequencies at which they appear in the basic supergroup can be measured together with the supergroup reference pilot at any point where the basic supergroup is available, for example the supergroup distribution frame.

Fixed-frequency selective measuring sets used for pilots can with advantage be arranged to operate a recorder.

Continuously variable selective measuring sets are used for general purposes when it is required to measure signals at discrete frequencies, for example a test signal on a channel in its position in the wideband spectrum.

5. *Compensating for the losses of test-trunks and test-cords*

A broad distinction can usefully be made between centralized measuring apparatus which is often necessarily remote from the transmission equipment and rack-mounted measuring apparatus which can be installed near to the transmission equipment or mobile measuring apparatus which can be brought up close to the transmission equipment.

5.1 *Centralized measuring apparatus*

Examples of this are automatic measuring apparatus for circuits etc. or centralized measuring centres serving remote installations. In these cases it is often the practice to build out the loss of the test-trunk or test-circuit with pads or amplifiers, sometimes equalizing if necessary, and off-setting any residual loss by suitably increasing the sending level or the receiving sensitivity so that the measuring instrument effectively indicates the level at the remote transmission equipment.

5.2 *Measuring apparatus mounted or brought close to the transmission equipment*

In this case the preferred technique is to keep the testing cords as short as possible. The calibration technique can often be arranged to allow for the loss of the test-cords.

The test-cords should be short compared with the shortest wavelength within the spectrum of signals being measured. When this is not possible a test lead may be derived which is effectively decoupled from the transmission path (for example by means of a test hybrid which may be a transformer or a network of resistors) the test lead being properly terminated by the measuring apparatus. In these circumstances it is useful to arrange for the test lead to be similar in composition and length to the transmission path from the transmission equipment to the associated distribution frame so that measurements at the end of the test lead are as if they were made at the distribution frame.

6. *Maintenance of test equipment*

It is difficult to make a succinct summary that does justice to the wide variety of practices adopted by administrations and private operating companies.

6.1 *Simple checks of the testing equipment*

Most signal generators and level-measuring sets have built-in calibrating equipment by means of which the sets can be calibrated at a reference frequency. Such calibration is generally performed prior to each use or as often as required.

Checks of the reference frequency and reference signal level in the generator or level-measuring set are performed at frequent intervals by the repeater station staff, often in accordance with instructions provided by the manufacturers of the equipment.

6.2 *Check of equipment specification characteristics*

In many cases repeater station staff are expected to make periodical checks of the more important specification requirements (every 3 months for example) of their equipment, recalibrating if necessary and possible. Sometimes visiting inspectors do this.

Faulty equipment or equipment requiring more complicated recalibration are sent to centralized repair centres or in some cases to the manufacturer (with whom, presumably, the administration has some agreement concerning repair and recalibration of equipment). In many cases a substitute instrument is returned immediately (if available), although in some cases the staff must wait until the instrument is repaired or recalibrated. At centralized repair centres (or at the manufacturer's) opportunity is taken to verify all the specified characteristics of the instrument against the specification.

Country or organization	Periodicity of checks: By repeater station staff	At a regional centre	At a national centre	Is substitute equipment provided?	Comments
Federal Republic of Germany		Every two years		No reply	Additional checks of complex equipment proferred by manufacturers
United Kingdom	At 3-monthly intervals, at reference frequency only		Every two years	Yes	U.K. thinks that the two-year interval is possibly too long and would advocate one year
Norway	Checked periodically by visiting inspectors		* –	Yes	* Checks are performed but no time interval given
Cable and Wireless	Every six months			No reply	
Netherlands			Every two years	If required	It is intended to check every year
Switzerland	Every three months * Every three years **			No	* Signal generator output checked at 1 mW. Level-measuring sets are then checked against the generator ** Checks against equipment specifications performed by manufacturer's staff
Sweden			Every year	Yes	
RAI	Periodical checks		Periodically when necessary	Yes	
O.R.T.F.	Periodical checks *			No reply	* Signal generators are checked against standard instruments. Level-measuring sets are checked by means of the signal generators

Country or organization	Periodicity of checks			Is substitute equipment provided?	Comments
	By repeater station staff	At a regional centre	At a national centre		
O.R.F.	At six-monthly intervals		*		* Special calibrations where necessary at a laboratory
A.B.C.	Weekly; at reference frequency and other spot frequencies *			Yes	* General maintenance and treatment of complicated faults by special maintenance department
Finland	Periodically *	Annually **		Yes	* Simple checks ** Checks of performance characteristics at a maintenance and repair centre
Austria	Periodically *	Annually **		Yes	* Simple checks ** Checks of performance characteristics at a maintenance and repair centre
N.T.T.	Regular routine maintenance		*	Yes	* Analysis of faults and major overhaul (sometimes effected by the equipment manufacturer)
A.T.T.		Half to three years dependent upon complexity of the instrument		Yes	
Poland		Annually		No	

7. *Power supply for measuring apparatus*

7.1 *Portable equipment*

In general, portable equipment should be suitable for operation from a battery of dry (non-spillable) primary or secondary cells contained within the instrument; when secondary cells are used opportunity could be taken to arrange for the instrument to be mains-operated and to charge the internal secondary cells when it is so operated.

There should be some means of measuring the on-load supply voltage and an indication given when the cells should be replaced (or recharged). Some administrations arrange for portable test equipment used in remote areas to be operated from the car battery in the testing officer's vehicle.

When the power requirement exceeds that which could reasonably be expected from a battery contained within the instrument, the instrument should be suitable for operation from public mains supply and also from power supplied by the a. c. generating sets sometimes used at small or remote stations. In these cases the portable test equipment should be designed to operate satisfactorily in the face of, typically, $\pm$ 10% voltage changes and $\pm$ 10% power supply frequency changes. This might be achieved by incorporating a regulated power unit in the test set.

7.2 *Rack-mounted equipment*

Practice varies—some administrations provide a special a.c. power supply devoted to measuring apparatus. This supply is closely regulated and frequently checked (twice daily by one administration). Others incorporate regulators in the test equipment, which is then operated from normal a.c. or d.c. station supplies. The test equipments are expected to operate satisfactorily in the face of $\pm$ 10% supply voltage variations.

The effect of supply voltage variations on test equipment is checked at periodicities varying from every six months (for valve equipment) to every two years (for transistor equipment).

8. *Other desirable characteristics of measuring instruments that should be taken into account*

8.1 *For selective measuring sets*

a) requirements for pass band;
b) requirements for rejection band;
c) requirements for suppression of unwanted frequencies, e.g. image frequencies, beat frequencies;
d) requirements for overload of the wideband section of heterodyne sets.

8.2 *For portable sets*

a) mechanical characteristics including:
portability
resistance to mechanical shock;

b) safety including:
earthing, insulation, etc.;

c) characteristics under extreme climatic conditions, such as those encountered in northern and equatorial countries.

8.3 *Effect on the performance of*

a) ambient magnetic and electric fields;

b) earthing arrangements.

In addition to the above, certain administrations have suggested that the following items should be specified, called for, or considered:

a) output sockets for external meters, frequency meter, recorders or earphones;

b) limit to the back-lash on frequency dials;

c) output level accuracy to be maintained over the whole of the range of frequency dial;

d) reduction of effect of parallax where high accuracy is required (one method suggested is to use a meter with a mirror behind the pointer);

e) movement of meter-needle to be in the same direction as dial rotation;

f) *clockwise* rotation of controls should *increase* the quantity concerned;

g) type or rectification used in level-measuring sets;

h) time constant of indicating device;

j) a requirement for the non-harmonic content in signal generator output signal (same limit as for the harmonic requirement);

k) a limit to the disturbing signals generated in level-measuring instruments which may be injected into the circuit being measured;

l) scales on level-measuring sets graduated in value of power level with respect to 1 milliwatt (in dBm or dNm) by steps of not more than 0.5 dB or 0.5 dNp. Calibration should be made with reference to a sinusoidal signal;

m) internal means for calibration of high-frequency test signal generators and level-measuring sets are desirable. In other cases, and for primary calibration of the internal calibration circuits, ready means for checking the sets against a standard source of test power is needed. Means for adjusting the calibration of sets when checking against external sources should be so designed that the adjustments must be deliberate and not inadvertent. External sources used for calibration should be checked by means of a secondary standard which in turn is checked against a primary standard as often as necessary to ensure that the above requirements are met;

n) although a somewhat detailed requirement, one administration has suggested that the intermediate frequency in selective measuring sets be not greater than 50 kHz and that a socket be provided for an external meter to measure the level of the intermediate frequency signal;

o) another administration advocates that uniform symbols and operating signs be used, and that instructions be supplied by the manufacturer in the language of the country in which the set is to be used;

p) it is considered desirable that results of measurements be displayed in terms of departures from nominal values and that no knowledge be demanded of the test set operator of the nominal value. This could be implemented by building-out all measuring points where similar types of measurements are made to a common value, or by arranging the test set to automatically set its sensitivity in accordance with the measuring point to which it is connected. This is in particular reference to centralized test consoles at which a testing officer can measure a variety of quantities at a variety of points in a large installation;

q) one administration favours a visual indication when prescribed limits are exceeded or not attained.

SUPPLEMENT No. 2.2

MEASUREMENTS OF LOSS

1. *Définitions*

a) *Loss (in transmission)*

Loss is the decrease in power, usually expressed in decibels or nepers, in transmission from one point to another. Although the word is often used alone, for unambiguous expression it needs to be qualified.

b) *Insertion loss*

(See definition 05.22 of the I.T.U. *List of definitions of essential telecommunication terms.*)

The *insertion loss* of a two-terminal pair network inserted between a sending impedance Z_E and a receiving impedance Z_R is the expression in transmission units of the ratio P_1/P_2 expressed in transmission units, where P_1 and P_2 represent the apparent power in the receiving impedance Z_R *before* and *after* the insertion of the two-terminal pair network concerned.

This loss is given by the expression:

$$10 \log_{10} \left| \frac{P_1}{P_2} \right| \text{ decibels or } \frac{1}{2} \log_e \left| \frac{P_1}{P_2} \right| \text{ nepers.}$$

If the result has a negative sign, an insertion gain is indicated.

The measurement of insertion loss is made in accordance with Figure 1. The ratio of apparent power is usually based on the ratio of the voltages across Z_R *before* and *after* the insertion of the two-terminal pair network.

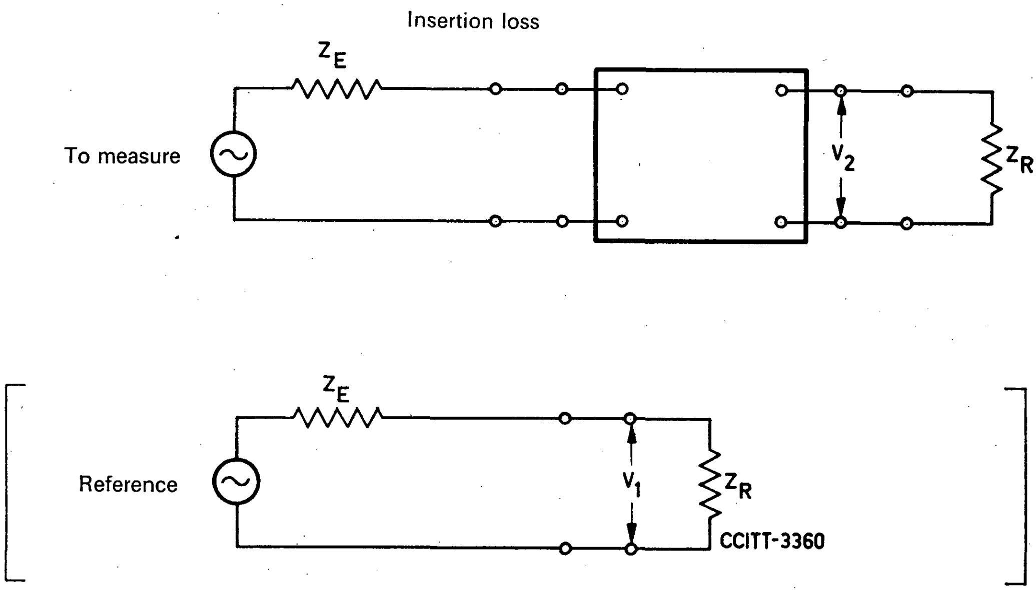


FIGURE 1

c) *Composite loss*

(See definition 05.20 of the I.T.U. *List of definitions of essential telecommunication terms.*)

The *composite loss* of a two-terminal pair network inserted between two impedances Z_E (of the generator) and Z_R (of the load) is the expression in transmission units of the ratio

$$\left| \frac{P_0}{P_2} \right|$$

where P_0 is the apparent power that the generator Z_E would furnish to a load of impedance Z_E and P_2 is the apparent power that the same generator furnishes via the said two-terminal pair network to the load Z_R. If the number thus obtained is negative, then there is a *composite gain.*

In the same way as for insertion loss, composite loss concerns the ratio of two apparent powers, but in the case of composite loss the reference power against which the power delivered by the two-terminal pair network into the receiving impedance Z_R is compared does not depend on Z_R. For composite loss, the reference power is constant and does not depend on the generator. The measurement of composite loss is made in accordance with Figure 2.

When the generator and load impedances are equal, the composite loss becomes numerically equal to the insertion loss. Strictly speaking, the loss of telephone circuits, for example, is the composite loss rather than the insertion loss because when the load and gene-

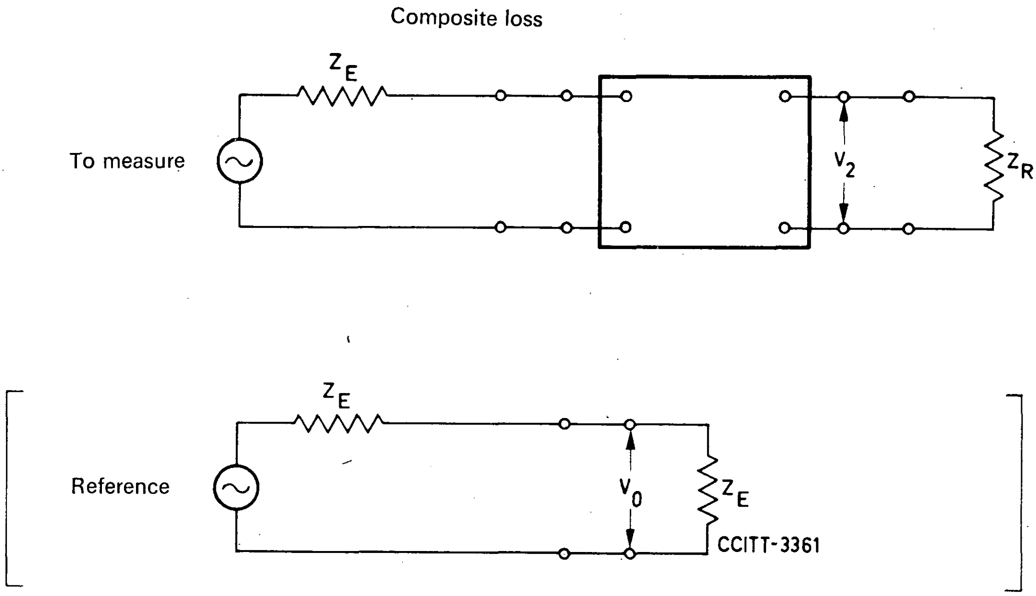


FIGURE 2

rator are some distance apart the requirements imposed by the definition of insertion loss cannot be met.

For the special case when the generator and load impedances consist of a non-reactive 600-ohm resistance, the composite loss is sometimes referred to as the " equivalent " of the circuit; more specifically it is the 600-ohm insertion loss of the circuit.

The " equivalent " is used for practical purposes to express the loss of a telephone circuit between two-wire ends. " Equivalent " should not be used for a line having an impedance different from 600 ohms (for example, using a carrier cable pair of some 150-ohm impedance or a coaxial pair of some 75-ohm impedance).

2. *Measurements in practice*

Testing equipment used for making loss or gain measurements consists basically of a suitable generator for providing the test signal and a measuring device for measuring the level of the received signal. For each equipment or system to be measured the generator will have to provide a test signal at a suitable frequency or over a range of frequencies and over an appropriate range of levels. The measuring device is basically a voltmeter but indicating voltage or power levels. The measuring equipment will usually include sending and receiving units to provide the desired sending and receiving conditions at impedances appropriate to the measurements which are to be made.

Two methods of measuring gain or loss are commonly used; these are direct-reading measurements and measurements by a comparison method.

When the two ends of the two-terminal pair network are accessible at the same point, these measurements are carried out as shown in Figures 1 and 2.

a) *Direct-reading measurements*

For such measurements the network or line N to be measured is inserted between a sending device G and a measurement set M (Figure 3).

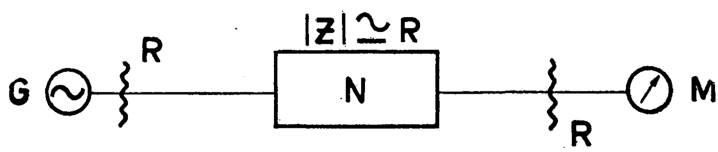


FIGURE 3

In practice the sending device G simulates a constant voltage generator of known source e.m.f. and impedance. The prime calibration of such an arrangement in the field is maintained with reference to the power developed by the generator in a thermo-couple of the correct impedance. The measuring set M is used to make a direct measurement of the *power* level of the received signal at the output of N. The difference between the sent and received power levels is a direct measurement of the insertion loss or gain of N. The generator and measuring circuits must be designed and used to give the appropriate sending and receiving impedance conditions. The diagram represents the simplest—and at the same time most usual—case in which terminal impedances are equal to the input and output impedances of the two-terminal pair network.

b) *Loss measurements using a comparison method*

For such measurements the output from the sending device G is connected via a branching network to provide two outputs, one of which is connected to the network

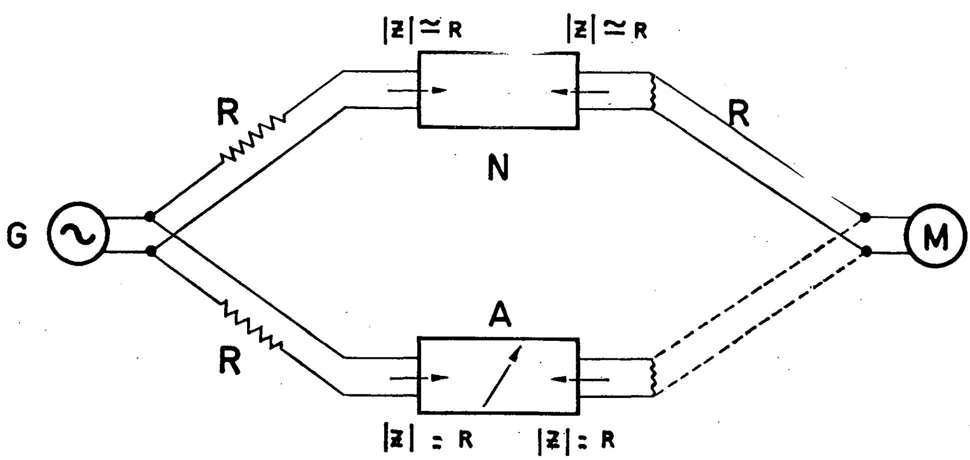


FIGURE 4

N to be tested and the other to a calibrated attenuator A. At the receiving end a measuring circuit M is used to compare the level of the signal received via the network under test and via the calibrated attenuator (Figure 4).

The loss of the attenuator A is adjusted so that the same level is indicated on the measuring meter when it is switched to either the network or the attenuator; the loss of the network is then given by the setting of the calibrated attenuator.

By an extension of this method it can be used to measure the loss of a circuit or system where the two ends are not available at the same point. In this case a second generator is required at the receiving end of the circuit under test. At the sending end the test signal generator is adjusted to send the required frequency at an appropriate level into the circuit under test. At the receiving end a second generator is used to send the same frequency at the same level into a calibrated attenuator. The measuring circuit is used to compare the level of signal received via the circuit under test and the signals from the calibrated attenuator, which is adjusted until the two levels are the same. The setting of the calibrated attenuator then gives the loss of the circuit under test.

It should be noted that these comparison methods do not require the use of a calibrated measuring device. An uncalibrated indicator of appropriate sensitivity may be used, the accuracy of the measurements being a function of the accuracy of the calibrated attenuator. Due regard must be paid to the sending and receiving impedance conditions when making the measurements. The diagram represents the simplest—and at the same time most usual—case, in which the terminal impedances are equal to the input and output impedances of the quadripole and to the input and output impedances of the attenuator.

c) *Measurement of " equivalent "*

To measure the " equivalent ", the circuit to be measured is fed at one end from a 600-ohm generator, the other end being terminated with 600 ohms. The measured value of equivalent does not depend on the e.m.f. of the generator used.

In practice a " standard generator " is often used for convenience (see the definition of a " standard generator " in definition 12.18 in the I.T.U. List of *Definitions of essential telecommunication terms,* paragraph 6, below). The equivalent is then equal (but with opposite sign) to the absolute power or voltage level at the end of the circuit closed across 600 ohms.

SUPPLEMENT No. 2.3

LEVEL MEASUREMENTS

1. *General*

These are measurements made for determining the level of a test signal at different points. They are always made with a high resistance voltmeter as the basic instrument.

In different countries, different terms are used to describe level measurements and these differences are a possible source of misunderstanding.

Three factors are involved in these measurements:

1. The reference value enabling the results to be expressed in terms of a ratio (and hence in transmission units) may be either a reference power or a reference voltage.

2. The expression of the results in transmission units may be in either decibels or nepers.

3. The measurements made may be either bridging measurements (through levels) or terminated level measurements:

   a) bridging measurements (through levels): the (high resistance) instrument is bridged across a circuit in its working condition; or

   b) terminated level measurements: the circuit is disconnected at the point of measurement and terminated with a pure resistance (usually provided within the instrument for use as required) the measurement then being made across the terminals of that resistance.

These various factors are independent. Bridging measurements are not particularly associated with a voltage reference, nor terminated measurements with a power reference. Neither should nepers be considered to be particularly associated with a voltage reference nor decibels with a power reference. National usage may make such an association, but a different association may occur in other countries.

2. *National practice in the United Kingdom*

In the United Kingdom transmission measurements are normally expressed as power ratios in decibels relative to 1 mW. Through level measurements and terminated measurements are made with an instrument calibrated in decibels relative to 1 mW of power in a specified pure resistance *R*: e.g. for a measurement at a 600-ohm point, the instrument is one graduated in decibels relative to the voltage produced across a pure resistance of 600 ohms when 1 mW is dissipated in it. With such an instrument a reading of 0 decibel relative to 1 mW will be obtained with a voltage of 0.775 volt across the terminals of the instrument. An instrument calibrated in this way will therefore indicate the true power level at the point of measurement only in the case where the impedance of the circuit at this point is equal to *R*, the resistance which defines the calibration of the measuring instrument.

Transmission measurements made in the United Kingdom therefore assume that the circuit impedance has its nominal impedance and care is taken in the design of equipment to ensure that the impedance at the measuring points is as close as possible to the nominal value. In practice, the deviation from the nominal impedance is very small and any errors resulting from the use of instruments calibrated in terms of the nominal impedance are usually negligible. If the impedance Z beyond the measuring point should differ from the nominal value R, the departure of the reading from the true value would be given by the expression $10 \log_{10} \frac{R}{Z}$ decibels.

For the various nominal impedances encountered in practice, measuring instruments calibrated in terms of these various impedances or with appropriate scale change facilities are used. Instruments calibrated in decibels relative to 1 mW dissipated in 600, 140 and 75 ohms are commonly used in the United Kingdom.

In the case where a measurement is made with an instrument calibrated in terms of a resistance R, which is grossly different from the nominal impedance at the point of measurement, the reading will be appropriately corrected to express the result in terms of a power ratio in decibels relative to 1 mW, e.g. a measurement made at a 75-ohm point using an instrument calibrated in terms of 1 mW dissipated in 600 ohms will be corrected by the factor $10 \log 600/75 = 9$ dB.

i.e. True power level relative to 1 mW = meter reading + 9 dB.

The meter used for any particular measurement is specified by stating the value of resistance R in which a power of 1 milliwatt must be dissipated in order to produce across that resistance a voltage which, when connected to the meter, would produce a reading of 0 dB. The meter is often referred to as an " R-ohm meter ", e.g. 600-ohm meter, etc. Care should be taken to avoid any confusion between:

a) the resistance R specifying the scale calibration and

b) the internal (high) resistance of the measuring set.

3. *National usage in France* (absolute levels)

In France, when bridged measurements are made (and fairly often in the case of terminated level measurements), the instrument is calibrated to show " absolute voltage level ", i.e. the logarithm of the ratio to 0.775 volt[1] of the voltage existing at the instrument terminals, regardless of the nominal impedance of the circuit at the point under consideration.

From this reading, knowing the reference impedance Z of the circuit beyond the point considered, an absolute power level can be obtained by adding to the reading:

$$\frac{1}{2} \log \left| \frac{600}{Z} \right| \text{ nepers.}$$

For terminated measurements, Z is the terminating impedance used to terminate the circuit when making the measurement.

In actual fact, the methods described in paragraphs 2 and 3 are not fundamentally different. The readings of instruments used for the method given in paragraph 2 differ from those of instruments used for the method in paragraph 3 by a constant amount equal to

[1] Voltage at the terminals of a pure 600-ohm resistance when a power of 1 mW is dissipated in the latter.

$$\left(10 \log_{10} \frac{R}{600}\right) \text{dB or} \left(\frac{1}{2} \log_e \frac{R}{600}\right) \text{nepers.}$$

It could be said that the measurements made according to paragraph 2 are measurements of absolute voltage level for which the reference voltage at zero reading is no longer necessarily 0.775 V, but

$$0.775 \times \sqrt{\frac{R}{600}} \text{ volts}$$

where R is the reference impedance of the measuring instrument.

In the case of speech frequency measurement, R is in most cases equal to 600 ohms so that the two methods of measurements give the same value.

PUISSANCE POWER		1 mW	1 mW	1 mW
TENSION VOLTAGE		0,775 V	0,374 V	0,275 V
MESURES FAITES AU ROYAUME-UNI MEASUREMENTS AS MADE IN U.K.	APPAREIL UTILISE INSTRUMENT USED	APPAREIL DIFFERENT SUIVANT LA LIGNE A MESURER "600 OHM-METER" DIFFERENT INSTRUMENT DEPENDING ON THE LINE IMPEDANCE	"140 OHM-METER"	"75 OHM-METER"
	GRANDEUR MESUREE QUANTITY MEASURED	PUISSANCE (lecture de "THROUGH LEVEL") POWER (reading of "THROUGH LEVEL")		
	LECTURE SUR L'APPAREIL METER READING	0 dB	0 dB	0 dB
PUISSANCE EMISE POWER SENT	1 mW			
IMPEDANCE DE LA LIGNE LINE IMPEDANCE		600 Ω	140 Ω	75 Ω
MESURES FAITES EN FRANCE MEASUREMENTS AS MADE IN FRANCE	LECTURE SUR L'APPAREIL METER READING	0 Np ou-or 0 dB	0,7 Np ou-or -6 dB	-1,0 Np ou-or -9 dB
	GRANDEUR MESUREE QUANTITY MEASURED	NIVEAU ABSOLU DE TENSION (tension rapportée à 0,775 V) "600 OHM THROUGH LEVEL" (voltage ratio, referred to 0.775 V) (BEST CORRESPONDING EXPRESSION)		
	APPAREIL UTILISE INSTRUMENT USED	APPAREIL IDENTIQUE QUELLE QUE SOIT LA LIGNE SIMILAR INSTRUMENT WHATEVER THE LINE IMPEDANCE		

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FIGURE 1

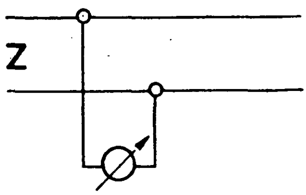
4. *Differences in scales and terminology in different countries*

Figure 1 shows the differences in the readings obtained, depending on the method of measurement and the type of instrument used.

The equivalent English and French terms for the various ways of making measurements are given below:

1. *Bridged measurements:*

FRENCH METHOD



French term	*Corresponding English term*
Niveau absolu de tension	Voltage level (referred to 0.775 volt) or 600-ohm through level

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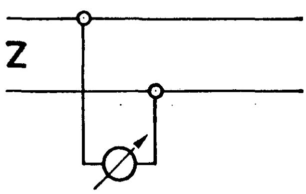
U.K. METHODS

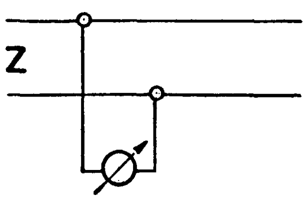
Normal line measurements



(Meter scale appropriate to circuit impedance)

English term	*Corresponding French term*
Through level	" Niveau absolu de puissance mesuré en dérivation"

(Special measurement: e.g. carrier supply lead)



(Meter scale not appropriate to circuit impedance)

R-ohm through level	No corresponding French term in all cases If the meter is a "600-ohm meter": niveau absolu de tension

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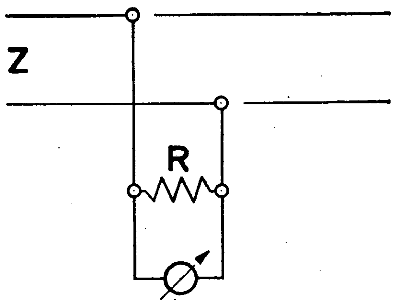
2. *Terminated measurement*



R = nominal value of Z
(meter scale and R appropriate to circuit impedance Z)

English term	*French term*
Terminated level	"Niveau absolu de puissance mesuré sur terminaison" and also "Equivalent" if a) at the sending end of the circuit, the generator is a 600-ohm generator, and b) $R = 600$ ohms

5. *Relative level*

(It would be more precise to call this " relative power level " but it is permitted to omit the word " power ".)

In general, in order to specify the levels of signals and noise in a communication system, it is desirable to define the levels at some reference point. The levels at any other point in the communication system can then be related to this reference point if the loss or gain between the two points is known.

The relative level of a point in a transmission system is an expression of the amount of gain or loss introduced by the system between the point in question and some other point in the system chosen to be the reference point. The abbreviation is dBr or dNpr (in which r signifies relative).

The conditions attached to the reference points of national systems may well be different from country to country and hence the reference level of the international system should not be referred to the reference level of a national system. When considering international connections a hypothetical point is used as the zero relative level point in the computation of nominal relative levels. Such a hypothetical point exists at the sending end of each channel of a four-wire switched circuit preceding the *virtual switching point*; it is defined as having a level of + 3.5 dB (+ 4.0 dNp) relative to that at the virtual switching point.

Any point having a zero relative level may be used as a " *transmission reference point* " but the phrase " International transmission reference point " should be reserved for the zero relative level point which is + 3.5 dB (+ 4.0 dNp) upstream from the send virtual switching point at the beginning of the international chain.

Any given international four-wire telephone circuit could be used for a variety of purposes. It could on one connection be used to connect a CT3 to a CT3 but on another connection it could be used to connect a CT2 to a CT1. Therefore, for international network design and maintenance purposes it is necessary to designate nominal relative levels for the circuit. The nominal relative levels for an international circuit at the reference frequency at the virtual switching points are:

—3.5 dBr (—4.0 dNpr), sending

—4.0 dBr (—4.6 dNpr), receiving.

with respect to the " international transmission " reference point.

In a transit centre, the virtual switching points of the two *international* circuits to be interconnected are considered to be connected together directly without any intermediate pad or amplifier.

In this way it is ensured that the nominal transmission loss of each international circuit between virtual switching points being 0.5 dB (0.6 dNp), a chain of n international circuits will have a nominal transmission loss in transit of n times 0.5 dB (0.6 dNp) in each direction of transmission.

On a chain of circuits, the international transmission reference point of the first of these circuits is chosen as the reference point for the chain. The actual relative levels on the second and subsequent circuits may well differ from the designated nominal relative level for each circuit; it is not necessary to consider these actual relative levels for design and maintenance purposes.

Where a carrier system is concerned, the relative level given for high-frequency points is that for one telephone circuit set up on one channel of the carrier system, all other channels being excluded, that is to say, supposing all other channels of the system to be inactive.

SUPPLEMENT No. 2.4

MEASUREMENT OF CROSSTALK

Crosstalk between different telephone circuits is caused chiefly by capacitive couplings between symmetric pairs and it may be assumed that the crosstalk attenuation diminishes by 6 dB per octave as the frequency increases.

The simplicity of this relationship affords the opportunity of characterizing the intelligible crosstalk attenuation by measurements made at a single frequency.

It can be shown that the result obtained when the attenuation of a crosstalk path is measured at 1100 Hz has approximately the same numerical value as that obtained when measuring the crosstalk from a source of uniformly distributed random noise, weighted to correspond to the conventional telephone signal, using a psophometer as the measuring instrument.

If desired the crosstalk attenuation can be measured at 800 Hz or 1000 Hz in which case the measured value will be 3 dB (for 800 Hz) or 1 dB (for 1000 Hz) lower than the effective intelligible crosstalk attenuation, i.e. if 70 dB is required then 73 dB must be obtained at 800 Hz (or 71 dB at 1000 Hz).

The following alternative methods of measurement are available:

1. Measurement of the crosstalk at a single frequency, generally the reference frequency 800 Hz or 1000 Hz.

2. Measurements of the crosstalk at several frequencies, for example 500, 1000, 2000 Hz. The results of such measurements could be averaged on either a voltage or a current basis.

3. Measurements made using a uniform spectrum random noise or closely spaced harmonic series shaped in accordance with a speech power density curve (*Blue Book*, Volume III, Recommendation G.227, Figure 26). The measurements will be made in this case by means of a psophometer.

4. Voice/ear tests, in which speech is used as the disturbing source and the crosstalk is measured by listening and comparing the received level with a reference source the level of which can be adjusted by some form of calibrating network.

The basic testing arrangement for all methods is shown in Figure 1. The disturbing signal is applied to the disturbing channel, at a level which generally should not exceed 0 dBm0 (1 mW at a zero relative level point), and the crosstalk level on the disturbed channel is then measured. Near-end crosstalk is measured at the end of the disturbed channel nearest to the source of the disturbing signal (i.e. in Figure 1 near-end crosstalk would be that measured by M1). Far-end crosstalk is measured at the end of the disturbed channel remote from the source of the disturbance (i.e. in Figure 1 far-end crosstalk would be that measured by M2).

The disturbing and disturbed channels may comprise the two directions of transmission of the same four-wire circuit in which case it is the near-end crosstalk (go-to-return crosstalk) which we require to measure. When the disturbing and disturbed channels are in different circuits the crosstalk is known as the between-circuit crosstalk. If the two channels are for opposite directions of transmission near-end crosstalk is important whereas when the channels are for the same direction of transmission it is the far-end crosstalk which must be considered.

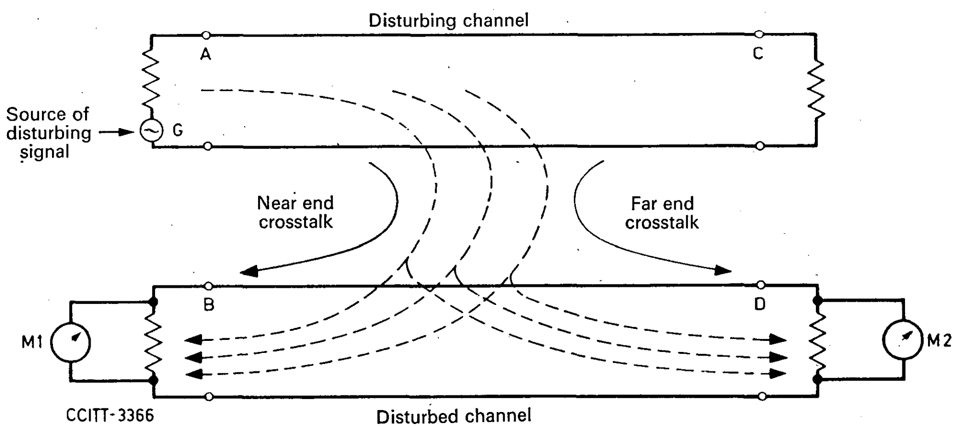


FIGURE 1

The near-end or far-end crosstalk measured may be expressed in one of two ways as follows:

Crosstalk attenuation—This is the ratio expressed in transmission units of the power delivered by a source (G in Figure 1) to a disturbing channel to the power received at the point of measurement on the disturbed channel, both channels being correctly terminated at both ends. Measurements of crosstalk attenuation are mainly used for direct measurement of crosstalk between cable pairs.

Signal/crosstalk ratio—It is generally more meaningful, when dealing with complete transmission systems, to express crosstalk in terms of a signal/crosstalk ratio and values specified by the C.C.I.T.T. are usually in terms of signal/crosstalk ratio. The signal/crosstalk ratio is the ratio, expressed in transmission units of the power level of the useful signal in the disturbed channel to the power level of the crosstalk signal in the disturbed channel, the disturbing and disturbed channels being energized so that at the point considered the wanted signal on each channel is at the same value as the nominal relative level for each of them at that point.

Relationship between crosstalk attenuation and signal/crosstalk ratio—Let:

i) crosstalk attenuation between two points be . . . . x dB

ii) nominal relative level of point on disturbed circuit at which the crosstalk is measured . . . . $+ y$ dBr

iii) nominal relative level of point at which disturbing signal is injected . $+ z$ dBr

Signal/crosstalk ratio $= x - (z + y)$ dB.

Crosstalk in exchanges—Generally, crosstalk measurements over various paths in telephone exchanges will be made using the single-frequency test (method 1 above) but when necessary the three-frequency test (method 2 above) can be used for greater accuracy.

Crosstalk on an international circuit or chain of international circuits—Measurement of crosstalk on complete circuits or chains of circuits (i.e. connections) should generally be made using method 3 above and the results expressed as a signal/crosstalk ratio. In the case of telephone circuits used for voice-frequency telegraphy the near-end signal/crosstalk ratio between the two directions of transmission should be measured at each telegraph channel carrier frequency, i.e. odd multiples of 60 Hz from 420 Hz to 3180 Hz inclusive. On long circuits or chains of circuits, difficulties may arise when making crosstalk measurements at single frequencies, owing to small variations in the frequency of master oscillators supplying translating equipment at various points along the circuit or chain of circuits.

Summary of some recommended crosstalk limits

A. *International exchanges*—(Recommendation G.142, B, *Blue Book*, Volume III)

i) Between different connections— $\nless$ 70 dB (80 dNp) (a connection is defined for this purpose as the pair of wires corresponding to one direction of transmission and connecting the input point of one circuit incoming to the exchange and the output of a different circuit outgoing from the exchange).

ii) When the connections (defined above) constitute the go-and-return channels of a chain of four-wire circuits the signal/crosstalk ratio should be $\nless$ 60 dB (69 dNp).

B. *International circuits*—(Recommendation G.151, D, *White Book* Volume III)

i) Between any two complete circuits in the terminal service position, the near-end or far-end signal/crosstalk ratio should be— $\nless$58 dB (67 dNp).

ii) The near-end crosstalk between go-and-return channels of the same four-wire telephone circuit.

a)	Ordinary telephone circuit	$\nless$43 dB (50 dNp)
b)	Circuits with a speech concentrator	$\nless$58 dB (67 dNp)
c)	Circuits with modern echo suppressors	$\nless$55 dB (63 dNp) (preferably $\nless$60 dB, 69 dNp)

SUPPLEMENT No. 2.5

MEASURING ERRORS AND DIFFERENCES DUE TO IMPEDANCE INACCURACIES OF INSTRUMENTS AND APPARATUS. USE OF DECOUPLED MEASURING POINTS

(Text supplied by the United Kingdom Post Office)

Accuracy of the impedances of transmission equipment and measuring apparatus

In order to ensure that errors in lining-up due to impedance errors are not excessive it is desirable that the return loss of measuring equipment (meters and oscillators) be at least 30 dB versus the nominal design resistance and the corresponding return loss of the transmission apparatus should be at least 20 dB.

The considerations leading to this limit are given below in which, for ease of computation, the nominal reference resistance is taken as 1 ohm and the nominal reference voltage as 1 volt:

Let the various impedances be designated as follows:

M = impedance of the meter used in the station.

S = impedance of the sending oscillator used at the station.

G = impedance of the equivalent generator representing the output of a receiving equipment. That is, the output impedance of the " left-hand " circuit.

T = impedance of the load presented by the input of a transmitting equipment. That is the input impedance of the " right-hand " circuit.

In order to estimate the error that might be introduced by departures from nominal of the various impedances involved consider the various steps successively taken when two circuits are independently measured and then connected together.

These steps are illustrated in Figure 1, from which it will be seen that there will, in general, be a change of voltage across T, the input impedance of the right-hand circuit.

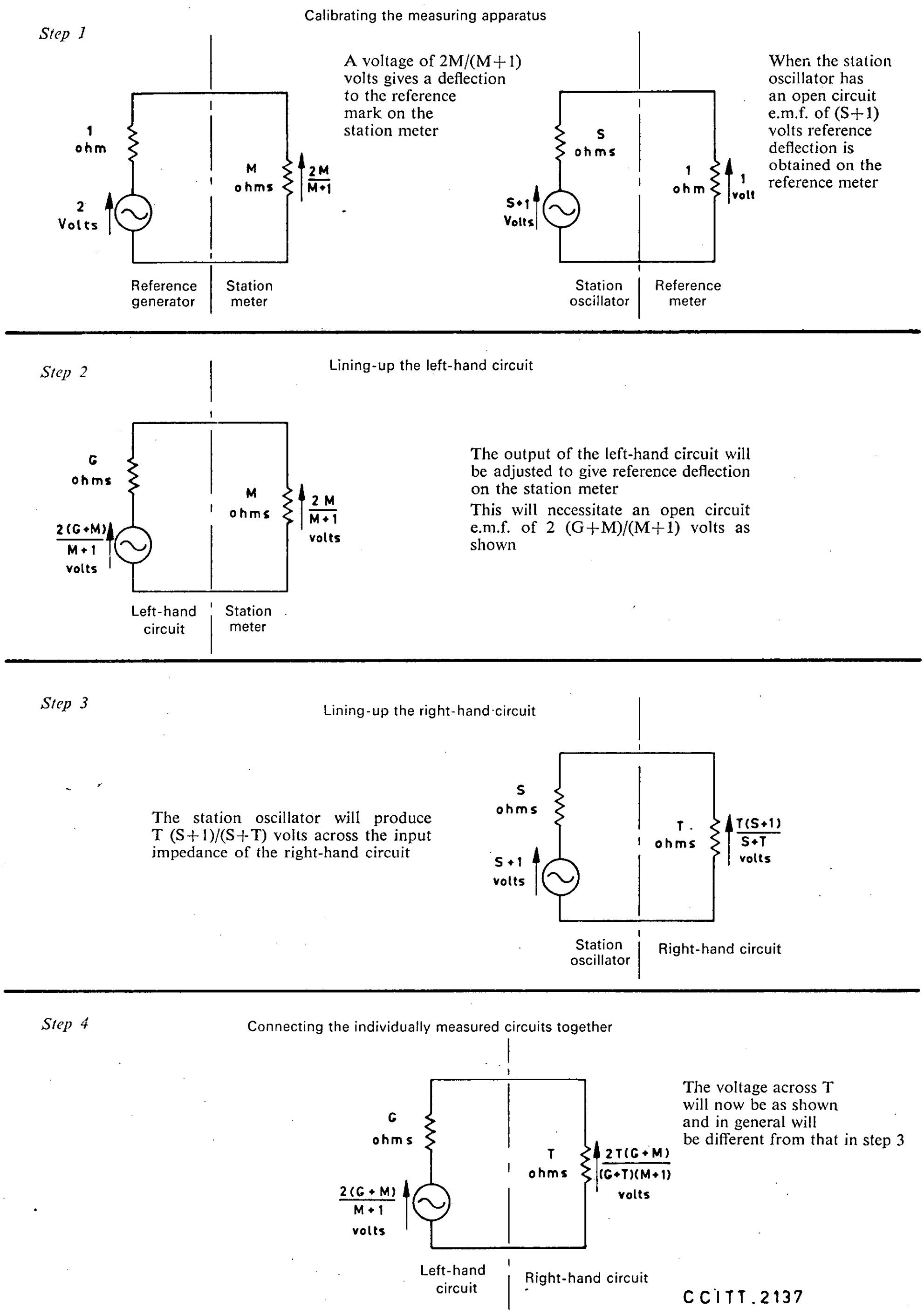


FIGURE 1. — **Successive steps in lining-up two circuits showing how errors can be introduced**

The ' reference generator ' and ' reference meter ' may be considered to be sub-standard instruments used to calibrate the normal day-to-day instruments, which latter are referred to as " station generator " and " station oscillator " in Figure 1.

The ratio of the two voltages established in steps 3 and 4 of Figure 1 is the voltage gain error ratio. Thus voltage gain error ratio = (voltage across T in step 4) $\div$ (voltage across T in step 3) so that positive error =

$$20 \log_{10} | 2(G + M)(S + T) \div (G + T)(M + 1)(S + 1) | \text{ dB} \tag{1}$$

This may be more conveniently re-expressed in terms of the reflection coefficients of G, M, S and T versus 1 ohm. Introducing the following notation, which uses lower-case letters to denote reflection coefficients:

$$\begin{aligned} g &= (G - 1)/(G + 1); \\ s &= (S - 1)/(S + 1); \\ m &= (M - 1)/(M + 1); \\ t &= (T - 1)/(T + 1); \end{aligned}$$

and substituting these into equation (1) leads to:

$$\text{Error} = 20 \log_{10} \left| (1 - gm)(1 - st) \div (1 - gt) \right| \text{ dB}$$

The reflection coefficients are complex quantities, since M, T, S and G are in general complex, so that the modulus of the error factor can assume a range of values. In order to evaluate the maximum possible values we assume an adverse (though probably unlikely) combination of phase angles such that the numerator is a maximum and the denominator is a minimum (or vice versa). This leads to:

maximum possible positive error:

$$20 \log_{10} \left| (1 + |g| \cdot |m|)(1 + |s| \cdot |t|) \div (1 - |g| \cdot |t|) \right| \text{ dB}$$

and maximum possible negative error:

$$20 \log_{10} \left| (1 + |g| \cdot |t|) \div (1 - |g| \cdot |m|)(1 - |s| \cdot |t|) \right| \text{ dB}$$

These quantities have been evaluated for a variety of values of the moduli of the reflection factors and the absolute maximum values (that is, the greater of the two) expressed as a function of return loss, as shown in Figure 2.

It will be seen that if the return loss of transmission apparatus (both sending and receiving) is 20 dB and the return loss of measuring instruments is 30 dB (which seem to be a pair of reasonably achievable targets) the maximum possible error is 0.14 dB. In practice one could reasonably expect the errors to be considerably less than this.

Difference between terminated level and through level transmission measurements

When the impedance of measuring instruments and transmission apparatus is other than the nominal value, differences will occur between terminated-level and through-level transmission measurements.

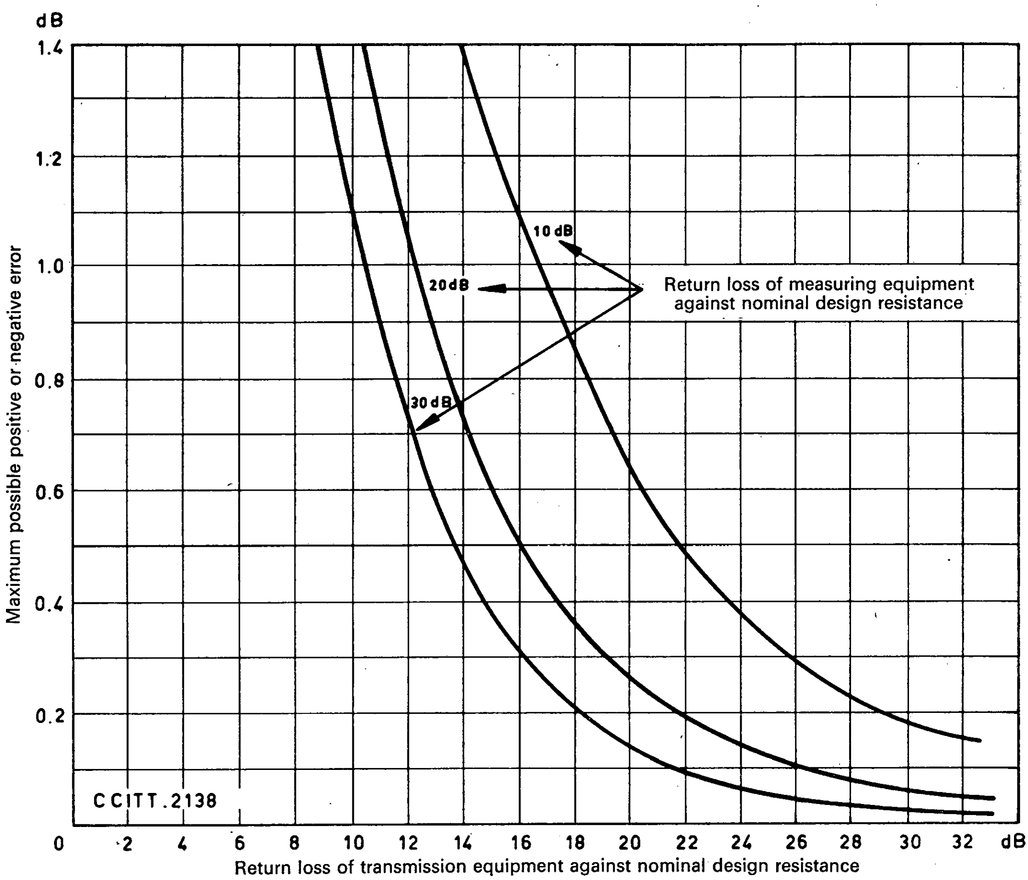


FIGURE 2. — **Errors due to impedance mismatches in measuring instruments and transmission apparatus**

In this section a method of calculating the maximum difference between terminated-level and through-level measurements is presented. A curve has been constructed showing this maximum difference as a function of the return loss (versus nominal design resistance) of the transmission apparatus and measuring instruments.

Method of calculating maximum difference

Figure 3 a shows the conditions when a terminated-level measurement is being made and Figure 3 b shows the conditions for through-level measurements. Impedances are designated as in the previous section.

With reference to Figure 3, assuming that the meter continues to give an accurate indication of the voltage at its terminals regardless of whether the internal impedance is in or out of circuit, then the maximum voltage difference ratio, that is the ratio of the terminated-level to the through-level will be:

Voltage difference ratio =

(voltage across T) $\div$ (voltage across M)

$$= T(G + M) / M (G + T) \tag{2}$$

As before set $t = (T-1)/(T+1)$, $g = (G-1)/(G+1)$, and $m = (M-1)/(M+1)$

Substituting these values into equation (2) leads to:

Voltage difference ratio =

$$\frac{(1+t)}{(1+m)} \frac{(mg-1)}{(tg-1)} \tag{3}$$

Maximizing this expression by selecting the most adverse combination of phase angles leads to the following expressions for the maximum voltage difference ratios:

Positive difference ratio =

$$(1+|m|)\,(1+|t|\cdot|g|) \div (1-|t|)\,(1-|m|\cdot|g|) \tag{4}$$

Negative difference ratio =

$$(1+|t|)\,(1+|m|\cdot|g|) \div (1-|m|)\,(1-|t|\cdot|g|) \tag{5}$$

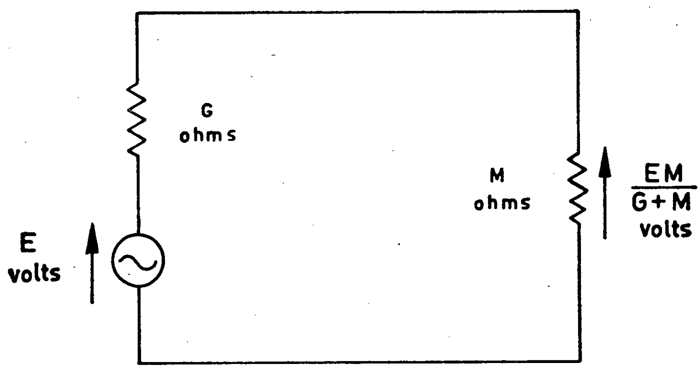


FIGURE 3 a. — **Terminated-level measurement**

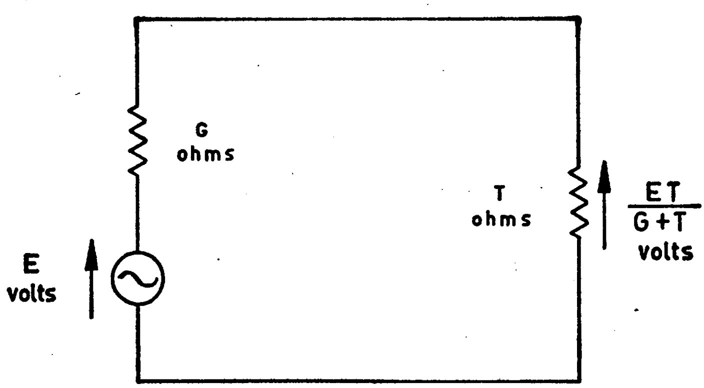


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FIGURE 3 b. — **Through-level measurement**

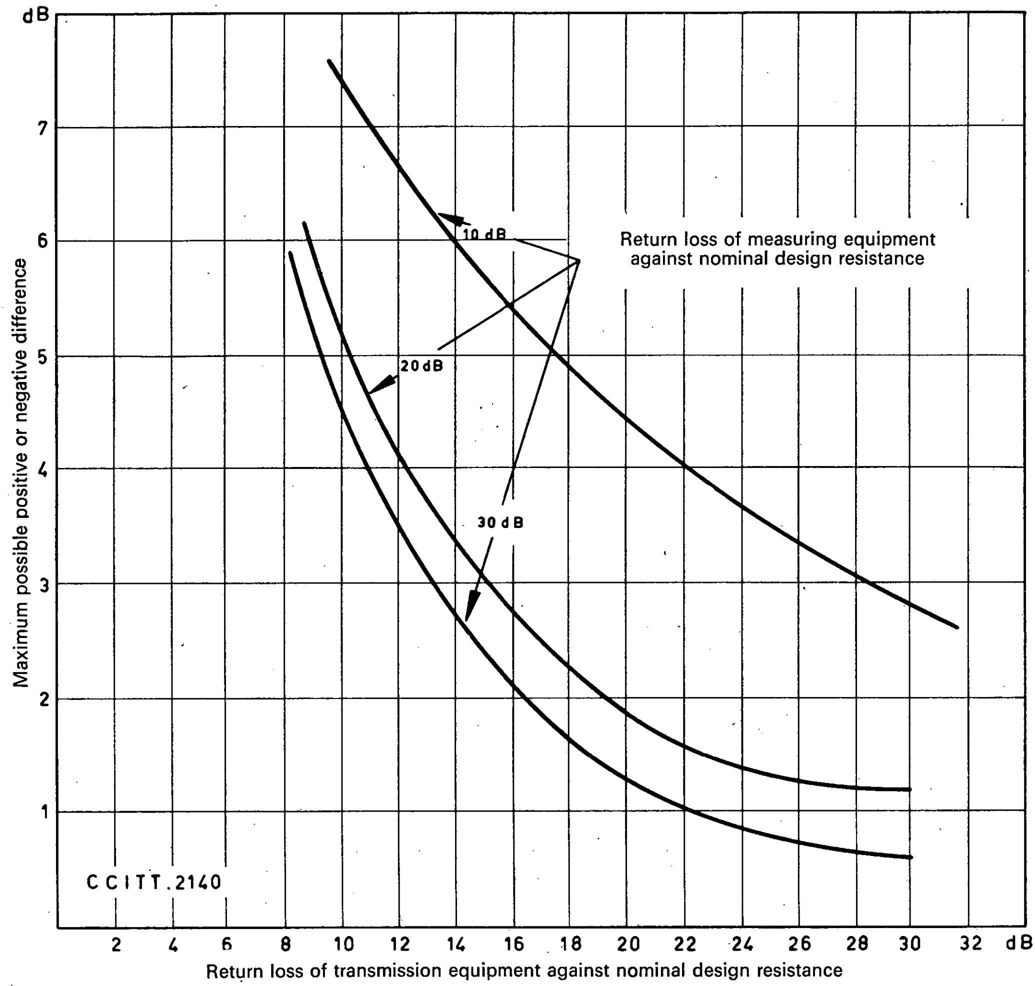


FIGURE 4. — **Difference between through-level and terminated level measurements due to impedance mismatches in measuring instruments and transmission apparatus**

The expression giving the greatest absolute difference has been used to plot the curves in Figure 4 which thus shows the maximum possible difference between through-level and terminated-level measurements as a function of return loss (versus the nominal design resistance) of the measuring equipment and the transmission equipment. As can be seen, large differences can occur but they should not be regarded as errors although they may become a source of error if, for example, transmission equipment is readjusted in a vain attempt to " correct " the difference.

Use of decoupled measuring points

There are, in principle, two ways in which a decoupled test-point can be provided with passive components (i.e. ignoring the use of buffer amplifiers):

— test hybrids, either transformer or resistive;

— tapping resistors.

It is useful to distinguish between *test hybrids* which are here taken to be arrangements which effectively decouple the transmission path and the measuring path from each other and *tapping resistors* which are here taken to be arrangements which only decouple the measuring point from the transmission path but not vice versa. Collectively these two methods are here referred to as *decoupled measuring points*. It is recommended that these distinctions be preserved.

In order to minimize the effect of incorrect operation of measuring apparatus on transmission systems it is considered desirable that measuring points should be effectively decoupled from the transmission path. In this way short circuits or open circuits at the measuring point need have only negligible repercussions on the transmission path. A typical limit would be that short-circuiting an otherwise open-circuit test point should not cause a change in level in the main path of more than 0.1 dB (0.1 dNp).

Another advantage of the test-hybrid type of decoupled measuring point is that the two sets of measurements (through-level and terminated level) recommended to be made for some lining-up procedures, for example, Recommendation M.46, can be replaced by another, single set of measurements with a consequent saving of time and effort.

The use of decoupled measuring points is generally confined to groups, supergroups and higher assemblies where misoperation can effect large bandwidths.

Test hybrids

When a test hybrid is used, the transmission path and the measuring path are mutually decoupled one from the other so that, in particular, measurements at the test point give no guarantee that the indicated level is in fact that which is being transmitted on the main path. When the test hybrid is symmetrical an opportunity is afforded of being able to use the double output to establish an alternative path or route with patching cords, with no interference to the signals on the main path or route.

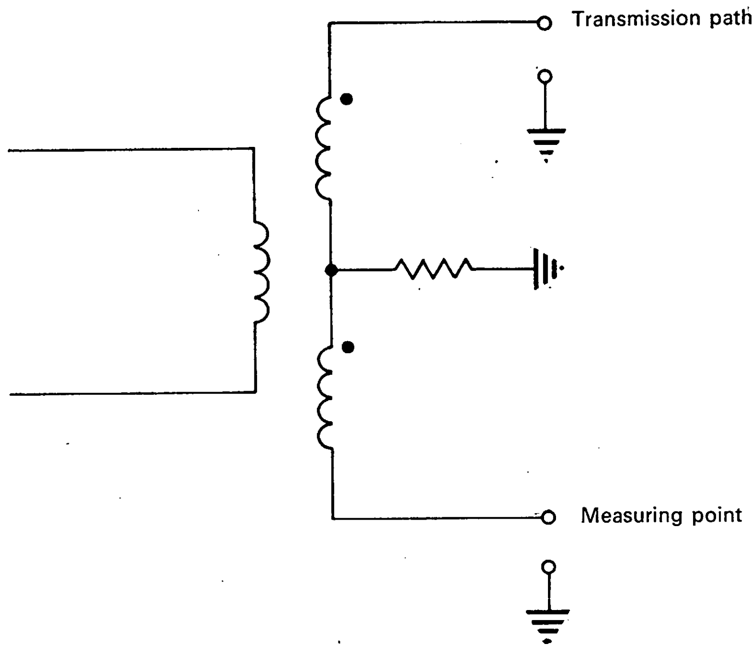
Some countries have found it convenient to use the test hybrid arrangement for injecting test signals, e.g. intersupergroup test signals. There is, however, a risk that unwanted and interfering test signals will be inadvertently connected to the transmission path.

Symmetrical transformer type test hybrids introduce a nominal 3-dB loss in the transmission path which has to be made up in some way if standard levels at distribution frames are to be preserved. Alternatively the standard level can be changed.

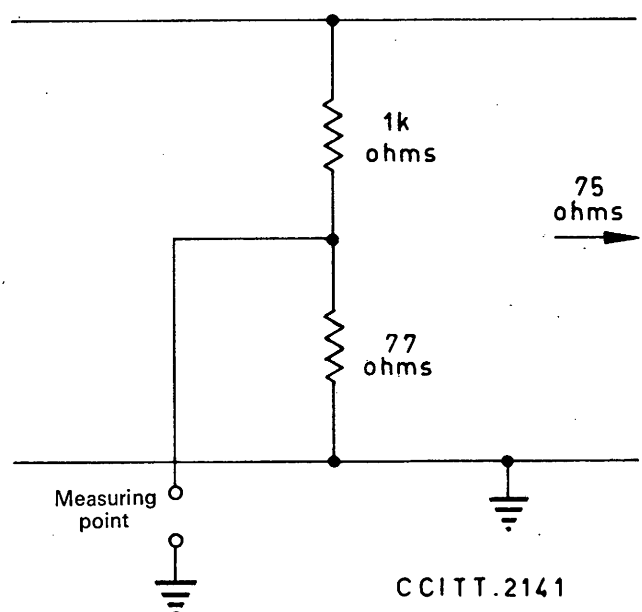
Assymetrical test hybrids can be arranged to introduce less loss in the transmission path but the facility of using the double output in patching procedures is forfeited, and furthermore the level of the signal available at the measuring point is reduced.

Tapping resistors

The measuring point is decoupled from the transmission path but not vice versa so that a change in the impedance closing the transmission path will be detected at the measur-



Test hybrid transformer which decouples the measuring point from the transmission path and vice versa



Tapping resistors which decouple the measuring point from the transmission path but not vice versa

FIGURE 5. — **Examples of decoupled measuring points**

ing point. Hence this method can in principle be arranged to afford measurements which are a true indication of the power in the transmission path but it necessarily follows that there could be a difference between in-station tests (when equipment is terminated with nominal impedances) and in-service tests (when equipment is connected into the circuit).

A typical arrangement is shown in Figure 5. The return loss (versus 75 ohms in the example shown) of the impedance presented by the measuring point would need to be specified.

Tapping resistors are physically small and the arrangement introduces negligible loss in the transmission path. The level of the signal available for measuring is reduced. There is no opportunity of using the measuring point in patching procedures.

SUPPLEMENT No. 2.6

ERRORS IN THE INDICATIONS GIVEN BY LEVEL-MEASURING INSTRUMENTS DUE TO INTERFERING SIGNALS

In general, when the level of a signal is being measured in the presence of an interfering signal a reading error will be produced by the interfering signal and the magnitude of the error will depend upon the waveform of the signals and the type of detector within the measuring instrument.

Types of instruments

Detector-indicator instrument circuits may be classified according to which parameter of the signal waveshape is indicated:

a) *Peak value*—These are instruments, often with full-wave rectification, with a short charge time-constant and a long discharge time-constant. Most practical instruments should properly be referred to as quasi-peak indicating instruments.

b) *Root-mean-squared value*—These are instruments incorporating non-linear elements of overall square-law characteristic, such as thermal detectors. Some instruments indicate r.m.s. values only for input signals with sinusoidal waveforms, the indication for complex waveforms being inaccurate. Only true r.m.s. instruments are dealt with here.

c) *Mean full-wave linear rectified value*—These are instruments which normally incorporate rectifier circuits. For a rectifier the change from non-conducting to conducting, and vice versa, occurs at the instant at which the applied wave-form passes through zero, so that a complete half-wave is transferred from source to load and the mean-value arises from the integration of the half-wave. A rectifier bridge circuit is normally employed so that the instrument records the mean full-wave linear rectified value.

Reading errors

The reading errors produced by sinusoidal interfering signals of various levels relative to the wanted sinusoidal signal are shown in Figure 1.

Curve 1 a gives the maximum possible error of any instrument assuming that the two signals are of the same frequency and are exactly in-phase. It also gives the maximum possible error of a (true) peak reading instrument providing that the two signals are not harmonically (or sub-harmonically) related.

Curve 1 b gives the corresponding maximum possible error when the two signals are exactly in anti-phase. In this case the error is negative—i.e. the level of the compound signal is less than the level of the wanted signal.

Curve 2 gives the mean error of a true r.m.s. reading instrument for any two signals of different frequency.

Curve 3 gives the maximum error of a mean linear-rectified indicating instrument for any two signals the frequencies of which are neither identical nor harmonically (or sub-harmonically) related.

Harmonically related signals

1) *Peak reading instrument*—Curve 1 a indicates the error caused by an interfering sinusoidal signal harmonically (or sub-harmonically) related to the wanted signal when the relative displacement is such as to produce the largest possible peak value, i.e. a peak value equal to the sum of the individual peak values of the component sinusoidal signals.

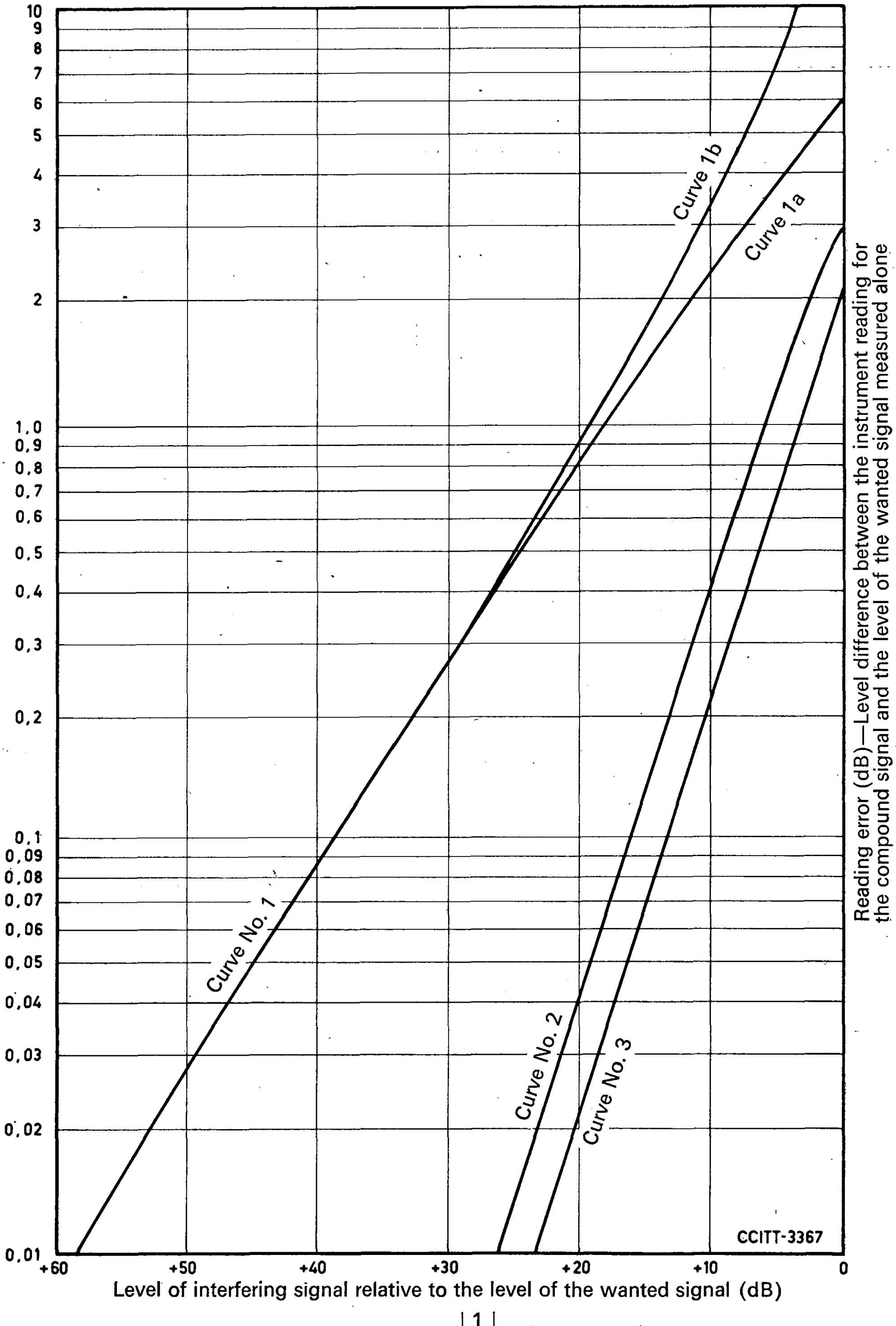
2) *True r.m.s. reading instrument*—Curve 2 indicates the error caused by an interfering sinusoidal signal harmonically (or sub-harmonically) related to the wanted signal.

3) *Mean linear-rectified reading instrument*

a) Odd harmonics (or sub-harmonics)—The maximum possible errors for any odd harmonic (or sub-harmonic) interfering signals may be plotted using the equation $20 \log_{10} (1 \pm \frac{a}{n})$ dB, where n is the odd harmonic (or sub-harmonic) order. Odd harmonics (or sub-harmonics) can cause positive or negative errors and the appropriate sign in the expression should be used. Such curves indicate the maximum possible error which occurs when the maxima of the wanted signal and interfering signal coincide.

b) Even harmonics (or sub-harmonics)—Curve 2 indicates the maximum possible error occurring when the maxima of the wanted signal and interfering signal coincide.

Even harmonics (or sub-harmonics) give rise to only positive errors.



$(20 \log_{10} \left| \frac{1}{a} \right| \text{dB})$

FIGURE 1. — **Reading errors produced by interfering signals**

SUPPLEMENT No. 2.7

MEASUREMENT OF GROUP DELAY AND GROUP DELAY DISTORTION

In a transmission system with a phase characteristic $B(\omega)$ the group delay at a particular angular frequency ω_0 in the passband of the system is given by the slope of the phase characteristic at that angular frequency, that is

$$\tau_g(\omega_0) = \left.\frac{dB}{d\omega}\right|_{\omega = \omega_0}$$

In general, this quantity is not the same as the phase delay which is given by

$$\tau_p(\omega_0) = \frac{B(\omega_0)}{\omega_0}$$

In physically realizable telecommunication systems energy or information cannot be transported with delays less than τ_g and in such systems $\tau_g \geqslant \tau_p$. These quantities are illustrated in Figure 1.

The group delay τ_g cannot be less than zero in such systems. It follows that the phase characteristic cannot have a negative slope. Furthermore, if the minimum group delay is finite and non-zero, the phase characteristic of such a system cannot have a zero slope—i.e. there can be no turning points on the $B(\omega)$ curve [1].

Nyquist method of measuring group delay

If a carrier signal of angular frequency c is amplitude-modulated with a modulating signal of angular frequency p and $p \ll c$, the phase shift suffered by the envelope of the transmitted signal is a direct measure of the differential phase change at c and thus provides a means of measuring the group delay at c.

In particular, if the input signal to a transmission system with a phase characteristic $B(\omega)$ and with a uniform gain characteristic in the neighbourhood of c is a modulated

[1] It is possible to construct four-terminal networks having a steady-state insertion phase characteristic with negative slopes and turning points (see for example Signalbeschleunigung durch negative Gruppen- und Phasenlaufzeit — J. Wobst; *Nachrichtentechnik* — 14 (1964) Volume 6).

Nevertheless in real time even such networks cannot deliver a signal at the output in advance of it being applied to the input so that there is no violation of the law of cause and effect.

Fortunately telecommunication circuits which span physical distances do not in general display such subtleties and the restricted statements made in the text above are applicable to such systems.

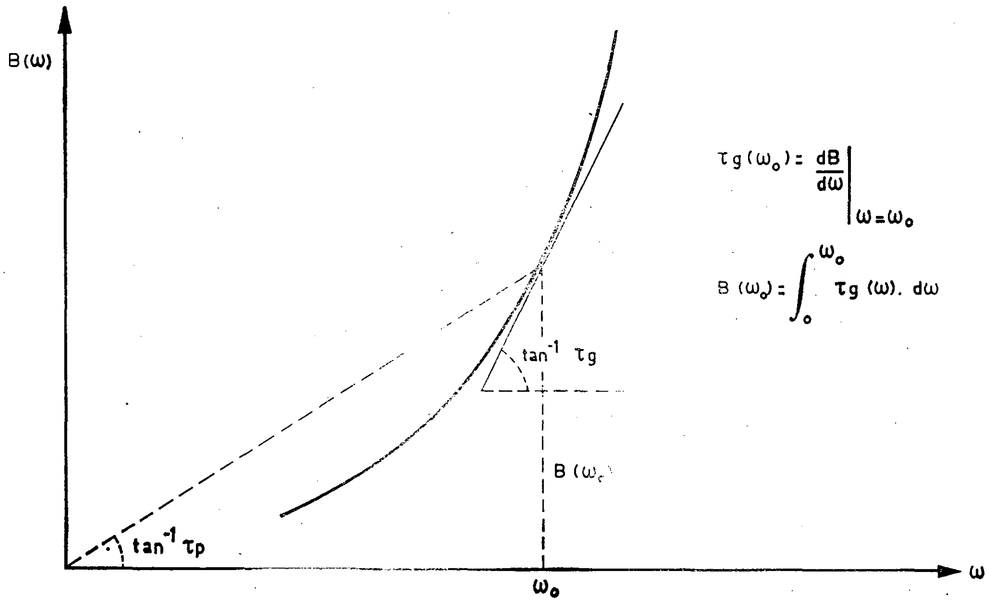


FIGURE 1

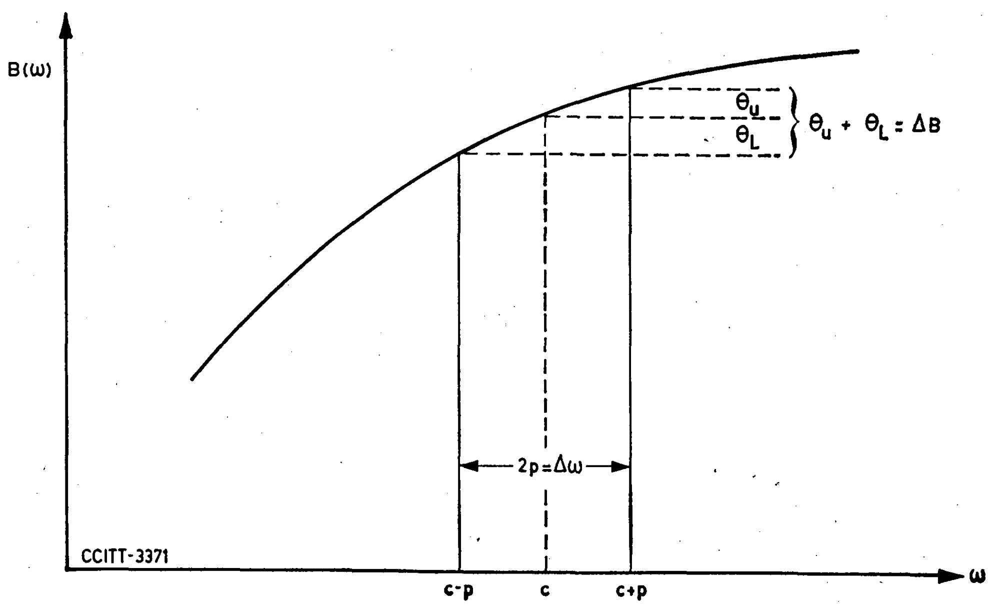


FIGURE 2

carrier signal $(1 + m \sin pt) \sin ct$, it may be shown that the modulating signal, after it has been recovered by square law detection at the receiver, is of the form $k \sin (pt + \phi)$

where
$$\tan \phi = \frac{\sin \theta_U + \sin \theta_L}{\cos \theta_U + \cos \theta_L}$$

in which θ_U and θ_L are the phases of the received upper and lower side-frequencies relative to the phase of the received carrier as shown in Figure 2.

The expression for $\tan \phi$ can be rearranged as:

$$\tan \phi = \tan \left(\frac{\theta_U + \theta_L}{2}\right)$$

Whence
$$\phi = \frac{\theta_U + \theta_L}{2} \quad \text{(ignoring the } n\pi \text{ ambiguity)}$$

But as is apparent from Figure 2

$$\frac{\theta_U + \theta_L}{2} = \frac{\Delta B}{2}$$

Hence, if the phase shift can be measured and the modulating angular frequency p is known, then since

$$\frac{\phi}{p} = \frac{\Delta B}{2p} = \left.\frac{\Delta B}{\Delta \omega}\right|_{\text{around } c} \approx \left.\frac{\mathrm{dB}}{d\omega}\right|_{\omega = c}$$

a direct measure of the group delay is obtained.

The foregoing description is in terms of an amplitude-modulated carrier signal. Frequency modulation can also be used. There is, however, no noise advantage because the modulation index must be small (for example, 0.2 at the lower carrier frequencies) if $\Delta\omega$ is to approximate to $d\omega$ in this case. There are, therefore, only two principal side-frequencies and the line signal is very similar to that produced by amplitude modulation.

Range of delay measurement

The maximum range of group delay that can be measured with certainty is dependent on the periodic time of the modulating frequency, e.g. for a modulating frequency of 25 Hz the unambiguous range is $\frac{1}{25}$ second $= 40$ ms. In instruments in which a harmonic of the modulating frequency is selected before phase detection the range is proportionally reduced.

Relative group delay

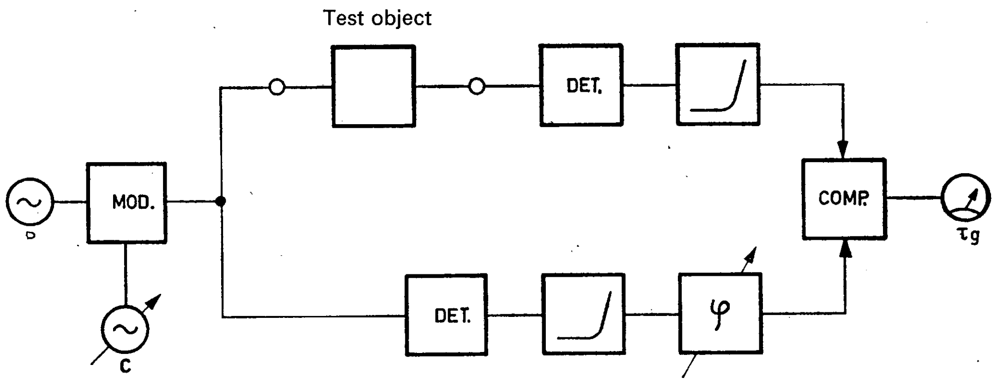
Although group delay is an absolute quantity, in most practical methods of measurement based on the Nyquist principle, it is only possible to measure the group delay at a particular frequency relative to that at another.

This restriction does not give rise to any difficulty in measuring group delay distortion but leads to measurements being referred to a reference frequency and since this may not be the frequency of minimum group delay, negative values are possible.

Principles of measuring instruments

Measuring instruments are usually arranged according to one of the following schemes:

1) Input and output of the test object both available to the tester (e.g. a filter)

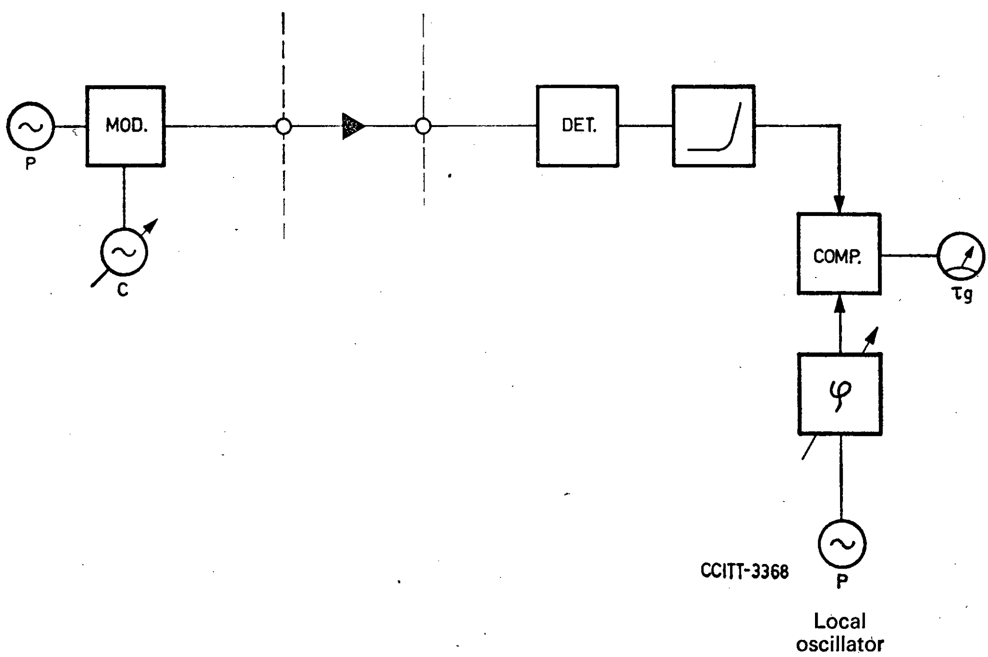


P is the modulating oscillator
C is the carrier oscillator
φ is a variable phase network adjusted so that the indicated delay is zero at the reference carrier frequency

2) Input and output not available at the same place (e.g. a telephone circuit)

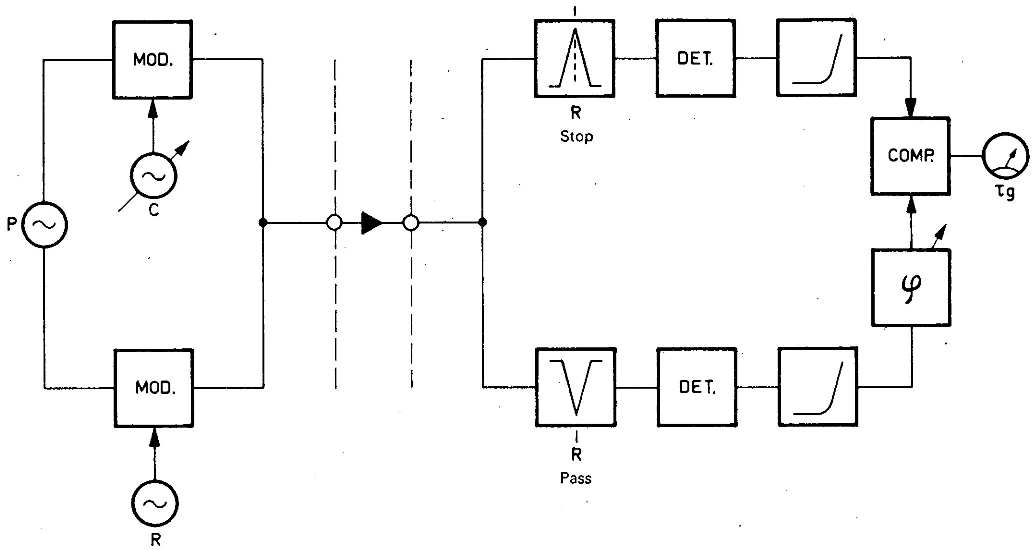
a) only one direction of transmission available

i) two modulating oscillators



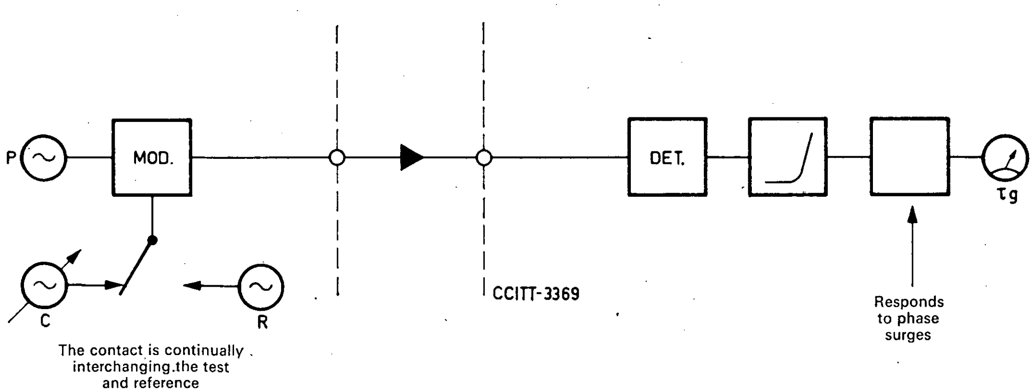
The stability of the local oscillator with respect to the sending modulating oscillator over the period of measurement is important

ii) one modulating oscillator



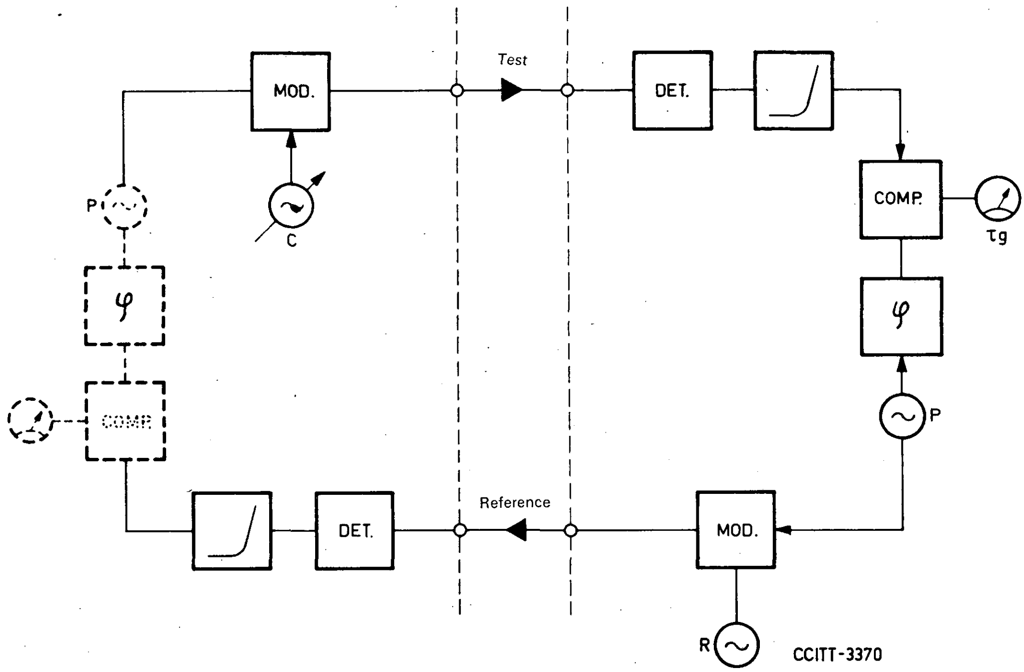
R is the reference carrier oscillator

Frequency-division system



Time-division system

b) both directions of transmission available



The two directions of transmission form a loop so the modulating oscillator and comparator may also be at the sending end as shown dotted

All the methods illustrated above suggest that the phase difference between the modulating signal recovered from the carrier frequency and the reference frequency is measured by means of a phase-shifting network and a comparator operating directly on sinusoidal signals. In practical realizations other methods are sometimes used. For example, the zero-crossing of the two sinusoids may be detected and used to alternately control a bistable trigger, thus producing a pulse train the mean amplitude of which is proportional to the width of the pulses which, in turn, is proportional to the phase difference between the original sinusoids. A variant of this method is to measure the time interval between successive zero crossings directly by conventional digital techniques, thus obtaining a direct measure of the delay-time.

When the test and reference modulating frequencies are obtained by dividing down from a high frequency, it is possible to use a series of decade switches operating on the decade dividers to adjust the phase of the reference modulating frequency at the receiver, so that the residual phase difference between the received and reference modulating frequencies is small and may be read with high accuracy on the most sensitive range of the meter circuit.

Sources of error in group delay measurement

The following are potential sources of error some of which are avoided by particular synchronizing schemes.

Errors arise from certain characteristics of the test object and imperfections of the measuring apparatus.

Characteristics of the test object

— Gain and phase distortion;
— Non-linear distortion;
— Non-linear group delay characteristic;
— Frequency shift;
— Noise and unwanted signals.

Imperfections of the measuring apparatus

— Inaccurate phase measurement;
— Asynchronism between free-running modulating and reference oscillators;
— Inaccuracy in the absolute frequency of the modulating oscillator;
— Inaccuracy in the absolute frequency of the carrier oscillator.

These topics are discussed in the following sections.

Effect of gain and phase distortion over the band $\Delta\omega$

If the gain characteristic of the transmission system is not uniform over the band $\Delta\omega$, the two side-frequencies will have different amplitudes. In principle, this can introduce errors. Let $G(\omega)$ be the gain characteristic and let A_U and A_L be the amplitudes of the upper and lower side-frequencies relative to that at the carrier frequency, which may be assumed to be unity with no loss of generality. This is illustrated in Figure 3.

The expression given above for ϕ, the phase angle of the recovered modulating signal, now becomes a function of the amplitudes A_U and A_L and is

$$\tan \phi = \frac{A_U \sin \theta_U + A_L \sin \theta_L}{A_U \cos \theta_U + A_L \cos \theta_L}$$

a) If $\theta_U = \theta_L = \frac{\Delta B}{2}$, i.e. no phase curvature over the range $\Delta\omega$, then the expression for $\tan\phi$ degenerates to $\tan\frac{\Delta B}{2}\cdot$ That is, the measured phase angle is not a function of the gain distortion.

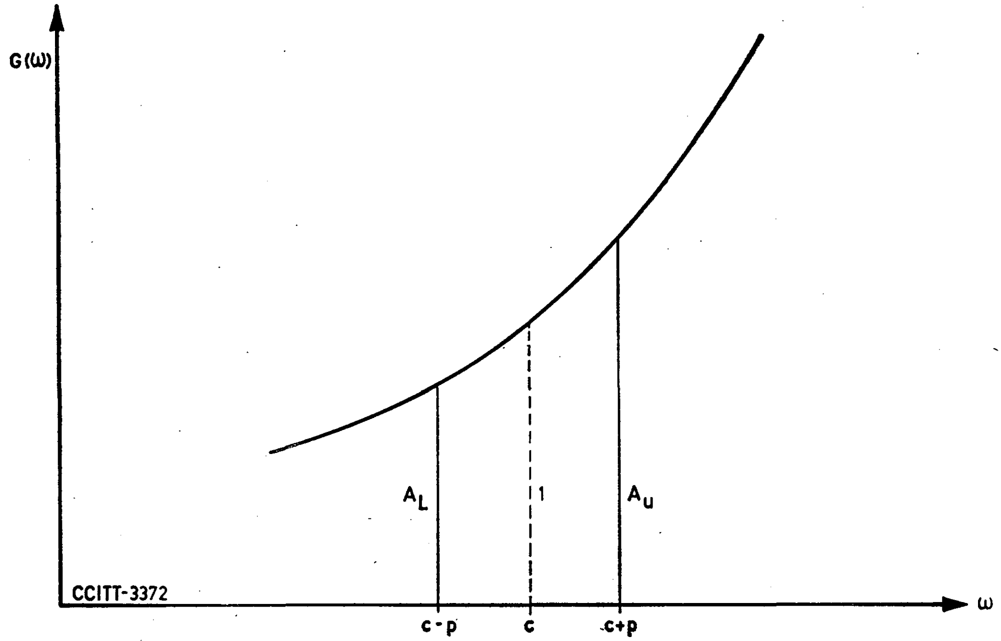


FIGURE 3

b) If there is some phase curvature, i.e. $\theta_U - \theta_L$ is small but not zero

then
$$\tan \phi = \tan \left[\frac{\Delta B}{2} - \frac{A_U - A_L}{A_U - A_L} \cdot \frac{\theta_U - \theta_L}{2} \right]$$

That is, a phase error of

$$\epsilon = - \frac{A_U - A_L}{A_U + A_L} \cdot \frac{\theta_U - \theta_L}{2} \text{ radians}$$

has been introduced (ignoring the $n\pi$ ambiguity).

Assuming only parabolic phase curvature, it may be shown that this may be rewritten as

$$\epsilon = \frac{A_U - A_L}{A_U + A_L} \cdot \frac{p^2}{2} \cdot \frac{d\tau_g}{d\omega}$$

which indicates that the measured values of group delay defining the turning points, e.g. maxima and minima of the measured group delay characteristic, are free from errors due to gain distortion.

In principle the effects of gain distortion can be avoided by the use of single sideband or double sideband suppressed carrier modulation. In the case single sideband modulation the measurement result is referred to a frequency midway between the carrier and the sideband.

Non-linear distortion

Gross non-linear distortion can give rise to errors where the test and reference modulated carrier signals are transmitted simultaneously through the test object. Interference between the two signals leads to the production of unwanted sidebands and harmonic distortion. This type of distortion may also produce measurement errors in instruments in which a harmonic of the modulating frequency is selected for phase comparison. The other methods illustrated in the previous section are free from error in the presence of non-linear distortion.

Non-linear group delay characteristic

The general case is difficult to evaluate but an important type of non-linear group delay characteristic that is often encountered is one with a quasi-sinusoidal ripple in the characteristic. Such characteristics are typical of equalized networks and also of bilateral networks with simple terminal impedance irregularities, telephone circuits, for example. An idealized example of a portion of such a characteristic is shown in Figure 4.

The cycle of variations is repeated every q radians along the ω-axis and from physical considerations τ_0, the average value of the group delay cannot be less than T, the amplitude of the sinusoidal variation.

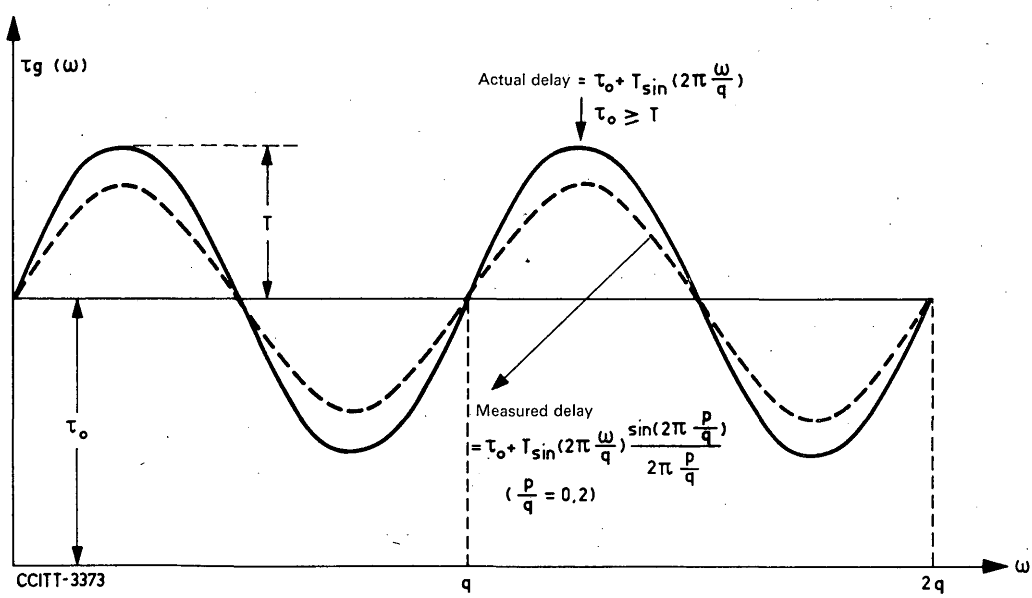


FIGURE 4. — **Sinusoidal delay characteristic illustrating error between measured and actual delay**

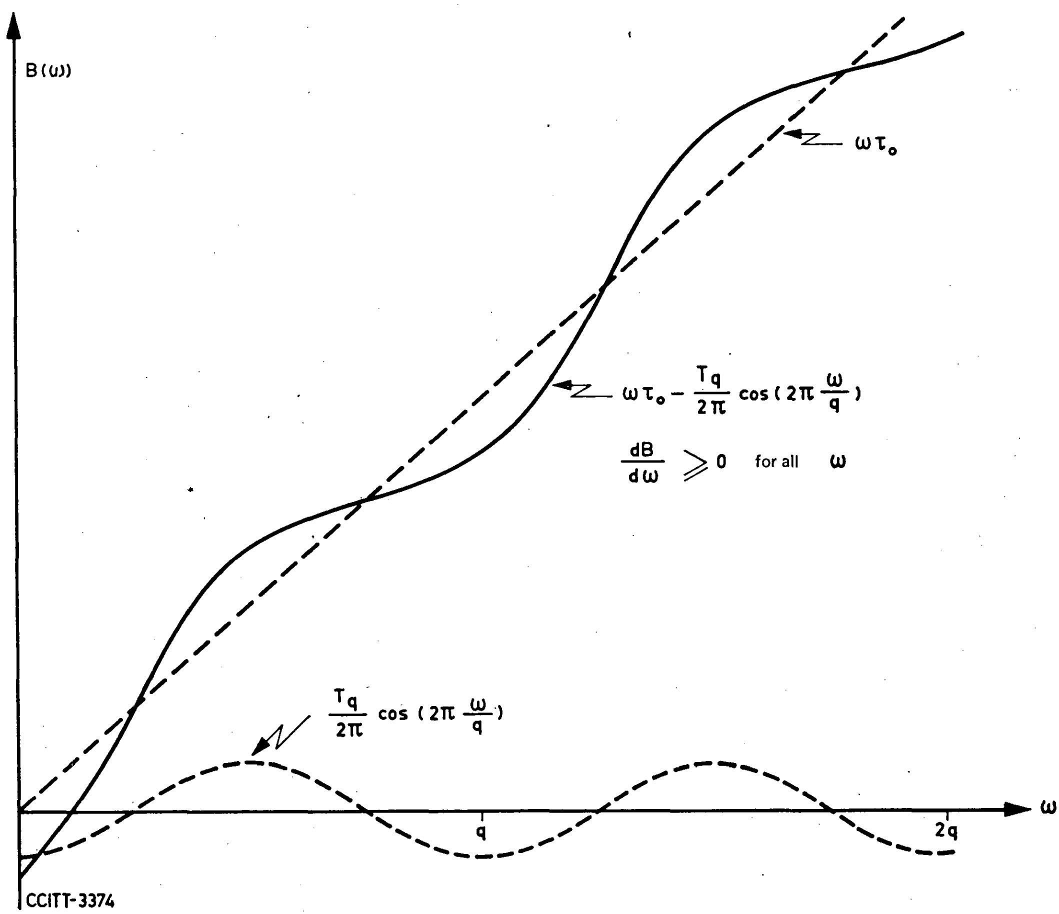


FIGURE 5. — **Phase characteristic**

A phase characteristic giving rise to such a group delay characteristic is

$$B(\omega) = \int_0^{\omega} \left[\tau_0 + T \sin\left(2\pi \frac{\omega}{q}\right)\right] d\omega$$

$$= \omega\tau_0 - \frac{Tq}{2\pi} \cos\left(2\pi \frac{\omega}{q}\right)$$

which is illustrated in Figure 5.

It can be shown that the measured delay is given by

$$\left.\frac{\Delta B}{\Delta \omega}\right|_{\text{around } c} = \tau_0 + T \sin\left(2\pi \frac{c}{q}\right) \cdot \frac{\sin x}{x}$$

in which

c = carrier angular frequency

q = ripple angular frequency

$$x = 2\pi \frac{p}{q} = 2\pi \cdot \frac{\text{modulating frequency}}{\text{ripple frequency}}$$

whereas the true delay is

$$\left.\frac{dB}{d\omega}\right|_{\omega = c} = \tau_0 + T \sin 2\pi \frac{c}{q}$$

A comparison between the measured and the true delay characteristics shows that the effect of increasing the modulating frequency is to reduce the amplitude of the measured delay ripple. Figure 4 shows the difference between the true delay (solid curve) and the measured delay (dotted curve) for a modulating frequency/ripple frequency ratio of 0.2.

The proportional error in the amplitude of the measured delay ripple is given by

$$\frac{(\text{actual amplitude}) - (\text{measured amplitude})}{\text{actual amplitude}} = 1 - \frac{\sin 2\pi \dfrac{p}{q}}{2\pi \dfrac{p}{q}}$$

Figure 6 shows the percentage error as a function of the modulating frequency/ripple frequency ratio.

Frequency shift

The principal cause of frequency shift in telecommunication networks is asynchronous carrier frequencies in frequency division multiplex systems. This has the effect of offsetting the frequency of every transmitted signal by a constant amount but the resultant demodulated output signal incurs no change of frequency, the only uncertainty in the measured result being the exact carrier frequency at which the measurement is being made. The same considerations apply to the reference signal if this is transmitted on a fixed carrier frequency.

Some error will occur if the frequency shift of a section of the test circuit varies during the measurement period and thus constrains the carrier signal and its attendant side fre-

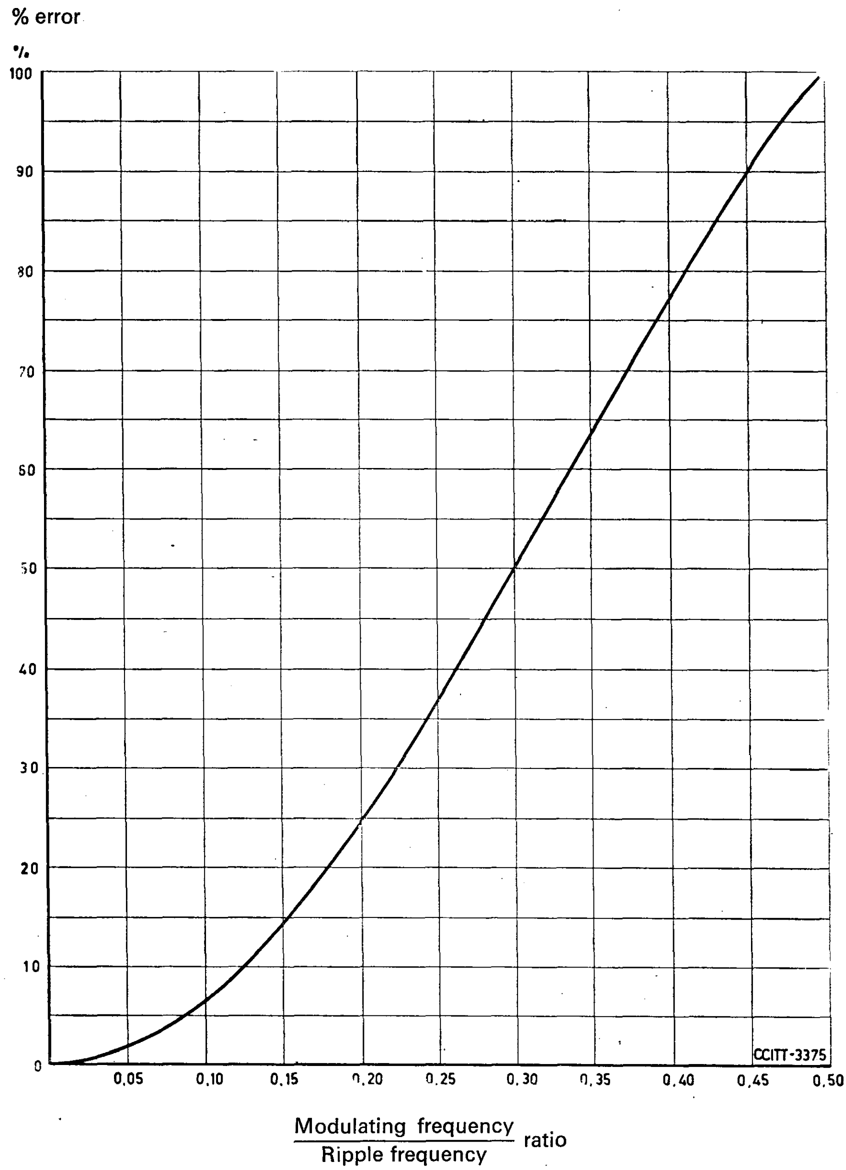


FIGURE 6. — **Percentage error in measured delay as a function of the modulating frequency/ripple frequency ratio**

quencies to excurse the group delay characteristic of successive circuit sections. This may introduce changes in the received phase of the modulating frequency and give rise to errors. A reference carrier could be subject to similar changes.

Noise and unwanted signals

a) *Noise*

In principle, instruments incorporating a phase comparator are subject to error if noise or other unwanted signals enters the comparator. Such noise can arise in the test object which might, for example, be a telephone circuit.

If the noise power is uniformly distributed, the following expression for the r.m.s. error in the measured group delay is valid for low noise powers, i.e. good signal/noise ratios.

$$\text{r.m.s. error} = \frac{1}{mp}\sqrt{\frac{\text{noise power entering phase comparator}}{\text{power of the carrier signal}}}$$

in which m and p are the modulation index and the modulating angular frequency respectively.

The noise power entering the comparator depends on the noise power arising in the test object and the effective bandwidth of the phase comparator.

Group delay measuring sets in which the output of the phase comparator is averaged over some (relatively) long period can be arranged to be almost immune against practical line noise power levels because the phase comparator is not called upon to transmit changing information so that its effective bandwidth can approach zero. If a (relatively) rapid change of phase is required to be handled (for example for a sweep display) then the phase comparator requires a finite non-zero bandwidth and the output may no longer be free from the effects of noise.

Some instruments use comparator bandwidths of the order of 0.01 to 0.1 times the modulating frequency, e.g. 0.4 to 4 Hz for a 40-Hz modulating frequency.

Example of the use of the noise error formula

Consider a telephone-type circuit (300 to 3400 Hz) with a psophometric noise power level of -50 dBm0p. The carrier level is arranged to be -10 dBm0, the modulation index is 0.4, the modulating frequency 40 Hz and the effective comparator bandwidth 4 Hz. The band-limited, uniformly-distributed noise power level corresponding to -50 dBm0p is $-50 + 2.5 = -47.5$ dBm0 and the effective bandwidth of this noise power level is $3400 - 300 = 3100$ Hz. Hence the noise power level in the 4-Hz bandwidth of the phase comparator is reduced to $-47.5 - 10 \log (3100/4) = -47.5 - 28.9 = -76.4$ dBm0.

The power level of the carrier signal being -10 dBm0 the decibel-expression of the quantity under the root sign is $-76.4 - (-10) = -66.4$ dB, corresponding to a power ratio of $(1/2089)^2$.

Hence

$$\text{r.m.s. error} = \frac{1}{0.4\ 2\pi 40} \cdot \frac{1}{2089} \text{ second} = 4.76\ \mu\text{s}$$

i.e. about 5 μs r.m.s. error.

Figure 7 indicates the r.m.s. error in group delay measurement for a variety of modulating frequencies as a function of the signal/noise ratio in the test object. The signal/noise ratio of the abscissa is

$$10 \log_{10} \left| \frac{\text{carrier signal power}}{\begin{array}{c}\text{weighted random noise power, uniformly distributed over,}\\ \text{and confined to, the band 300-3400 Hz}\end{array}} \right| \text{dB}$$

A modulation index of $m = 0.4$ has been assumed and the comparator bandwidth has been normalized to 1 Hz.

The curves can be used for other values of the parameters as follows:

i) *Comparator bandwidths other than 1 Hz*

If the comparator bandwidth is y Hz enter the abscissa at the required signal/noise ratio *less* 10 log y dB. For example, the error corresponding to a signal/noise ratio of 40 dB, a modulating frequency of 40 Hz and a comparator bandwidth of 4 Hz is to be found on the 40-Hz curve against a signal/noise ratio of $40 - 10 \log 4 = 34$ dB, that is 5 μs approximately.

ii) *Modulating frequencies other than those shown*

The error is inversely proportional to the modulating frequency. For example the errors associated with a modulating frequency of 200 Hz would be $^1/_{10}$th of those indicated by the 20-Hz curve.

iii) *Modulation index other than 0.4*

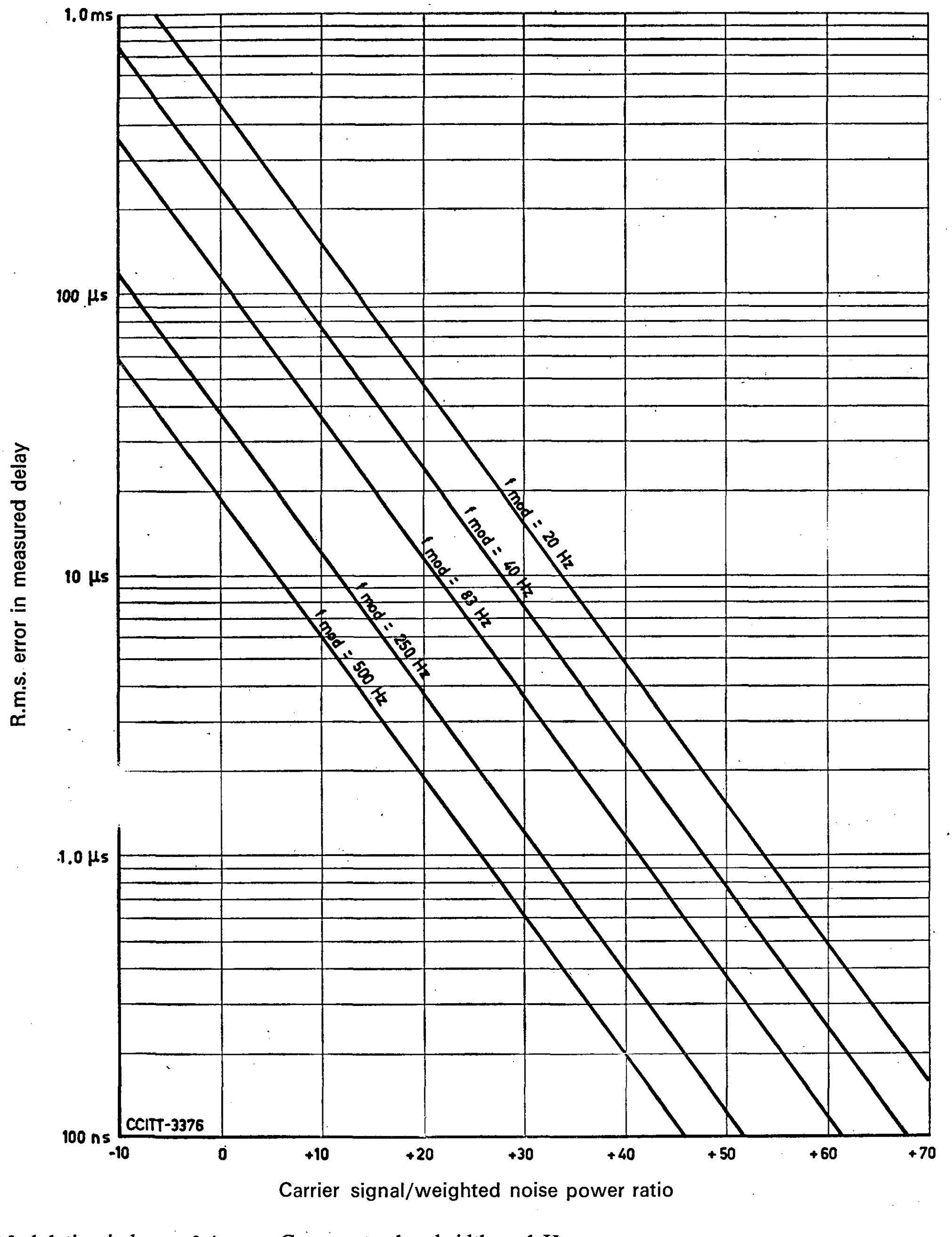
The error is inversely proportional to the modulation index. Hence for a modulation index of y multiply the ordinate by $0.4/y$.

b) *Single-frequency interfering signals*

The analogous expression for the error due to a single-frequency interfering signal falling in the measurement interval can be obtained and is given by

$$\text{error} = \frac{1}{mp} \cdot \frac{\text{amplitude of the interfering signal}}{\text{amplitude of the carrier signal}}$$

This formula does not involve the weighted/unweighted noise power factor (2.5 dB) or the ratio of 1 Hz/3100 Hz (35 dB) for the comparator bandwidth. Hence the curves of Figure 7 may be used for this case by entering the abscissa at the required signal/noise



Modulation index = 0.4 Comparator bandwidth = 1 Hz

FIGURE 7. — **R.m.s. error in delay measurement as a function of the carrier signal/weighted noise power ratio (the noise being uniformly distributed over and confined to the 300-3400-Hz band) for a range of modulating frequencies**

ratio *less* 33 dB. Thus if the carrier signal/interfering signal ratio is 50 dB, the error at a modulating frequency of 40 Hz will be found on the 40-Hz curve against a signal/noise ratio of 50 — 33 = 17 dB, that is 30 μs approximately.

Inaccurate phase measurement

If the required resolution for group delay is $\Delta\tau_g$ seconds and the attainable phase measuring accuracy is $\Delta\phi$ radians the necessary modulating angular frequency is

$$p \geqslant \frac{\Delta\phi}{\Delta\tau_g} \text{ radians/second.}$$

If the modulating frequency is f Hz ($= p/2\pi$) and $\Delta\phi$ is in degrees, then the relationship becomes

$$f \geqslant \frac{\Delta\phi^\circ}{360\ \Delta\tau_g} \text{ Hz.}$$

For example, if the phase measuring accuracy is 0.25° and a delay resolution of 10 μs is required, then the modulating frequency is given by

$$f \geqslant \frac{0.25^\circ}{360^\circ \times 10^{-5}} = 69.5 \text{ Hz.}$$

As the demand for higher delay accuracy increases (i.e. a lower $\Delta\tau_g$) the modulating frequency must be higher. However, as the modulating frequency is increased, the resolution of fine-grain delay distortion is reduced. Hence, the choice of modulating frequency is a compromise between accuracy of measurement and resolution of fine-grain distortion.

Figure 8 shows the phase measuring accuracy required as a function of the delay measuring accuracy for a range of modulating frequencies.

Asynchronism between free-running modulating and reference oscillators

Some practical group delay measuring instruments use independent free-running modulating and reference oscillators. This places a requirement on their relative short-term stability if errors due to asynchronism are to be acceptably small. If the modulating angular frequency is p radians/second and the reference angular frequency is $(1 + k)\,p$ radians/second then phase difference at a rate of $(1 + k)\,p - p = kp$ radians/second is being accumulated during a measurement period.

If the duration of a measurement period is M seconds the total phase difference accumulated will be kMp radians corresponding to an anomalous delay time of kM seconds.

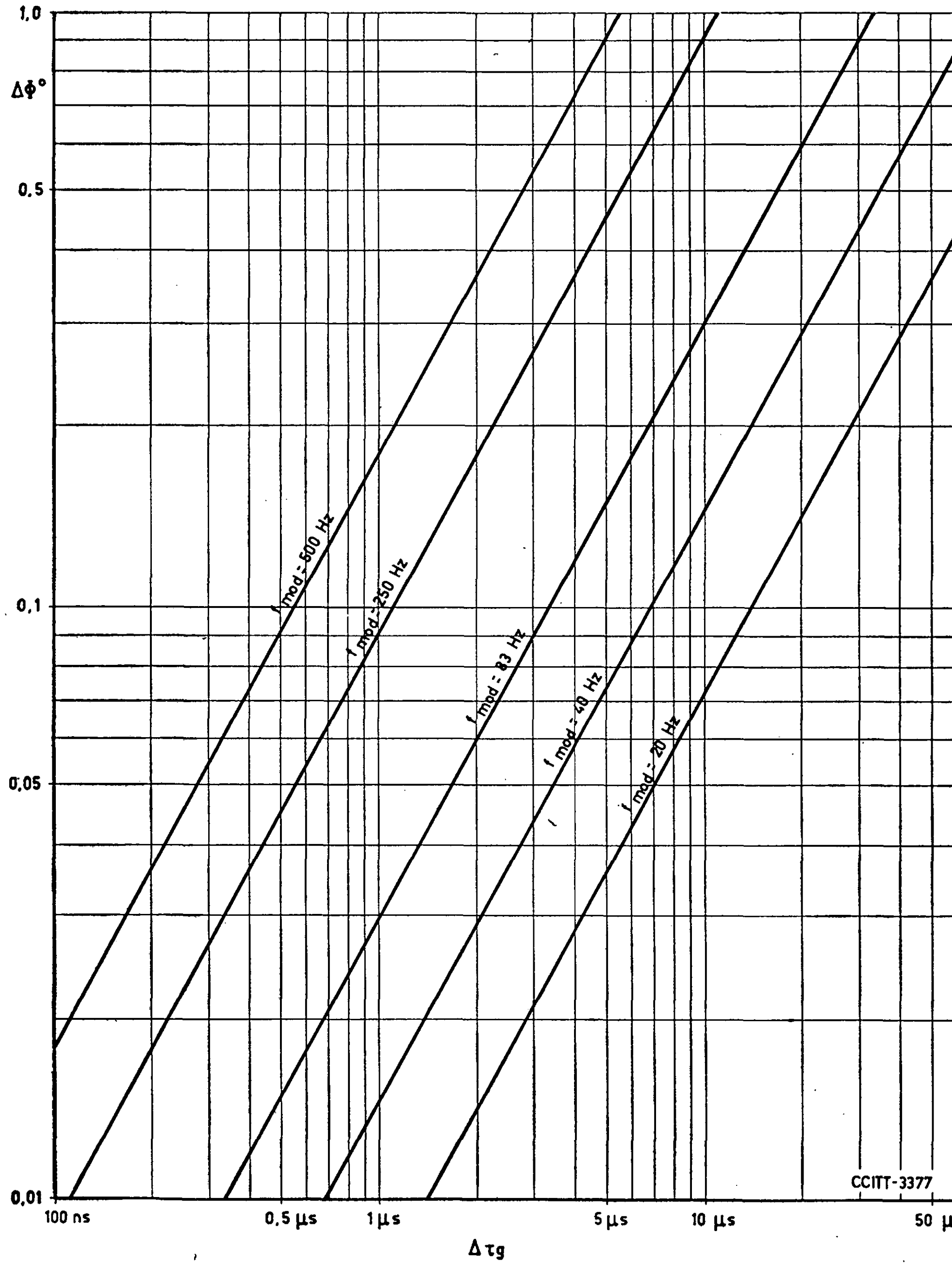


FIGURE 8. — **Required phase measuring accuracy** $\Delta\phi$ **as a function of the delay measuring accuracy** $\Delta\tau g$ **for a range of modulating frequencies**

If this error is not to exceed ϵ seconds, $kM \leqslant \epsilon$ or $k \leqslant \frac{\epsilon}{M}$.

For example in order not to accumulate more than 1 μs error over a period of 10 minutes requires $k \leqslant \frac{1\ \mu s}{600\ s} = 1.7 \times 10^{-9}$.

If, in this example, the tolerance was to be shared between the two oscillators each would have to have a short-term stability of somewhat better than 1 part in 10^{-9}.

Inaccuracy in the absolute frequency of the modulating oscillator

The accuracy obtainable is of the same order as the setting accuracy of the frequency of the modulating oscillator. For example a modulating signal with a 1% greater frequency than that for which the instrument is calibrated will explore a 1% wider portion of the phase characteristic. Assuming a substantially linear phase characteristic over the $\Delta\omega$ band this will result in a phase difference 1% greater than it would otherwise be. Hence calculated values of distortion (i.e. the difference between group delays measured at two or more frequencies) will also be in error by 1%.

Inaccuracy in the absolute frequency of the carrier oscillator

The error due to the frequency of the carrier oscillator being different from the indicated frequency is in effect an uncertainty in the carrier frequency at which the measurement was made. Such uncertainty is common to all transmission measurements which are functions of frequency.

Other methods of measuring group delay

Alternative methods to the Nyquist principle rely on direct measurement of the phase characteristic over the passband of the test object. These methods are suitable only for laboratory measurements. Among them are:

a) A null method in which the phase and amplitude of one of two signals are varied so that the signals are made equal and opposite to the other.

b) A vector sum-and-difference method in which two paths are supplied from a common source. The first path contains an attenuator and the second the test object. The amplitudes of the two output voltages being made equal, the phase angle can easily be determined from the vector sum and difference of the output voltages.

c) The π-frequency method. The input to the test object is connected to a sinusoidal source of variable frequency. The input and output signals are connected to the X and Y amplifiers of an oscilloscope (which must have identical phase characteristics). Those frequencies at which the test object introduces an integral multiple of π radians, which is indicated by a straight line Lissajou display, are noted. Let them be f_1, f_2, f_3 Hz etc. in ascending order of magnitude. The average group delay over the first interval f_1 to f_2 is given by

$$\frac{\Delta B}{\Delta \omega} = \frac{\pi}{2\pi\,(f_2 - f_1)} = \frac{1}{2\,(f_2 - f_1)} \text{ second.}$$

Similarly the average group delay over the next interval is $\dfrac{1}{2\,(f_3 - f_2)}$ second, and so on.

From these calculated values a plot of the group delay as a function of frequency can be constructed by assigning the delay of each interval to the mid-frequency of the interval.

The following worked example (which is somewhat artificial) illustrates the principle.

π-frequencies	kHz	$2\,(f_{n+1} - f_n)$ kHz	Group delay μs	Mid-interval frequency $\dfrac{f_n + f_{n+1}}{2}$ kHz
f_1	5			
		20	50	10
f_2	15			
		40	25	25
f_3	35			
		50	20	47.5
f_4	60			
		40	25	70
f_5	80			

The entries in the last two columns would be used to construct a graph of the group delay characteristic.

SUPPLEMENT No. 2.8

MEASUREMENTS OF SUDDEN PHASE CHANGES ON CIRCUITS

Method 1

Using go and return paths of the circuit being tested (may not be suitable for satellite circuits). The go and return paths of the *same circuit* are looped at the far end, thus eliminating frequency deviation between the sending and receiving points. There is a phase difference between the sent and received signals which is a function of the total phase difference on the circuit.

Since the two signals applied to the ring modulator in Figure 1 have the same frequency, the voltage applied to the recording ammeter A will include a d.c. component as a function of the phase difference between the two signals. If, therefore, the phase difference is constant, the ammeter reading will also be constant, while sudden phase variations in the transmission system will be recorded as sudden changes in the ammeter readings.

However, the ammeter reading also depends on the level of the signal received, which means that the reading will also be affected by changes in the attenuation of the transmission system. This dependency can be partially avoided if the signal received passes through a peak-clipper before being applied to the modulator. However, this independence will be achieved only when the level of the signal received is higher than the limiting threshold ofthe peak-clipper. If it can be assumed that the phase change is constant for a long period of time, apart from the occurrence of sudden phase changes, the influence of attenuation variations can be eliminated without using a peak-clipper, if the phase-shift element shown in Figure 1 is adjusted so as to give a difference of 90° between the signals transmitted and received. By such adjustment, a d.c. component of 0 is obtained, which means that only phase changes and not attenuation changes produce deflections of the needle.

Method 2

Using only one direction of transmission circuit being tested (suitable for any satellite circuit). In this method a signal is sent from one of the terminal stations and measurements are made at the station at the other terminal.

In Figure 2, the received signal and a signal having the same frequency derived from a local oscillator are applied to a modulator so that, at its output, there is a direct current which is applied to the recording ammeter A. An RC network having a suitable time constant enables this d.c. voltage to be applied to synchronize the 800-Hz oscillator. The voltage applied to the ammeter is thus a function of the phase difference between the signals. If there is a sudden phase variation, the voltage at the output of the modulator is modified and hence the synchronizing voltage of the oscillator is also modified which tends to produce a proportional change of phase in the oscillator, so that the difference in phase between the two signals tends to return to the same value as that which existed before the phase change.

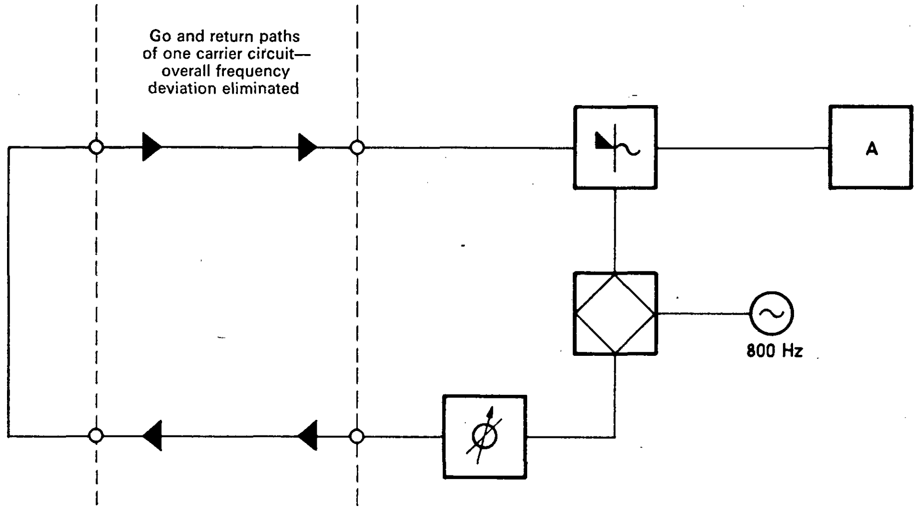


FIGURE 1. — Measurement of sudden phase changes using the go and return paths of one carrier circuit

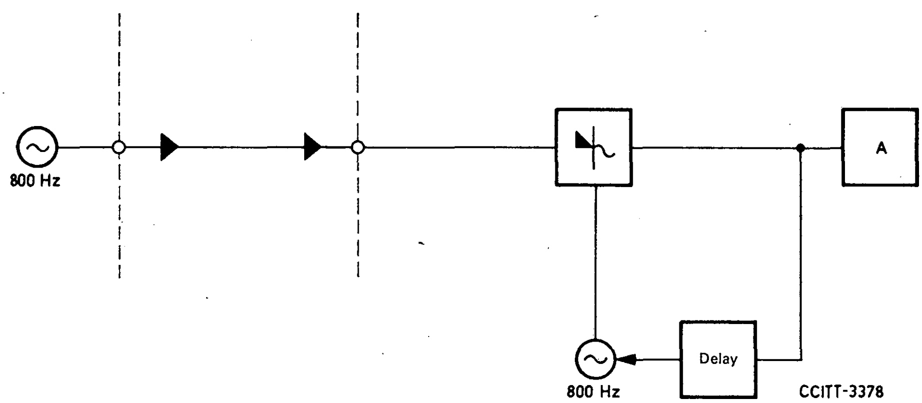


FIGURE 2. — Measurement of sudden phase changes using only one direction of transmission of the carrier circuit

Because of the RC network, the synchronizing voltage will be delayed with respect to the voltage at the modulator output and thus the ammeter will have time to register a deviation. It is pointed out the ammeter will, in the case of a sudden phase change, indicate a change and will then return to its original position. To obtain maximum sensitivity for phase changes, the difference in phase between the two signals should be adjusted to 90°, so that the voltage at the output of the modulator is zero.

This adjustment is made by means of the oscillator frequency control. To ensure maintenance of the phase difference at about 90°, the frequency range over which oscillator synchronization is possible should exceed the greatest range of variation in the received signal frequency, synchronization then enables the required phase difference (90°) to be maintained over this frequency range. Also, the two 800-Hz oscillators must have very good frequency stability. To prevent variations of the level of the received signal from influencing the deviation of the pointer, the signal is passed via a peak-limiter before being applied to the modulator. The condition for a deviation of the pointer to provide a measure of the phase change is that the duration of the phase change shall be short in relation to the time constant of the RC network.

An equipment for the recording of sudden phase changes

(Note by the Danish Administration)

A test signal of a frequency between 1000 and 2000 Hz is transmitted on to a telephone channel. At the receiving end the equipment recording sudden phase changes is connected. The received signal goes through a limiter, an amplifier and a Schmitt trigger. At the output from the Schmitt trigger the signal has been shaped into a square wave voltage, the magnitude and form of which is independent of the level of the input signal.

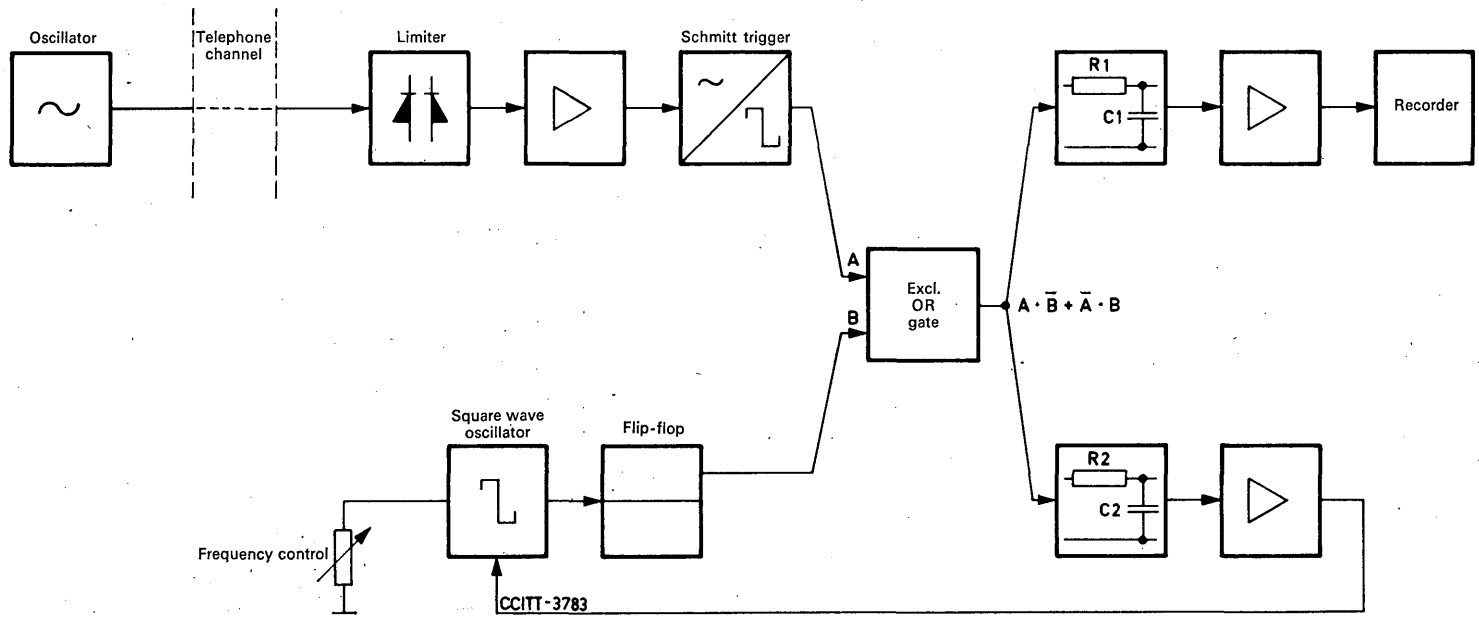
A built-in square wave oscillator generates a voltage, the frequency of which is twice the frequency of the received signal. This voltage is fed to a flip-flop that halves the frequency, so that a square wave voltage of the same frequency as that of the received signal is obtained. The purpose of this arrangement is to have equal lengths of the two half-periods of the voltage. The frequency of the square wave oscillator is governed partly by a manual frequency control and partly by an external synchronization voltage.

Signal A from the Schmitt trigger and signal B from the flip-flop are fed to an exclusive OR gate working as a phase detector. If the two signals A and B are in phase the gate will produce a negative d.c. voltage. In the case of a phase difference of 180° between signals A and B the output is also a d.c. voltage, this time of positive polarity. For a phase difference of 90° a square wave voltage is produced with a frequency that is twice the frequency of the input frequencies with half-periods of equal lengths. For all other values of phase difference the output voltage will also be a square wave, but the lengths of the two half-periods will differ. The mean value of the voltage is a measure of the phase difference between A and B, being proportionate with the numerical value of the phase difference.

The phase detector is connected to a recording meter via an RC network and amplifier, and via another RC network and amplifier a synchronization voltage is applied to the square wave oscillator. The time constants of the two RC networks are different, $R_2 C_2$ being much greater than $R_1 C_1$, so that the synchronization voltage for the oscillator is delayed relative to the voltage applied to the meter.

Therefore, if a change takes place in the phase of the received signal, the meter will show a deviation from its steady deflection, until the phase of the oscillator has been corrected by the synchronization voltage. The correction will correspond to the change of the phase of the received signal, and thus the phase difference between A and B will be back at its original value.

The phase difference between A and B is set at 90° by means of the manual frequency control of the oscillator which will act as a phase control when synchronism has been obtained.



Equipment for the recording of sudden phase changes on circuits

SUPPLEMENT No. 2.9

VIBRATION TESTING

1. *Introduction*

1.1 Vibration testing technique provides a method of testing transmission equipment for "contact defects" in order to locate and clear them before they cause difficulties in service. The expression "contact defects" is used in its very broadest sense.

1.2 The performance of a telephone transmission system is generally assessed in terms of the quality of the service given to the user or operating services. When this gives rise to fault reports, the cause may not be found unless the fault persists long enough to be located by the use of transmission testing equipment. As a result of their long persistence, many intermittent contact defects will cause a degradation of service over long periods, resulting in a series of fault reports before location and clearance are possible by the maintenance staff. During this period, service time and engineering effort are wasted.

1.3 Contact defects are undoubtedly one of the major causes of instability and interruptions on circuits. They may result from faulty design or during component manufacture or panel assembly. They may occur during the installation of equipment or during service.

Unless special testing equipment is provided, the localizing of all contact defects is unlikely. In order that the design performance of a circuit shall be achieved, it is essential that every contact defect be eliminated.

This can be done by applying a vibration test to every point in the circuit and then by making a very careful visual inspection; this should be followed by continuous observation of the level of a signal sent over the circuit for a period of at least 24 consecutive hours during weekdays by means of a recording decibel-meter. If this latter test shows that the overall loss of the circuit is not stable, further tests should be made.

2. *Principle of test*

The basic principle of a vibration test involves the passing of a test signal of sufficiently low level and of suitable frequency through the equipment to be examined and the application in stages of a gradually increasing intensity of vibration to each part of the equipment.

The effect of a contact defect under vibration is that the test signal is modulated by the change in the electrical conditions at the fault that arises due to the vibration. The resulting sidebands at the output of the equipment are detected by a suitable device and are amplified by a high-gain loudspeaker amplifier so as to produce audible "clicks".

Some modern equipment, however, may be liable to damage by vibrations and shocks exceeding a certain intensity. Care is therefore necessary. See paragraph 6.3 below in this connection.

3. *General requirements of vibration-testing equipment*

3.1 *Frequencies of test signals*

For most purposes a single frequency test signal will suffice and a frequency approximately in the middle of the transmission band of the equipment under test is normally chosen. Tests at one frequency may not be sufficient for a filter, equalizer or wideband amplifier and it is preferable to make several vibration tests at different test frequencies when the results of a single frequency test are not conclusive.

For testing audio-frequency equipment, the test frequency must lie within the range 300-3400 Hz, but as the major components of valve microphonic noise lie below 1000 Hz it is best to avoid test frequencies in the range 300-1000 Hz.

For testing the transmission paths of carrier-frequency equipment in the group bands of 12-60 and 60-108 kHz and the supergroup band 312-552 kHz, for example, at least three frequencies are necessary. The arithmetic mean frequencies of 36, 84 and 432 kHz would be convenient frequencies to choose.

For testing carrier-frequency generator equipment, the effects of vibration may be observed on the normal outputs of the equipment.

3.2 *Sensitivity*

3.2.1 It is assumed in general that any perceptible variation in the resistance of a connection under vibration is symptomatic of a fault condition which may, in time, become worse; variations of the order of 0.01 ohm or more should be regarded as significant in most cases.

Elementary "demodulator" type testers are capable of indicating transmission variations down to about 0.1 decibel and such variations would be brought about by changes of about 14 ohms in a 600-ohm circuit and about 1.8 ohm in a 75-ohm circuit. It should be borne in mind, too, that circuit impedances of transmission equipment may be as high as a megohm or more and that many of the more important connections are remote from the main transmission paths.

3.2.2 Experience shows, however, that for general work in the field, sensitivity to variations of less than 0.01 dB are not advisable owing to the misleading effects which can be caused during vibration tests by such items as quartz crystals, iron-cored inductors and transformers, even when these are free from faults.

Other factors in the detection of defective connections are the phase and the duration of the variations they cause. In comparing testing equipments, it is convenient to consider only the amplitude of the variations applied to them. It is desirable to record variations having a duration of the order of at least one millisecond in order to obtain clear indications. Thus the bandwidth of the tester should be at least 500 Hz and preferably 1000 Hz.

3.3 *Levels of test signals*

3.3.1 Experience with vibration testing methods has shown that it is essential for a loudspeaker to be used as the final indicating device so that the operator can distinguish aurally the amplitude and time characteristics of the variations produced by the intermittent connections and so be able to correlate transmission variations with movement or vibration of the part of the equipment being tested. The main difficulty in design arises from the necessity to obtain a satisfactory signal-to-noise ratio.

3.3.2 It is desirable to transmit the test signal through the equipment under test at a level that is not high enough to cause electrical breakdown of the tarnish and other alien films that may form on connections. The great majority of such films are believed to require a peak potential difference of about 0.1 V to cause breakdown. For this reason a test signal of −20 dB relative to test level is generally assumed to be desirable. This corresponds to 0.11 V and 0.04 V peak at zero level points in a 600-ohm and 75-ohm circuit respectively.

The variations of 0.01 dB that it may be required to detect are equivalent to interfering signals nearly 60 dB below the test signal. In some units of transmission equipment the total noise power in a bandwidth of 1000 Hz may be of the order of 80 dB below test level, this noise being made up of speech babble, tone and other interference due to crosstalk, to power supply couplings, valve microphony and inherent random noise.

Assuming that a minimum signal-to-noise ratio of 10 dB is necessary for satisfactory operation of the tester, it appears that to detect a variation of 0.01 dB in the test signal, the minimum level of test signal required would be about − 10 dB relative to channel test level (i.e. $-80 + 10 + 60 = -10$ dB). If it is required to detect a variation of 0.001 dB a minimum test signal level of + 10 dB would be required.

3.3.3 The above requirements are mutually opposed. It is believed, however, that the best overall result is obtained when the level of the test signal is about equal to the normal channel test level, though in practice it may be advantageous to make additional tests at a level of the order of − 10 dB relative to channel test level.

4. *Methods of detection*

A number of circuit arrangements are suitable for the detection of faulty contacts. Three principal arrangements described below are referred to as 4.1 "Bridge", 4.2 "Demodulator", and 4.3 "Sideband".

4.1 *Bridge method*

4.1.1 This is based on the principle of connecting the test signal from the output of the equipment under test to a bridge, and opposing it with another signal equal to it in amplitude and phase, so that the resultant signal is zero. Any subsequent change of level in one of the signals, such as will be caused by variation of attenuation or phase in the equipment under test, gives rise to an output from the bridge which is made audible on a loudspeaker.

Figure 1 shows the principle for audio-frequency testing.

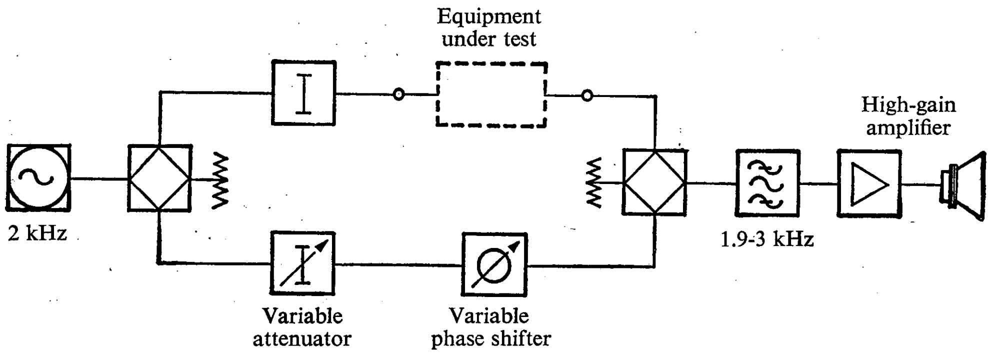


FIGURE 1

4.1.2 Points of importance in this method of detection are:

a) The oscillator should have a high short-term stability of frequency to prevent the appearance of an out-of-balance signal from the bridge due to oscillator frequency drift. This might be accentuated, due to the fact that practical forms of variable phase-shifters are to some extent frequency-dependent.

b) The band-pass filter is necessary to reduce the level of background noise, and of harmonics of the test signal; the width of its passband should be of the order of 1000 Hz.

c) The main considerations in the choice of test frequency are:

i) The range below 1000 Hz should be avoided because it contains the major components of valve microphonic noise.

ii) The combined sensitivity characteristics of a loudspeaker and the human ear show an advantage in locating the test signal and sideband in the range 2000-4000 Hz.

iii) The test signal frequency should be located near one end of the passband of the filter to give an asymmetric effect in order to obtain the optimum signal-to-noise ratio under average conditions.

4.2 *Demodulator method*

4.2.1 The basic principle of this method of detection is that the test signal output from the equipment under test is passed through a suitable "demodulator" to a loudspeaker so that any modulation of the test signal caused by a defective connection can be made audible. The method is illustrated in Figure 2 as it would be used for testing carrier equipment.

It appears that when the resistance of a connection varies under vibration, the rate of change of resistance is sufficiently high for the modulated signal that it causes to contain substantial components in the audio-frequency range, i.e. for the variations to give rise to an audible crackle or series of clicks.

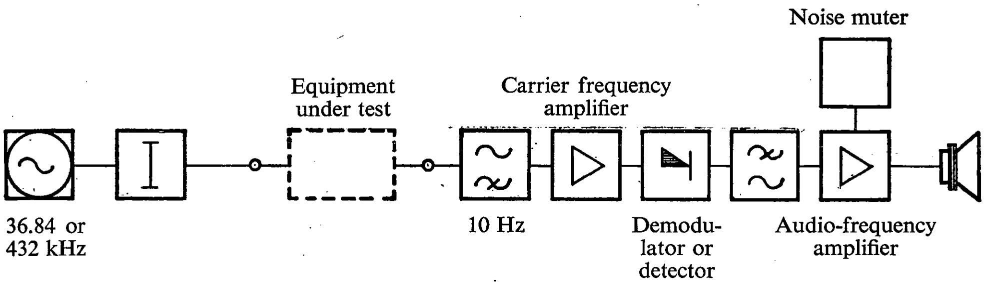


FIGURE 2

4.2.2 The main points of interest in this method are:

a) The 10-kHz high-pass filter serves to suppress any audio-frequency noise coming from the equipment under test. Whilst a better signal-to-noise ratio would theoretically be obtained by using a band-pass filter with a bandwidth of about 1000 Hz and by locating the test signal near one of the passband, it has been found in practice that such filters offer little advantage over high-pass filters when testing normal carrier equipment. The filter need not be included if the carrier-frequency amplifier has sufficient loss at audio-frequencies.

b) The noise muting device (preferably of the short time-constant type) associated with the audio-frequency amplifier is desirable in order to reduce or eliminate the usual continuous noise, which tends to be disturbing to the operator. The muting device needs to have an adjustable threshold in order to cater for the widely different conditions likely to be met in practice.

It is to be noted that whilst the noise muter gives a very great improvement in the signal-to-noise ratio in the loudspeaker, it does not give any substantial reduction in signal-to-noise ratio at the output of the equipment under test, i.e. it does not permit the level of the test signal to be reduced.

4.2.3 The method shown in Figure 2 can be used for audio-frequency testing if

a) the frequency of the oscillator is made appropriate to audio-frequency testing,

b) the cut-off frequency of the high-pass filter is reduced to about 2000 Hz,

c) the carrier-frequency amplifier is replaced by an audio-frequency amplifier,

d) the low-pass filter between the demodulator and the final audio-frequency amplifier gives sufficient attenuation at the test frequency and its harmonics so that the loudspeaker is normally silent. Discriminations of the order of 90 dB against the test signal frequency and 70 dB against second and third order harmonics are required if a sensitivity of 0.01 dB is to be achieved.

4.3 *Sideband method*

4.3.1 The principle of this method of detection, shown in Figure 3, is that the "fault modulated" test signal is passed through a filter which removes the test signal and one sideband, and allows the other sideband to pass to an audio-frequency amplifier, the output of which produces an audible signal in the loudspeaker.

This method is applicable only to audio-frequency testing.

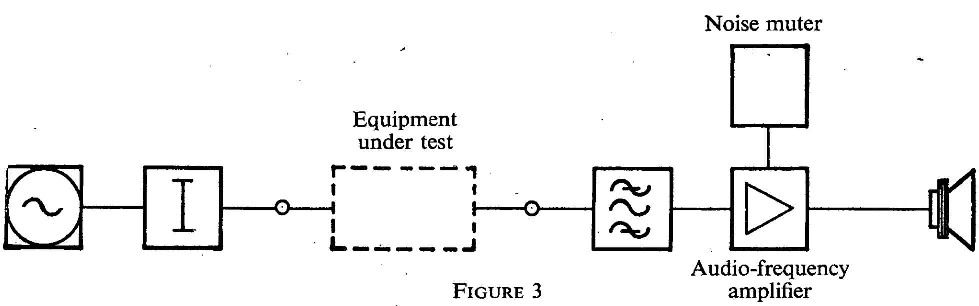


FIGURE 3

4.3.2 The main function of the band-pass filter is the same as that of the low-pass filter in the demodulator method and the filter should have the same order of discrimination against the test signal and its harmonics. In addition, it should also discriminate against valve microphonic noise.

The use of the noise muter circuit in this method makes the sounds reproduced in the loudspeaker similar to those obtained with the demodulator method.

5. *Comparison of methods*

5.1 The main differences between the three methods are that, whereas the bridge method is responsive to both slow and fast vibrations in the equipment under test, the demodulator and sideband methods respond only to fast variations and in this sense the bridge method may be said to be the most sensitive. This is an obvious advantage when equipment is to be tested as critically as possible.

Sensitivity to slow variations, however, may be a disadvantage under some conditions of use. For example, in testing an amplifier not having a large amount of negative feedback, frequent re-balancing of the bridge may become necessary owing to variations in gain caused by changes in power supplies, "warming up" conditions, etc. Also, the testing of a gain control switch, for example, may necessitate re-balancing of the bridge for each position of the switch.

5.2 For carrier-frequency testing, the demodulator method is thus to be preferred for general field work, its lack of sensitivity to slow variations being outweighed by the fact that it needs neither critical nor frequent adjustment. Furthermore, it can be used for testing carrier-frequency generator equipment for which the bridge method is not suitable.

5.3 The performance obtained by using either the demodulator or the sideband method is practically identical but the sideband method is attractive because of its relative simplicity.

6. *Method of applying vibration and precautions*

6.1 In applying the vibration test, the nature of contact defects and the resulting ease with which many of them can be temporarily cleared must always be kept in mind. Defects have been found which are so unstable that by gently blowing on them their presence is revealed by clicks in the loudspeaker. This extremely slight disturbance may even be sufficient to break them down completely. It is therefore most essential, in order to avoid breaking down contact defects, not to cause disturbance to the whole of the equipment under examination.

6.2 At the beginning of the vibration test, before any covers are removed or U-links or similar connections are disturbed, the test signal and detecting device are connected to the equipment. External U-links are then moved almost imperceptibly whilst listening for clicks in the loudspeaker. The equipment cover may then be removed, easing it off as carefully as possible. Clicks from the loudspeaker during these operations indicate that a contact defect has been disturbed.

Experience has shown that components and wiring on panels are best tested in a systematic sequence: e.g., variable gain-controls are rotated slowly, valves displaced carefully and slowly with a very slight rotary action in the valveholders, then with the aid of a small insulated tool, such as the handle of a screwdriver, cable forms, tags, soldered connections and components are gently touched (not tapped) whilst listening for clicks from the loudspeaker. A click may be heard when a connection is lightly touched but may not recur when touched a second time because the defect has been broken down. However, such a defect might be revealed at a later stage in the test.

6.3 The procedure is then repeated, very lightly tapping all connections, tags, components (including valves) and the cause of any clicks is investigated. When located, any defect is cleared before continuing the test. Valves that are abnormally microphonic or that have loose electrodes are replaced. Iron-cored transformers and inductors are tested for dry joints and microphony by lightly tapping each accessible surface of the component assembly.

The procedure is then repeated a third time, tapping harder so that contact defects mechanically held by resin or rivets are disturbed and so that sufficient vibration is transmitted from cans to components and wiring inside the cans.

Assemblies which contain transistors and other semi-conductors should be tested using a controlled impact device such as a spring-loaded impact tool in order to ensure that they are not damaged in testing. Point-contact diodes should not be vibration-tested. They can be tested by varying the direct current through them, keeping the current within the rated limits of the diode. Most contact troubles will be revealed with this type of testing when the diode warms up.

6.4 Finally, all wires and tags are pulled gently both ways along the axis of the wire and at right angles to it. This detects rigid mechanical joints that are unsound electrically. The pull is adapted to the type of wire and component involved so that no damage is caused. Wire that has been "nicked" in the process of removing insulation or wire that is brittle with age may easily be fractured by this process, but it is preferable for this fracture to occur whilst the equipment is under observation rather than for it to be caused, for example, by cleaning operations by non-technical staff.

6.5 A fractured wire that still gives electrical continuity would in due course corrode and an unstable defect would develop. Carbon resistors and small capacitors suspended in the wiring are repositioned if they are liable to touch tags, earth points or covers when lightly disturbed.

Completely sealed crystal filters using pressure-contact crystal mountings are gently struck with the closed fist along the length of the cover. Excessive vibration, however, may either temporarily clear an existing defect or completely displace a crystal in its mounting.

When equipment that contains valves is being tested, the power supply connections also are tested. Defects in busbar connections, fuses and voltage regulators also give rise to clicks in the loudspeaker when disturbed.

When the equipment has been freed from all defects, the cover is replaced and struck quite hard with the closed fist. No clicks should then be heard from the loudspeaker.

A small wooden-handled screwdriver weighing about 2 ounces is suitable for applying vibration to the equipment but, unless the handle is covered with rubber, it may not be possible to distinguish between the direct mechanical noise due to tapping and the simultaneous faint clicks from the loudspeaker. On the other hand, the ear can usually discriminate between a click expected at the moment of tapping and random clicks, even in the presence of steady noise.

A special pair of pliers with long flexible insulated jaws has been used for gripping wires during vibration tests.

7. *Application to new equipment*

Application of vibration testing to new equipment has shown some contact defects that have escaped detection at all stages in production, from component tests to final acceptance tests, and which would have been a maintenance liability until they were finally cleared as a result of investigations following fault reports.

It has been shown that by eliminating defects prior to functional tests, the time taken for acceptance tests can be reduced and programmes of acceptance testing can be arranged more effectively. Several months may elapse between the manufacture of components and the completion of a wired panel and dry-soldered connections in components may have had time to develop, so that they can be located by vibration tests made at the factory prior to normal electrical tests.

8. *Contact defects*

The types of contact defects encountered include many which are unwittingly cleared temporarily by the application of normal maintenance methods. The degradation of service due to them is not fully revealed by normal fault data. Contact defects may be found to be due to:

— unsoldered joints; defectively soldered joints ("dry joints"),

— variable wire-wound potentiometers,

— defective spot welding of resistance wires and valve electrodes, valveholder contacts and valve pins,

— U-link springs and sockets,

— dry riveted and screwed connections,

— plug and jack sleeve or springs,

— spring contacts in jacks and keys,

— unwetted relay contacts,

— broken wires in loose mechanical contact,

— spurious contacts between wires, or between wires and earth,

— loose connections on copper oxide rectifiers,

— bad contacts on pressure-mounted crystals in crystal filters,

— poor connection of screened conductors,

— poor connections on heat coils and mountings,

— poor connection between line fuses and mountings.

9. *Continuous monitoring*

9.1 *General arrangements*

Vibration testing is a highly skilled operation, but even with qualified staff the elimination at the first attempt of all contact defects on the equipment used in a circuit is not certain. Continuous observation of a circuit is therefore most desirable to confirm that the circuit is free from faults. Such observations are made on circuits by means of a test tone and one or more recording decibelmeters.

9.2 *Stability of a circuit*

Provided that a transmission path is free from contact defects and unstable components and provided that the equipment is operated from stabilized power supplies, then variations in transmission level are due to fundamental changes such as the variation in attenuation with temperature of coaxial and carrier cables. For audio-frequency circuits, the temperature effect is very small and therefore it would be expected that day-to-day changes in level of a test signal transmitted over the transmission path would also be small.

The use of recording decibelmeters has shown that, if a circuit is free from defects, the changes in level with time may vary between 0.2 dB and 1 dB, depending on the length of the circuit and type of amplifying equipment. A 400-mile audio-circuit using amplifiers with negative feedback should not vary by more than $\pm$ 0.2 dB. A circuit with contact defects, faulty components or valves shows considerable variation in level over short periods, and if the defects are disturbed, transient changes occur which may disconnect a circuit for a few milliseconds. A contact defect in the feedback path of an amplifier may cause momentary rises in recorded level.

In general, a defect likely to affect the overall loss of a circuit behaves in a characteristic manner and exhibits a characteristic trace. With experience, it is sometimes possible, therefore, to diagnose the type of defect from a record taken over a period of time on a decibelmeter.

9.3 *Continuous monitoring on transmission paths in service*

One contact defect of a recurring transient nature can be, and often is, the cause of a bad fault record for a circuit. From the point of view of the maintenance and operating staffs, however, it is unsatisfactory to withdraw a circuit from service for long periods, for vibration testing and continuous monitoring, to find perhaps only one defect; this aspect is even more serious when the H.F. path of a carrier or coaxial system is concerned.

Continuous monitoring on transmission paths in service is therefore attractive from both the service and the maintenance points of view. It allows lost circuit time due to faults to be reduced and improvement in circuit performance to be made between reported faults. It permits the maintenance engineer to carry out his work in clearing faults without being pressed to restore a circuit or system to service before he is satisfied it is fault-free. It also allows him periodically to check the performance of circuits in service, and to detect and clear a defect before service is seriously affected or a fault reported.

10. *Interpretation and typical recorder traces*

10.1 *Typical recorder traces*

Typical specimens of recorder traces obtained on circuits in service are shown in Figures 4 to 8.

10.2 *Interpretation of chart records*

Figure 4 shows the recorder trace of a 400-mile looped audio V.F. telegraph circuit 2½ years after overhaul using vibration testing.

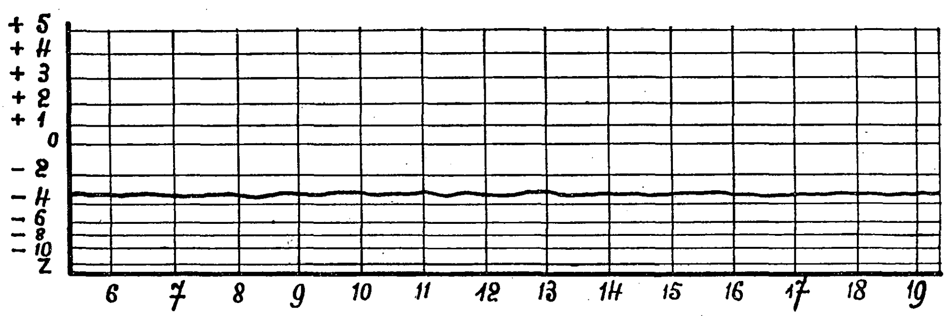


FIGURE 4. — **Typical trace recorded on a 400-mile looped audio V.F. telegraph circuit 2½ years after vibration testing**

Figure 5 shows the recorder trace of a 450-mile carrier circuit routed over 250 miles of 12-channel carrier and 200 miles of coaxial path. Using 60-kHz pilot monitors, defects were observed on the 12-circuit carrier path and finally located by vibration testing. The coaxial path was overhauled at all stations, involving the withdrawal of the system from service at week-ends for six months.

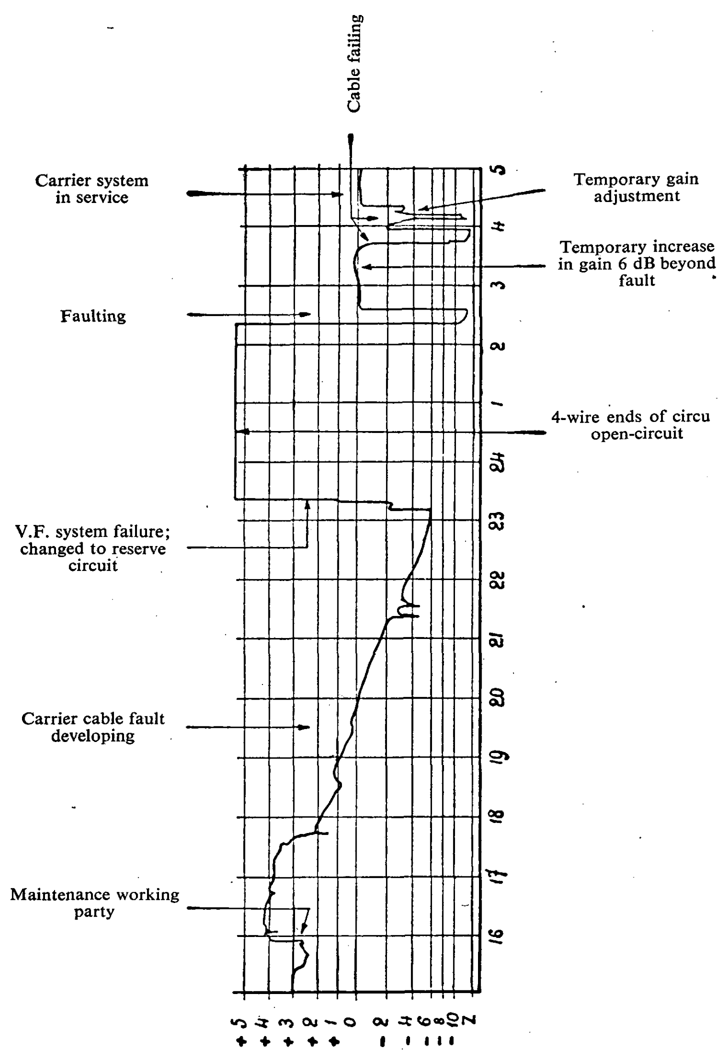


FIGURE 5. — **Typical trace taken on a 450-mile carrier circuit**

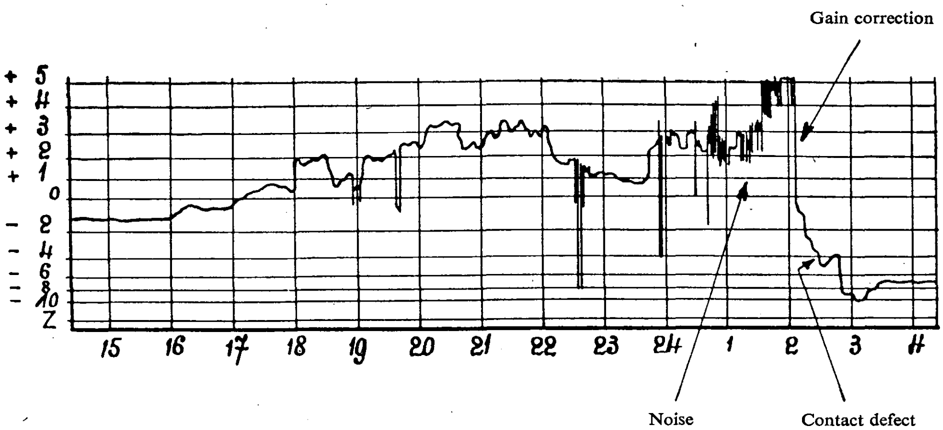


FIGURE 6. — **Trace on a 450-mile carrier circuit**

Figure 6 shows the recorder trace of successive failures of a v.f.t. system on a carrier channel due to inter-electrode contact in the valve in the carrier channel panel. The fault was reported in both cases and in both cases the action recorded was "measured and found O.K.".

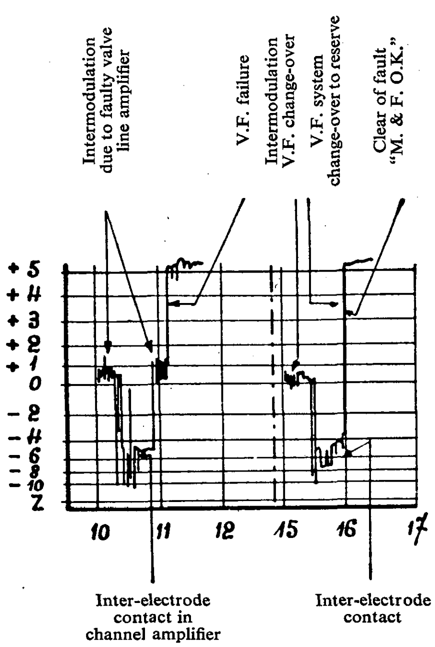


Figure 7 shows successive failures from a contact defect which was located at an unattended repeater station. The duration of the failure and the time at which it occurred made diagnosis and location of the fault extremely unlikely by normal fault procedure and transmission measurements.

FIGURE 7. — **Traces produced by an inter-electrode contact in a valve in a carrier channel panel**

Figure 8 shows the effect of a typical symmetric pair cable fault.

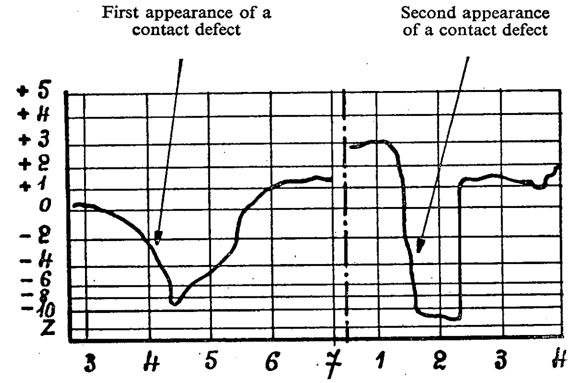


FIGURE 8. — **Traces produced by a contact defect**

SUPPLEMENT No. 2.10

METHOD FOR MEASURING THE FREQUENCY SHIFT INTRODUCED BY A CARRIER CHANNEL

The principle of the method is that the harmonic relationship between two sinusoids is destroyed if to both is added the same frequency shift. Figure 1 is a block schematic of the arrangement and is largely self-explanatory. From one 1000-Hz oscillator are derived two signals, one at 1000 Hz and the other at 2000 Hz, which are both transmitted. At the receiving end of a channel introducing Δ Hz shift they are no longer harmonically related and the frequency shift can be extracted and counted while at the same time a cathode-ray oscilloscope can be arranged to indicate the sense of the frequency shift. This method is used by the United Kingdom Administration and others.

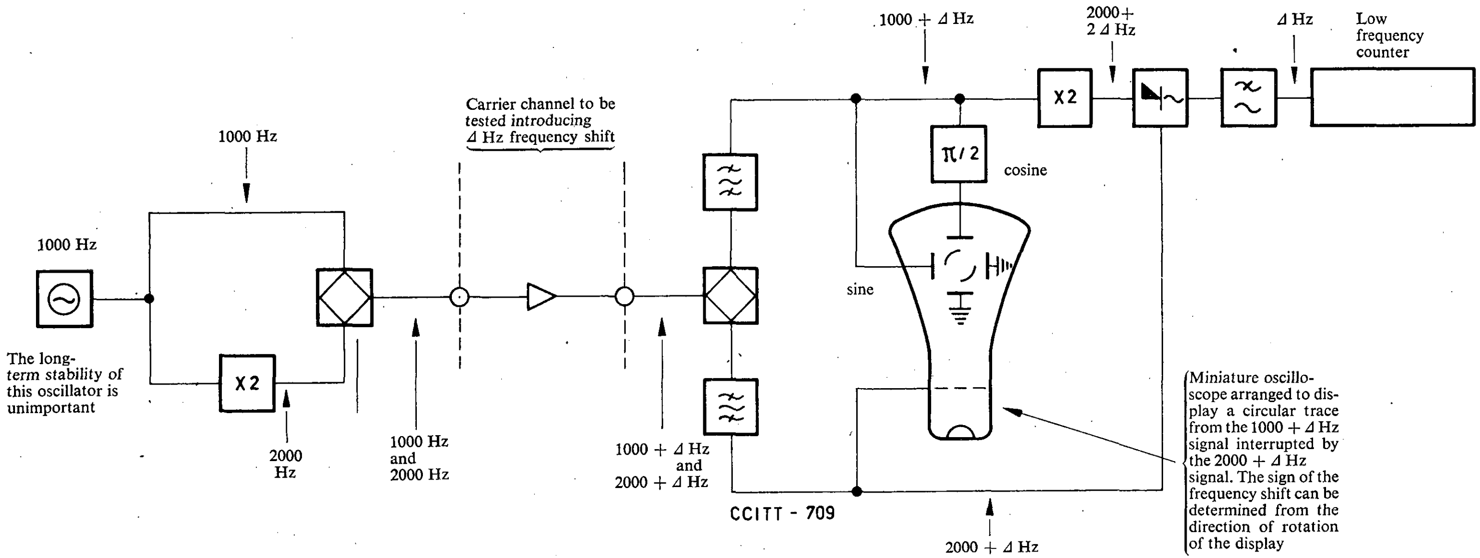


FIGURE 1. — **A method for measuring the frequency shift introduced by a carrier channel**

SUPPLEMENT No. 3.1

MEASURING INSTRUMENT REQUIREMENTS
SINUSOIDAL SIGNAL GENERATORS AND LEVEL-MEASURING INSTRUMENTS

A. *Direct-reading, general-purpose, continuously-variable sinusoidal generators (not sweep frequency)*

Table 1 is a list of the essential performance requirements of a range of direct reading, general purpose continuously variable sinusoidal generators.

If discrete frequencies are required suitable nominal values for international purposes are given in Recommendation M.58 for telephone-type circuits and Recommendation N.21 for sound-programme circuits.

B. *Direct-reading, general purpose wideband and selective level-measuring instruments (not sweep display or fixed frequency)*

Table 2 is a list of the essential performance requirements of a range of direct-reading, general purpose wideband and selective level-measuring instruments.

Other instruments are being studied by the C.C.I.T.T., for example, general-purpose sweep-display instruments; special-purpose fixed-level, fixed-frequency instruments for pilot-frequency level measurement etc. This supplement will be augmented in future editions to include such instruments. For information, *Blue Book*, Volume IV, Supplements 3, 12, 13, 14, 15 and 16 contain descriptions (and in some cases, specifications) for a variety of other measuring instruments.

TABLE 1

Essential performance requirements for sinusoidal signal generators
(not sweep generators)

	Telephone-type circuits	Sound-programme circuits	Groups, supergroups, and 12-, 60-, 120-, and 300-channel systems	Mastergroups, super-mastergroups and 900- to 2700-channel systems
1	2	3	4	5
Frequency				
a) range	200 Hz to 4 Hkz	30 Hz to 20 kHz	4 to 1400 kHz	60 kHz to 17 MHz
b) accuracy of initial setting, without frequency counter, at 20°C and nominal power supplies	± 1% ± 1 Hz	± 1% ± 1 Hz	below 120 kHz: ± 0.2% ± 100 Hz 120 kHz and above: ± 0.2% ± 1 kHz	± 0.002% ± 300 Hz
c) stability				
— per hour at 20°C and with nominal power supplies	± 1%	± 2%	± 0.01% ± 250 Hz	± 0.005% ± 250 Hz
— per 10°C over a specified range of temperature and with nominal power supplies (Note)	± 0.1%	± 0.1%	± 0.1% ± 250 Hz	± 0.002% ± 10 Hz
— per 10% change in power supply at 20°C	± 0.5%	± 0.5%	± 0.05% ± 250 Hz	± 0.001% ± 10 Hz
Output level				
a) range	+ 10 to −40 dBm (+12 to −45 dNm)	+ 20 to −40 dBm (+23 to −45 dNm)	+10 to −60 dBm (+12 to −70 dNm)	+10 to −60 dBm (+12 to −70 dNm)
b) accuracy at 0 dBm (0 dNm) and at the reference frequency at 20°C and with nominal power supplies	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.2 dB (± 0.2 dNp)	± 0.2 dB (± 0.2 dNp)
c) accuracy at any level or frequency within the range	± 0.5 dB (± 0.6 dNp)	± 0.5 dB (± 0.6 dNp)	± 0.5 dB (± 0.6 dNp)	± 0.5 dB (± 0.6 dNp)

TABLE 1 *(cont.)*

	Telephone-type circuits	Sound-programme circuits	Groups, supergroups, and 12-, 60-, 120-, and 300-channel systems	Mastergroups, super-mastergroups and 900- to 2700-channel systems
1	2	3	4	5
Output level (cont.)				
d) Stability				
— per hour at 20°C and with nominal power supplies	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)
— per 10°C over a specified range of temperature and with nominal power supplies (Note)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)
— per 10% change in power supply at 20°C	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)
Purity of output				
Ratio of total output power to power of unwanted signals (noise, harmonic and non-harmonic frequencies)	at least 40 dB (46 dNp)	at least 50 dB (57 dNp)	at least 46 dB (53 dNp)	at least 46 dB (53 dNp)
Output impedance				
a) nominal value (other values may be specified if required)	600 ohms balanced	600 ohms balanced or not greater than 6 ohms balanced for constant voltage techniques	75 ohms unbalanced or 150 ohms balanced or 600 ohms balanced	50 or 75 ohms unbalanced
b) return loss against the nominal value	at least 30 dB (35 dNp)	at least 30 dB (35 dNp)	at least 30 dB (35 dNp)	at least 30 dB (35 dNp)
c) balance about earth (where applicable)	at least 40 dB (46 dNp)	at least 60 dB (70 dNp)	at least 40 dB (46 dNp)	

Note. — The range of temperature on which the apparatus must satisfactorily operate must be specified. This depends very largely on geographical location.

TABLE 2

Essential performance requirements of wideband and selective level-measuring instruments
(not sweep-display or fixed frequency)

	Telephone-type circuits	Sound-programme circuits	Groups, supergroups, and 12-, 60-, 120-, and 300-channel systems	Mastergroups, super-mastergroups and 900- to 2200-channel systems
1	2	3	4	5
Frequency				
a) range	200 Hz to 4 kHz	30 Hz to 20 kHz	4 to 1400 kHz	60 kHz to 17 MHz
b) nominal bandwidth for selective measurements (Note 1)	40 Hz	40 Hz	600 Hz and 4 kHz	600 Hz and 4 kHz
Range of input level				
a) wideband	+20 to −50 dBm (+23 to −58 dNm) down to −70 dBm (±80 dNm) with reduced accuracy	+20 to −50 dBm +23 to −58 dNm) down to −70 dBm (−80 dNm) with reduced accuracy	+20 to −50 dBm (+23 to −58 dNm)	+20 to −50 dBm (+23 to −58 dNm)
b) selective	+20 to −80 dBm (+23 to −92 dNm)	+20 to −80 dBm (+23 to −92 dNm)	+20 to −90 dBm (+23 to −100 dNm) down to −110 dBm (−127 dNm) with reduced accuracy	+20 to −90 dBm (+23 to −100 dNm) down to −110 dBm (−127 dNm with reduced accuracy
Measuring accuracy				
a) at 0 dBm (0 dNm) and at the reference frequency at 20°C and with nominal power supplies if internal calibration is provided	± 0.2 dB (± 0.2 dNp) ± 0.1 dB (± 0.1 dNp)	± 0.2 dB (± 0.2 dNp) ± 0.1 dB (± 0.1 dNp)	± 0.2 dB (± 0.2 dNp) ± 0.1 dB (± 0.1 dNp)	± 0.2 dB (± 0.2 dNp) ± 0.1 dB (± 0.1 dNp)
b) at any level and frequency within the ranges (Note 2)	± 0.5 dB (± 0.6 dNp)	± 0.5 dB (± 0.6 dNp)	± 0.5 dB (± 0.6 dNp)	± 0.5 dB (± 0.6 dNp)

TABLE 2 *(cont.)*

	Telephone-type circuits	Sound-programme circuits	Groups, supergroups, and 12-, 60-, 120-, and 300-channel systems	Mastergroups, super-mastergroups and 900- to 2200-channel systems
1	2	3	4	5
Stability of indicated level (Note 3)				
a) per hour at 20°C and with nominal power supplies	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)
b) per 48 hours at 20°C and with nominal power supplies	± 0.3 dB (± 0.4 dNp)	± 0.3 dB (± 0.4 dNp)	± 0.3 dB (± 0.4 dNp)	± 0.3 dB (± 0.4 dNp)
c) per 10°C over a specified range of temperature and with nominal power supplies (Note 3)	± 0.5 dB (± 0.6 dNp)	± 0.5 dB (± 0.6 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)
d) per 10% change in power supply at 20°C	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)	± 0.1 dB (± 0.1 dNp)
Level of unwanted signals				
Generated by the instrument itself and appearing at the input terminals relative to the lowest acceptable input level measured at the input terminals	−20 dB (−23 dNp) or lower	−20 dB (−23 dNp) or lower	−20 dB (−23 dNp) or lower	−20 dB (−23 dNp) or lower
Input impedance				
a) nominal value for terminated level measurements. Other nominal values may be specified if required	600 ohms balanced	600 ohms balanced or at least 20×10^3 ohms balanced for constant voltage techniques	75 ohms unbalanced or 150 or 600 ohms either balanced or unbalanced	50 or 75 ohms unbalanced
b) value for through-level measurements	at least 25×10^3 ohms balanced	at least 20×10^3 ohms	through-level measurements not recommended	through-level measurements not recommended
c) return loss against nominal value (for terminated-level measurements)	at least 30 dB (35 dNp)	at least 30 dB (35 dNp)	at least 30 dB (35 dNp)	at least 30 dB (35 dNp)

TABLE 2 (*concl.*)

	Telephone-type circuits	Sound-programme circuits	Groups, supergroups, and 12-, 60-, 120-, and 300-channel systems	Mastergroups, super-mastergroups and 900- to 2200-channel systems
1	2	3	4	5
Input impedance (cont.)				
d) balance about earth where applicable through-level or terminated-level	at least 40 dB (46 dNp)	at least 60 dB (70 dNp)	at least 40 dB (46 dNp)	
Image frequency rejection	at least 50 dB (58 dNp)	at least 50 dB (58 dNp)	at least 60 dB (70 dNp)	at least 60 dB (70 dNp)

Note 1. — It is necessary to specify in some detail the response characteristic of the nominal bandwidth for selective measurements.

Note 2. — Although the actual return loss of the input impedance is specified to be not greater than 30 dB (35 dNp) the instrument should be arranged (when connected to a generator of exactly the appropriate nominal value) to indicate the level that would be developed across an impedance, with a return loss of at least 40 dB (46 dNp) against the nominal value.

Note 3. — The stability limits include the effects of frequency variation of any built-in local oscillator in selective measuring sets.

Note 4. — The range of temperature over which the apparatus must satisfactorily operate must be specified. This depends very much on geographical location.

SUPPLEMENT No. 3.2

NOISE-MEASURING INSTRUMENTS FOR TELECOMMUNICATION CIRCUITS

1. *General*

In order to establish performance standards for telecommunication purposes, it is necessary to be able to measure the interfering effect of noise. For international telecommunications, it is important that the results of these measurements should be expressed in terms that are internationally understood. This supplement provides an up-to-date (1968) summary of the most widely used terms for expressing noise values.

In measurements of noise, it must be possible to make a quantitative assessment of the effects of noise on a listener such that two noises that are judged to be of equal interfering effect are given, in the measurement, numerically equal values. To achieve this result, two main factors must be taken into account, namely:

— the important qualities of the human hearing mechanism (subjective factor),

— the characteristics of the telecommunication system on which the measurement is to be made (objective factor).

To allow for the subjective factor, it is necessary to take into account the interfering effect of noise in the presence and absence of speech. This means that an assessment must be made of the relative interfering effects of single frequency noise components in a telephone connection, and of the way in which the ear adds these components as a function of frequency and time to give the overall effect.

Individual variations occur in respect of both the subjective factor and the objective factor, so that for a practical assessment of the interfering effect of noise, some standardized average characteristics must be agreed upon. Measurements are then made with a standardized instrument having these characteristics. For specific purposes, different instruments having different characteristics are required, and, furthermore, changes that result from progress in the design of telecommunication systems involve changes in the objective factor, and hence necessitate changes in measuring instrument characteristics.

The instrument developed for making noise measurements on telecommunications equipment consists essentially of a voltmeter having specified ballistic characteristics which is connected to the circuit on which the noise measurement is to be made, through a network having a specified attenuation/frequency characteristic called the "weighting characteristic". The two main specifiers of weighting characteristics, the C.C.I.F. (now the C.C.I.T.T.) and the American Telephone and Telegraph Company, have arrived at their respective weighting characteristics from subjective tests using particular telecommunications equipment. Each of them has specified two sorts of weighting characteristic—one for commercial telephone circuits and one for sound-programme circuits. The various weighting characteristics that have been specified, together with their origin and the date of their introduction are given in section 2. In a general way, all of the various characteristics have points in common. Their differences in detail prevent accurate and simple conversion of results obtained with one noise-measuring instrument into terms of the results that would be achieved with another, but approximate conversions can be made. These are shown in section 3. Details of C.C.I.T.T. psophometer specifications are given in C.C.I.T.T. Recommendation P.53 (*Red Book*, Volume V) and some relevant characteristics are shown in the following Figures 1-6 and Tables 1 to 4. The noise-measuring sets used in the U.S.A. are described in the Annex, which also gives graphically the various characteristics.

2. *List of weighting characteristics for psophometers and noise-measuring sets*

Type of characteristic	Specified by	Date of standardization
Speech circuit Sound-programme circuit	C.C.I.F. (Budapest)	1934 (superseded)
Speech circuit 144-line 144-receiver	U.S.A.	1941 (obsolete)
Speech circuit F1A line HA1 receiver	U.S.A.	1941 (obsolete)
Speech circuit	C.C.I.F. (Montreux)	1946
Sound-programme circuit	C.C.I.F. (Paris)	1949
Speech circuit C-message	U.S.A.	About 1959
Speech circuit Sound-programme circuit	C.C.I.T.T. (New Delhi)	1960 (minor changes only to 1946 and 1949 characteristics)
Sound-programme circuit (5 kHz)	U.S.A.	1941 [1]

[1] However, the most recent characteristic given for the U.S.A. noise-measuring set for sound-programme circuits differs from the one mentioned to the C.C.I.F. by the A. T. & T. Co. in 1947-48.

3. *Noise measurements on speech circuits*

3.1 *Comparison of weighting characteristics*

The various weighting characteristics at present in use for speech circuits are as follows:

Internationally — C.C.I.T.T. psophometer with 1960 weighting network

U.S.A. — Noise-measuring set with
- — 144-line weighting (obsolete)
- — F1A line weighting (obsolete)
- — C-message weighting

The measurements made with the C.C.I.T.T. psophometer are expressed in millivolts and limiting values are usually given in terms of voltage measured across a pure 600-ohm termination. Zero weighting occurs for a sinusoidal signal having a frequency of 800 Hz.

Measurements made with U.S.A. noise-measuring sets are expressed in decibels with respect to a specified noise reference power. For the various weightings, the reference power at 1000 Hz is:

144-line weighting (obsolete)	—90 dBm (measurements expressed in dBrn)
F1A line weighting (obsolete)	—85 dBm (measurements expressed in dBa)
C-message weighting	—90 dBm (measurements expressed in dBrnC)

There is some correspondence between the shapes of the various weighting characteristics. This correspondence makes possible more or less accurate conversions between the readings obtained with the various instruments. Since the U.S.A. 144-line weighting characteristic is obsolete, it is not considered further. The F1A line weighting characteristic is now also obsolete but is retained here for interest.

The shape of the latest (1960) C.C.I.T.T. psophometer characteristic for speech circuits is shown in Figure 1. It differs from C-message weighting as follows:

3.1.1 C-message and F1A line weightings give zero weight at the peak of the characteristic at 1000 Hz.

3.1.2 C-message weighting gives somewhat less weight to frequencies below 800 Hz and more weight to frequencies between 1500 and 3500 Hz than does the 1960 C.C.I.T.T. psophometer characteristic.

3.1.3 Psophometer weighting gives zero relative weight to frequencies of 800 Hz and 1200 Hz. At 1000 Hz, the weight is +1.0 dB.

The shape of the C-message weighting characteristic which is now standard in the U.S.A. is sensibly different from all others, though the difference in weighting at 1000 Hz and at 800 Hz for a sinusoidal signal is the same as for F1A line weighting.

The weighting coefficients for C-message weighting are given in Table 2. These values are in dB below the reference of 0 dB at 1000 Hz. The table also includes the overall tolerances within which the response of any noise-measuring set equipped for C-message weighting should fall. Figure 2 shows the nominal C-message weighting curve as plotted from the data in Table 2.

3.2 *Conversion for an 800-Hz sinusoidal signal*

From paragraph 3.1 above, it follows that for an 800-Hz sinusoidal signal producing 0.775 volt across a 600-ohm pure resistance, the following readings will be obtained:

Psophometer with C.C.I.T.T. 1960 weighting network	775 millivolts (this, under the conditions stated, corresponds to 0 dBm)

TABLE 1

Weighting coefficient for telephone circuits [1] (see Figure 1)

Frequency in Hz	Nominal value in dB relative to value at 800 Hz	Tolerances
50	−63.0	50 to 300 Hz ± 2 dB
100	−41.0	300 to 800 Hz ± 1 dB
150	−29.0	800 Hz ± 0 dB
200	−21.0	800 to 3000 Hz ± 1 dB
300	−10.6	3000 to 3500 Hz ± 2 dB
400	−6.3	3500 to 5000 Hz ± 3 dB
500	−3.6	
600	−2.0	
800	0.0	
1000	+1.0	
1200	0.0	
1500	−1.30	
2000	−3.00	
2500	−4.20	
3000	−5.60	
3500	−8.5	
4000	−15.0	
5000	−36.0	

[1] For more detailed values see Recommendation G.223 of Volume III of the *White Book.*

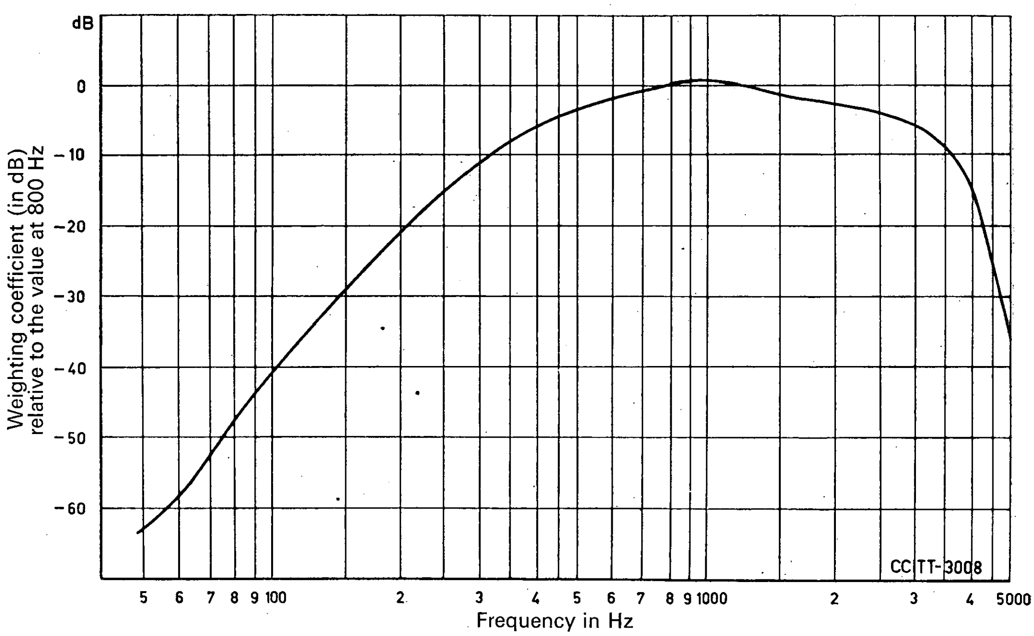


FIGURE 1. — **Curve of the C.C.I.T.T. psophometer weighting network used for noise measurements on telephone circuits**

TABLE 2

" *C Message* " *weighting coefficients* (see Figure 2)

Frequency in Hz	Nominal value in dB relative to value at 1000 Hz	Tolerances
60	55.7	60 to 300 Hz ± 2 dB
100	42.5	300 to 1000 Hz ± 1 dB
200	25.0	1000 Hz 0 dB
300	16.5	1000 to 3000 Hz ± 1 dB
400	11.4	3000 to 3500 Hz ± 2 dB
500	7.5	3500 to 5000 Hz ± 3 dB
600	4.7	
700	2.7	
800	1.5	
900	0.6	
1000	0	
1200	0.2	
1300	0.5	
1500	1.0	
1800	1.3	
2000	1.3	
2500	1.4	
2800	1.9	
3000	2.5	
3300	5.2	
3500	7.6	
4000	14.5	
4500	21.5	
5000	28.5	

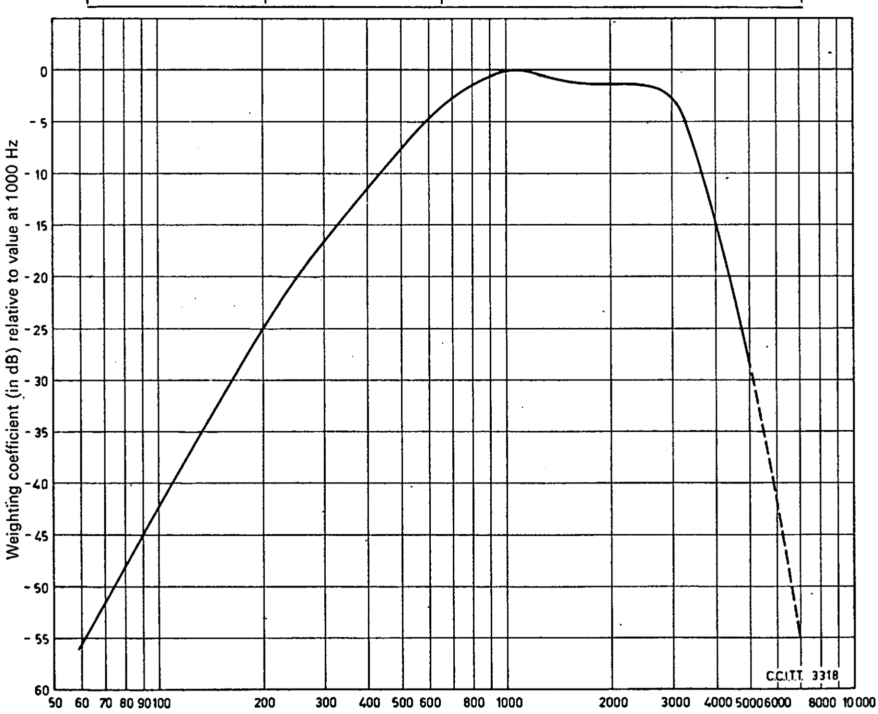


FIGURE 2. — " C Message " weighting curve

U.S.A. noise-measuring set

— with F1A line weighting	$+85 - 1 = +84$ dBa
— with C-message weighting	$+90 - 1 = +89$ dBrnC (rounded to the nearest dB)

However, apart from the difference between the various characteristics at 800 Hz and 1000 Hz, these results take no account of the shape of the characteristics, and it is only in the case of the F1A-line weighting characteristic which is about the same shape as the 1960 C.C.I.T.T. characteristic that the difference indicated above will be observed in measurements of noise.

A comparison of these various characteristics is given in Figure 3.

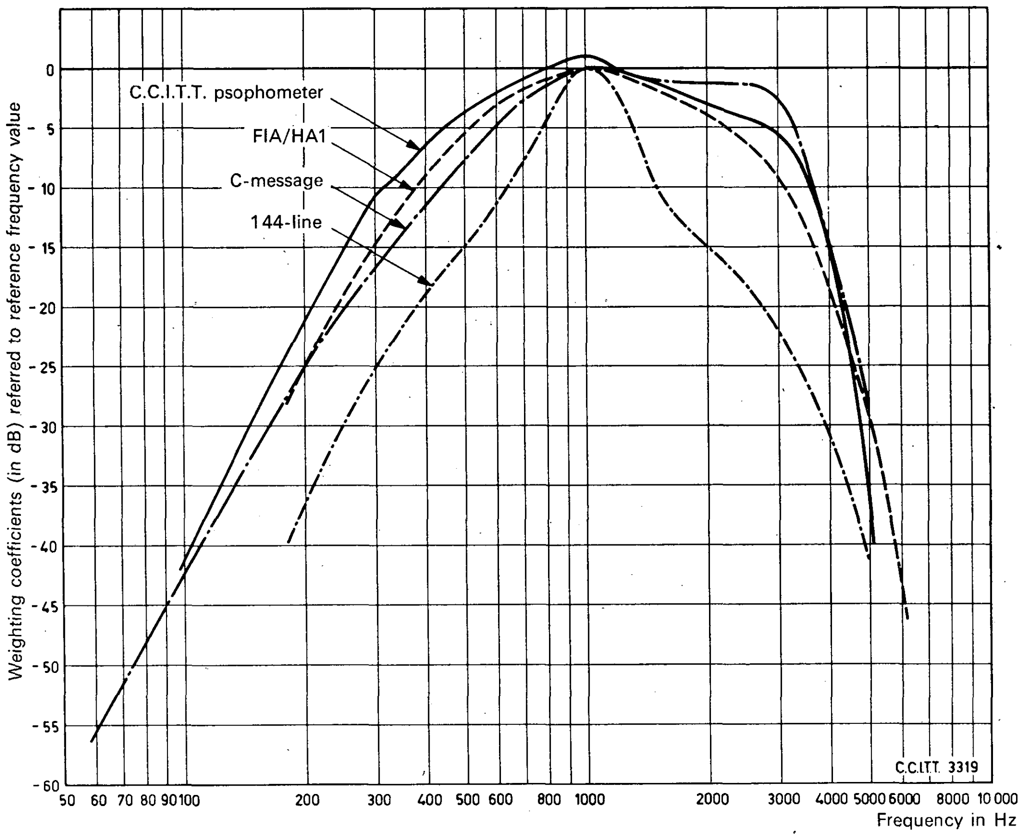


FIGURE 3. — **Comparative weighting curves of U.S.A. noise-measuring sets and the C.C.I.T.T. psophometer for telephone circuits**

All curves are referred to 1000 Hz except psophometric, which is referred to 800 Hz. The " 144-line " weighting curve is included for historical interest.

3.3 *Conversion factors for general*[1] *noise measurements*

3.3.1 *dBa to dBrnC*

It has been estimated that for measurements of general noise made in the U.S.A., the correspondence between measurements made with noise-measuring sets with F1A line and with C-message weighting can be rounded up to:

$+A$ dBrnC $= +B$ dBa $+6.0$[1]

The following general relationships are therefore approximately accurate for general noise measurements on a metallic circuit made with the various weighting networks at present in use.

3.3.2 *Millivolts psophometric to dBmp*

$$x \text{ dBmp} = 20 \log \frac{0.775}{y \times 10^{-3}}$$

where y is the reading in millivolts of a psophometer using the 1960 C.C.I.T.T. weighting network

x is the conversion into decibels referred to 1 milliwatt, assuming the measurement to be made across a 600-ohm pure resistance (the sign of x being appropriately chosen).

3.3.3 *dBa to dBmp*

x dBmp $= (B - 85 + 1)$, where B is the reading of the U.S.A. noise-measuring set in " dBa " (using F1A line weighting)

3.3.4 *dBrnC to dBa*

$+ B$ dBa $= A$ dBrnC -6[1]

where B is the reading of the set with F1A line weighting and A is the reading of the U.S.A. noise-measuring set with C-message weighting.

3.3.5 *dBrnC to dBmp*

$$\begin{aligned} x \text{ dBmp} &= (A - 85 + 1 - 6)^{1} \\ &= (A - 90) \end{aligned}$$

where A is the reading of the U.S.A. noise-measuring set with C-message weighting.

4. *Noise measurements on sound-programme circuits*

The present C.C.I.T.T. weighting characteristic for sound-programme circuits was adopted (except for the tolerance limits) by the C.C.I.F. in 1949. The values specified for the

[1] In the case of conversion involving values in dBrnC, different conversion factors need to be applied for different sorts of noise.

The figures given here refer to general noise on a circuit on a metallic line. For other sorts of noise, and for noise to earth, the value of 6 given here needs to be replaced by other values given in the Appendix to the Annex of this Supplement.

TABLE 3

Programme weighting coefficients used in North America (see Figure 5)

Frequency in Hz	Nominal value in dB relative to value at 1000 Hz	Tolerance
100	−26.3	±2
200	−17.3	
300	−12.2	
400	−9.0	
500	−6.6	
600	−4.7	±1
700	−3.2	
800	−2.0	
900	−0.8	
1000	0	
1500	+3.2	
2000	+4.8	
2500	+5.6	±2
3000	+6.0	
4000	+6.5	
5000	+6.5	
6000	+6.4	±3
7000	+5.8	
8000	+4.0	
9000	−1.5	±4
10 000	−8.5 [1]	

[1] The attenuation shall continue to increase at a rate not less than 12 dB per octave until the insertion loss of the network is not less than 60 dB.

characteristic are given in Volume V of the C.C.I.T.T. *Red Book,* page 131, and are re-reproduced in Table 4.

The curve of the weighting network is given in Figure 4.

The present characteristic was developed from figures supplied by the A.T. and T. Co. However, the characteristic now used in North America (see Table 3 and Fig. 5) is slightly different from that proposed to the C.C.I.F. in 1947/1948. As will be seen from Table 4, the nominal values of the C.C.I.T.T. weighting coefficients are approximately all within the tolerance range of the North-American weighting coefficients.

A graphical comparison between the limiting values of the C.C.I.T.T. weighting curve and the nominal weighting curve used in North America is given in Figure 6.

No information is available on whether or not a correction factor is necessary in respect of the C.C.I.T.T. and North-American sound-programme weighting coefficients.

TABLE 4

Comparison table of weighting coefficients as specified for the C.C.I.T.T. sound-programme circuit psophometer and for the programme weighting coefficient used in North America

Frequences (Hz)	Weighting coefficient relative to 1000 Hz for sound-programme circuits							
	C.C.I.T.T.					North America		
	nepers		dB		Tolerance range in dB	Tolerance range in dB	dB	
	Nominal	Tolerance	Nominal	Tolerance			Tolerance	Nominal
20 and below	$\leqslant -4.6$	—	$\leqslant -40$	—	—	—	—	—
50	−3.95	± 0.17	−34.3	± 1.5	−35.8 to −32.8	—	—	—
60	−3.70	± 0.17	−32.2	± 1.5	−33.7 to −30.7	—	—	—
100	−3.00	± 0.17	−26.1	± 1.5	−27.6 to −24.6	−28.3 to −24.3	± 2	−26.3
200	−2.00	± 0.17	−17.3	± 1.5	−18.8 to −15.8	−19.3 to −15.3	± 2	−17.3
300	—	—	—	—	—	−14.3 to −10.3	± 2	−12.2
400	−1.01	± 0.17	−8.8	± 1.5	−10.3 to −7.3	−11.0 to −7.0	± 2	−9.0
500	—	—	—	—	—	−8.6 to −4.6	± 2	−6.6
600	—	—	—	—	—	−5.7 to −3.7	± 1	−4.7
700	—	—	—	—	—	−4.2 to −2.2	± 1	−3.2
800	−0.22	± 0.17	−1.9	± 1.5	−3.4 to −0.4	−3.0 to −1.0	± 1	−2.0
900	—	—	—	—	—	−1.8 to +0.2	± 1	−0.8
1000	0	—	0	—	—	−1 to +1	± 1	0
1500	—	—	—	—	—	+2.2 to +4.2	± 1	+3.2
2000	+0.61	± 0.17	+5.3	± 1.5	+5.8 to +8.8	+3.8 to +5.8	± 1	+4.5
2500	—	—	—	—	—	+3.6 to +7.6	± 2	+5.6
3000	—	—	—	—	—	+4.0 to +8.0	± 2	+6.0
4000	+0.94	± 0.17	+8.2	± 1.5	+6.7 to +9.7	+4.5 to +8.5	± 2	+6.5
5000	+0.97	± 0.17	+8.4	± 1.5	+6.9 to +9.9	+4.5 to +8.5	± 2	+6.5
6000	+0.94	± 0.17	+8.2	± 1.5	+6.7 to +9.7	+3.4 to +9.4	± 3	+6.4
7000	+0.84	± 0.17	+7.2	± 1.5	+5.7 to +8.7	+2.8 to +8.8	± 3	+5.8
8000	+0.59	± 0.17	+5.1	± 1.5	+3.6 to +6.6	+1.06 to +7.0	± 3	+4.0
9000	−0.03	± 0.35	−0.3	± 3.0	−3.3 to +2.7	−2.5 to +6.5	± 4	−1.5
10 000	−1.12	± 0.35	−9.7	± 3.0	−12.7 to −6.7	−12.5 to −4.5	± 4	−8.5 [1]
13 000	$\leqslant -3.5$	—	$\leqslant -30$	—	—	—	—	—
20 000 and above	$\leqslant -4$	—	$\leqslant -35$	—	—	—	—	—

[1] The attenuation shall continue to increase at a rate not less than 12 dB per octave until the insertion loss of the network is not less than 60 dB.

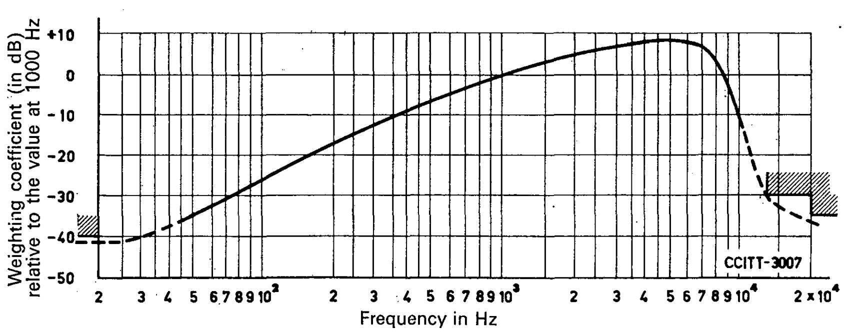
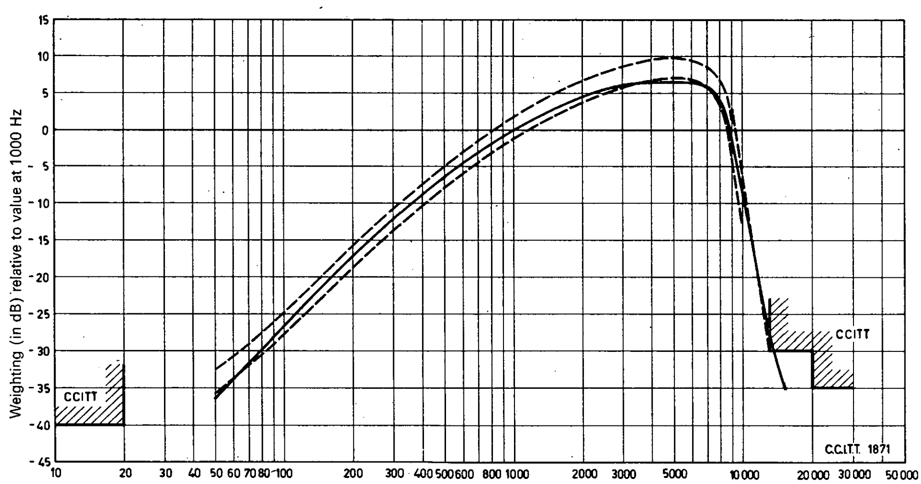


FIGURE 4. — **Curve of the C.C.I.T.T. psophometer weighting network used for noise measurements on sound-programme circuits**

FIGURE 5. — **Curve of the weighting network used in North America for noise measurements on sound-programme circuits**
(WE Instruction Bulletin No. 1302, Issue No. 1, 3A noise-measuring set 594 003 A)



– – – – – – Specified tolerance limits for 1960 C.C.I.T.T. weighting curve for noise measurements on sound-programme circuits (zero tolerance at 1000 Hz)

———— Curve of the programme weighting network used in North America

FIGURE 6. — **Comparison of the curves of weighting networks for noise measurements on sound-programme circuits**

ANNEX

(to Supplement No. 3.2)

Noise-measuring sets used in the U.S.A.

1. *General*

There have been several noise-measuring set combinations used in the U.S.A. The older sets are now largely replaced by the 3-type noise-measuring sets. A description of the obsolete sets is given below for historical interest, followed by a description of the 3-type sets.

1.1 *The 2A and 2B noise-measuring sets* (obsolete)

The 2A noise-measuring set, introduced in 1937, was the first device that adequately realized the primary objective of message circuit noise measurement. It was portable, and went a long way to imitate the important qualities of the hearing mechanism. A functional diagram of the set is shown schematically in Figure 7 below.

This set consisted of various input circuits, a number of filters to simulate weighting characteristics (the basic one for noise measurements being the 144 weighting), an attenuator, a three-stage vacuum tube amplifier, a quasi-r.m.s. (copper oxide) detector for power summation of weighted components and a decibel meter with a 200-millisecond integration time[1] to indicate the noise level in dBrn. Additional features included a self-contained battery power supply, and means for internal calibration. While these components were designated primarily from the standpoint of noise measurement, the set had other capabilities. For example, means were also made available for volume and sound level measurements—two features that were later standardized in other primary measuring devices.

The input impedances were chosen to be compatible with the telephone system. A 600-ohm line input was provided for making terminated noise measurements on trunk circuits. This input was designed to work with either the 144-line weighting or a flatter weighting suitable for the measurement of noise on 8-kHz programme circuits. In addition, a 200-ohm bridging impedance was supplied to measure noise across the receiver (the latter being low impedance). The weighting for receiver noise measurements was a modification of the 144-line weighting taking into account the line-to-receiver transfer characteristic of the deskband telephone.

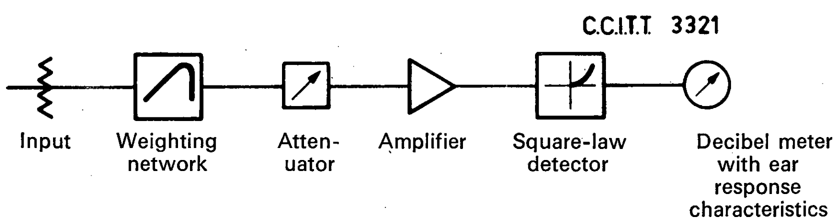


FIGURE 7. — **Schematic of 2A noise-measuring set**

[1] This is approximately the time required by the ear to appreciate the full loudness of a sound.

In addition to these three basic input arrangements, a 600-ohm bridging input was provided to enable the measurement of noise on working telephone circuits. The input circuit for noise-to-ground consisted of 100 000 ohms in series with the line input. This arrangement presented a high input impedance to ground and reduced the sensitivity to make the indicated noise-to-ground value comparable to the transverse noise value.

To make any of these measurements one simply connected the circuit under test to the proper input and adjusted the attenuator until the meter pointer gave a scale indication. The measurement was the sum of the attenuator setting and the meter indication. The former had a 60-dB range, whereas the meter scale had an 18-dB range. Reference noise in all cases was the meter reading (i.e. " zero ") obtained with 10^{-12} watts of 1000-Hz power dissipated at the point of measurement. The actual minimum measurable noise was in the order of 10 dBrn.

The " sound input ", in conjunction with a suitable microphone and matching transformer, permitted the set to be used for sound level measurements. While the minimum measurable level depended on the microphone and the transformer, the use of a standard condenser microphone and transformer enabled the measurement of sound level as low as 55 dB above reference. The weighting used in conjunction with such measurements corresponded closely to the " A " weighting currently found in sound level meters. The reference for sound measurements was chosen equivalent to 10^{-16} watts per square centimetre at 1000 Hz.

A major drawback of this set was that, for one-half of its 12 possible measurements, it was necessary to add various different correction factors to obtain the correct numerical magnitudes.

In essence, the 2B noise-measuring set was a modified 2A. Introduced in 1941, it incorporated the F1A line and the so-called HA1 receiver weighting for noise measurements in dBa, two extra sound weightings, and improved means of internal calibration. The new noise weightings were needed because of the advent of a new telephone set, which had a different response characteristic from the earlier desk telephone set for which the 2A set with its basic 144-line weighting had been designed.

For simplicity, the two new weightings were obtained by changing the responses of the 144-line and receiver networks. The result was that the modified networks had an inherent loss 12 dB greater at 1000 Hz than had had the original 144 networks. Since the reference level for F1A-HA1 weighted measurements was −85 dBm, compared with the reference level of −90 dBm for the two 144 weightings, the net difference in meter reading was 7 dB. Unfortunately, this necessitated a variety of additional correction factors for all F1A-HA1 noise measurements—the basic one being 7 dB for the F1A-HA1 line, receiver and noise-to-ground measurements.

1.2 *The 3-type noise-measuring set*

In the new 3-type noise-measuring set this situation no longer exists. This set is a scaled-down version of the 2B eliminating the volume, sound level, and receiver noise measurement features. It is a direct-reading set making the need for corrections unnecessary. In addition, the set is smaller and lighter due to the use of miniature components and transistor circuitry. It is more sensitive than either the 2B or 2A, and has an improved quasi-r.m.s. detector enabling bridging, terminating and noise-to-ground measurements to zero dBrn with C-message weighting.

Figure 8 gives a conversion chart suitable for conversion between C.C.I.T.T. and U.S.A. noise measurements on speech circuits.

Various correction factors are applied depending on the type of noise being measured. See the Appendix to this Annex in this connection.

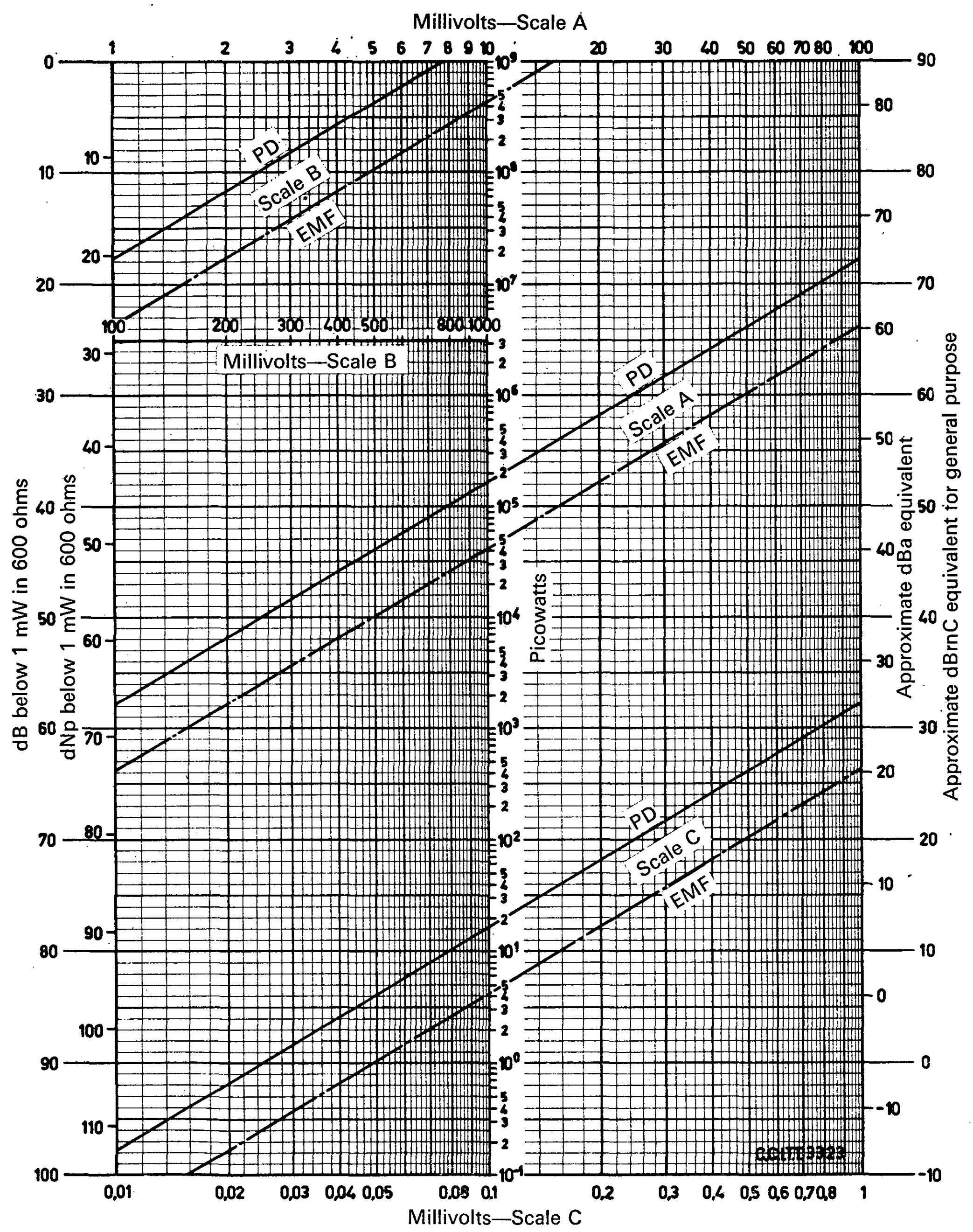


FIGURE 8. — **Comparison chart for potential difference (PD) and electromotive force (e.m.f.)—mV, dNp and dB below 1 mW in 600 ohms with dBrnC and dBa equivalents**

2. *Weighting characteristics*

The 3A set with the 497A network provides C-message weighting to give the characteristic for the measurement of message circuit noise. Networks for the measuring of noise on programme and special service circuits are also provided.

C-message weighting (C message WTG [1])

The shape of the C-message weighting characteristic (see the graph of Fig. 2), was determined by subjective tests of the relative interfering effects of single frequencies, as heard over a 500-type telephone set, both in the absence and presence of speech. This objective curve has since been verified and the tolerances established by measurements of production model 3-type noise measuring sets sampled at intervals since these sets have been available. C-message weighting may be also used for measurements of noise with respect to the earlier 300-type telephone set. The C-message weighting network is part of the plug-in 497A network package.

3-kHz flat weighting (3-kc flat WTG) [1]

The frequency response of the 3-kHz flat weighting is shown in Figure 9. This weighting network is included in the package of the 497A network and is used when extra sensitivity is needed to indicate the presence of low-frequency noise (20-Hz ringing current or 60 and 180 Hz from power induction).

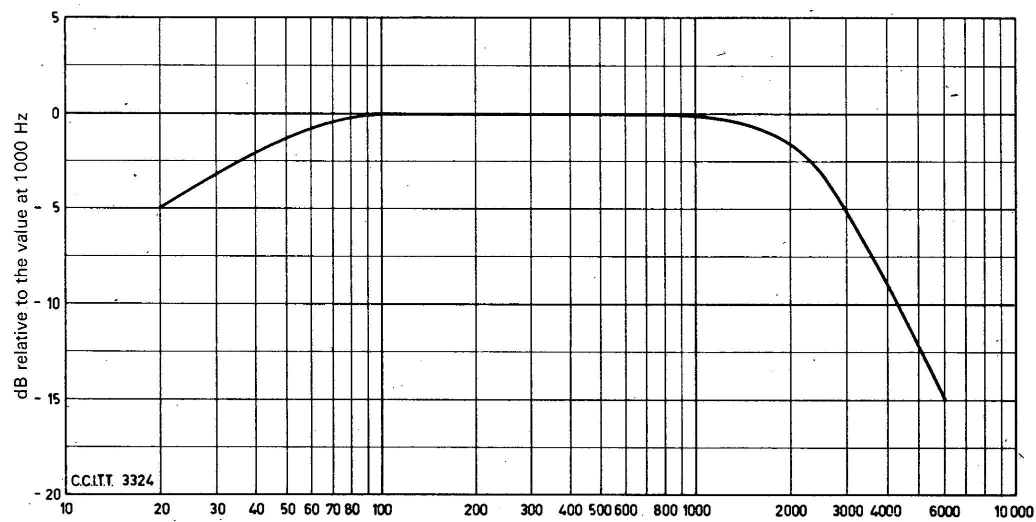


FIGURE 9. — **3-kHz flat weighting**

Programme weighting (Program WTG) [1]

For measurements of noise on programme circuits of bandwidths up to approximately 8000 Hz, the characteristics of the weighting used have been given in Figure 5. The programme weighting network is part of the 497B network package.

[1] The North-American code for these types of weighting is shown in brackets.

The programme weighting differs from the C-message weighting in that the design of weighting takes into account the frequency response of sound-programme circuits, rather than that of telephone circuits.

15-kHz flat weighting (15-kc flat WTG [1]).

The characteristics of the 15-kHz flat weighting are given in Figure 10. This network is packaged in the 497B plug-in unit.

The 15 kHz flat weighting is used to measure noise in studio-to-transmitter programme circuits and on those wired-music circuits having wider bandwidths than regular programme circuits.

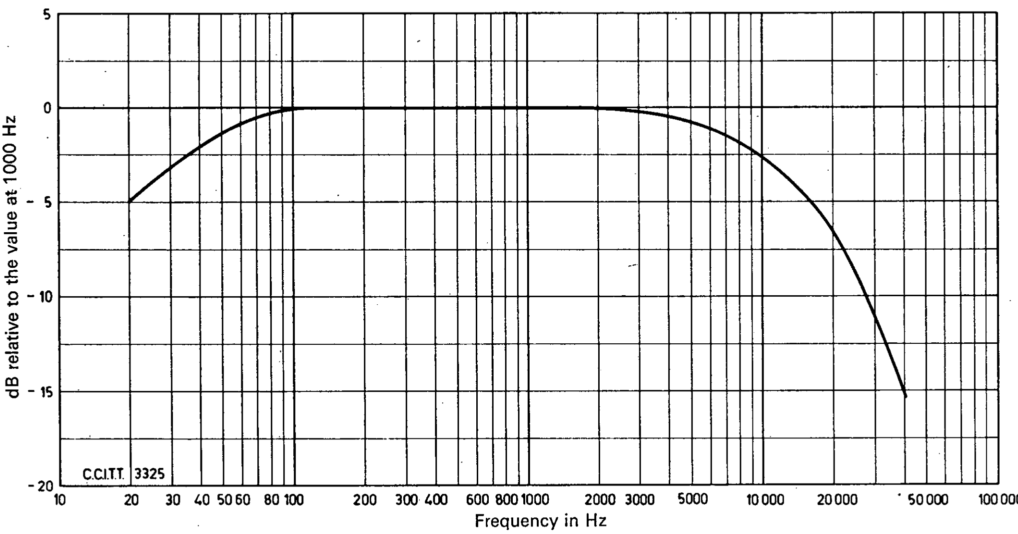


FIGURE 10. — **15-kHz flat weighting**

3. *References*

[1] D. A. LEWINSKI: A new objective for message circuit noise; *Bell System Technical Journal*, 43, March 1964, page 719. (See paragraph below.)

[2] W. T. COCHRAN and D. A. LEWINSKI: A new measuring set for message circuit noise; *Bell System Technical Journal*, 39, July 1960, page 911.

[3] A. J. AIKENS and D. A. LEWINSKI: Evaluation of message circuit noise; *Bell System Technical Journal*, 39, July 1960, page 879.

4. *Study of Question 4/XII by the C.C.I.T.T. in 1964-1968*

For this study, an extract was prepared for C.C.I.T.T. SG XII of the article mentioned above in reference [1]. This extract is reproduced below:

"In this article, noise is expressed in terms of readings with C-message weighting on the 3A noise meter now used in the United States. Because the weighting differs from that associated with the older 2B noise meter and the C.C.I.T.T. 1951 psophometer, the relationship among measurements with these instruments is influenced by the spectrum of the noise measured. If one milliwatt of white noise in the band 300-3400 Hz is applied to each, the following readings are obtained:

3A noise meter (C-message weighting)	88 dBrn
2B noise meter (F1A weighting)	81.5 dBa
C.C.I.T.T. psophometer (1951 weighting) . .	−2.5 dBm

Recognizing that the relationship will change for other noise spectra, the following rounded conversion factors are proposed for practical comparison purposes:

C.C.I.T.T. 1951 weighting		3A noise meter C-message weighting		2B noise meter F1A weighting
0 dBm	=	90 dBrn	=	84 dBa
−90 dBm	=	0 dBrn	=	−6 dBa
−84 dBm	=	6 dBrn	=	0 dBa

These conversion factors include the effect of the difference between the reference frequencies used (800 Hz in the C.C.I.T.T. psophometer, 1000 Hz in the American noise meters)."

APPENDIX TO THE ANNEX

(to Supplement No. 3.2)

Correlation between dBa and dBrn

The measurement of message circuit noise using the 2B noise-measuring set with F1A weighting is expressed in dBa (dBrn adjusted), while the 3A set with C message WTG reads directly in dBrn.

The relationship between dBa and dBrn depends upon the characteristics of the two weighting networks as shown in Figure 3. The Table below shows the relationship between dBa and dBrn for several types of noise that are frequently encountered in the field. For general use where type of noise is not identified, a noise metallic-correlation factor of 6 dB or noise-to-ground correlation factor of 10 dB should be used.

It is seen that the difference for the several types of noise is confined to a $\pm$ 1 dB range. The least difference between dBa and dBrn (5 dB) is applicable for power harmonic noise up to 540 Hz. The greatest difference occurs in the case of modulation product noise (characterized by frequency components in the upper part of the 3-kHz band). For single frequencies, the difference may be obtained from Figure 3.

Table showing approximate correlation between dBa and dBrn

Type of noise	Noise metallic			Noise to ground [1]		
	Measuring with			Measuring with		
	2B-NMS F1A dBa	3A-NMS C-mess. dBrn	Corr. factor dB	2B-NMS F1A dBa	3A-NMS C-mess. dBrn	Corr. factor dB
General message circuit type noise	20	26	6	20	30	10
Flat 3-kHz band-limited thermal noise	20	26	6	20	30	10
Power harmonics consisting of 180-300 and 540 Hz	20	25	5	20	29	9
Impulse type noise	20	26	6	20	30	10
Modulation product noise	20	27	7	20	31	11
Central office switching noise	20	26	6	20	30	10

[1] The correlation factor for noise-to-ground is higher than that for noise metallic because of the difference in the voltage divider ratio in the input circuit of the two sets.

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SUPPLEMENT No. 3.3

PRINCIPAL CHARACTERISTICS OF VOLUME INDICATORS

Type of instrument	Rectifier characteristic (Note 4)	Time to reach 99% of final reading (milliseconds)	Integration time (milliseconds) (Note 5)	Time to return to zero (value and definition)
(1) "Speech voltmeter" British type 3 (S.V.3) identical to the speech power meter of the A.R.A.E.N.	2	230	100 (approx.)	equal to the integration time
(2) Vu meter (United States of America) (Note 1)	1.0 to 1.4	300	165 (approx.)	equal to the integration time
(3) Speech power meter of the "S.F.E.R.T. volume indicator"	2	around 400 to 650	200	equal to the integration time
(4) Peak indicator for programme transmissions used by the British Broadcasting Corporation (B.B.C. Peak Programme Meter) (Note 2)	1		10 (Note 6)	3 seconds for the pointer to fall 26 dB
(5) Maximum amplitude indicator used by the Federal German Republic	1	around 80	5 (approx.)	1 or 2 seconds from 100% to 10% of the reading in the steady state
(6) OIRT—Programme level meter: Type A sound meter Type B sound meter		for both types: less than 300 ms for meters with pointer indication and less than 150 ms for meters with light indication	 10 ± 5 60 ± 10	for both types: 1.5 to 2 seconds from "0 dB" point at 30% of the length of the operational section of the scale

Notes to the table

Note 1. — In France a meter similar to the one defined in line (2) of the table has been standardized.

Note 2. — In the Netherlands a meter (type N.R.U.-ON301) similar to the one defined in line (4) of the table has been standardized.

The European Broadcasting Union has recommended its Members to use a meter whose electrical characteristics are similar to those described in line (4) of the table, for monitoring the level of international sound-programme transmissions. Its scale is graduated in dB relative to a TEST level corresponding to 0 dBm0, and it incorporates arrangements for increasing the integration time to approximately one second when it is required to compare volumes at widely separated locations.

Note 3. — In Italy a programme meter with the following characteristics is in use:

Rectifier characteristic: 1 (see note 4)
Time to reach 99% of final reading: approx. 20 ms
Integration time: approx. 1.5 ms
Time to return to zero: approx. 1.5 s from 100% to 10% of the reading in the steady state.

Note 4. — The number given in the column is the index n in the formula $[V_{(output)} = V_{(input)}{}^{n}]$ applicable for each half-cycle.

Note 5. — The "integration time" was defined by the C.C.I.F. as the "minimum period during which a sinusoidal voltage should be applied to the instrument for the pointer to reach to within 0.2 neper or nearly 2 dB of the deflection which would be obtained if the voltage were applied indefinitely". A logarithmic ratio of 2 dB corresponds to a percentage of 79.5% and a ratio of 0.2 neper to a percentage of 82%.

Note 6. — The figure of 4 milliseconds that appeared in previous editions was actually the time taken to reach 80% of the final reading with a d.c. step applied to the rectifying/integrating circuit. In a new and somewhat different design of this programme meter using transistors, the performance on programme remains substantially the same as that of earlier versions and so does the response to an arbitrary, quasi-d.c. test signal, but the integration time, as here defined, is about 20% greater at the higher meter readings.

SUPPLEMENT No. 3.4

AUTOMATIC MEASURING EQUIPMENT FOR SOUND-PROGRAMME CIRCUITS

A draft specification for such equipment has been published in an Annex to Question 13/IV in Volume IV of the *White Book*.

The final text of this Supplement will be published later.

SUPPLEMENT No. 3.5

C.C.I.T.T. AUTOMATIC TRANSMISSION-MEASURING EQUIPMENT No. 1 (FOR TELEPHONE-TYPE CIRCUITS)

1. *General*

The C.C.I.T.T. automatic transmission-measuring equipment is intended to make measurements replacing manual transmission measurements on batches of automatic (or semi-automatic) circuits and to present the results of such measurements in such a way as to facilitate automatic analysis for statistical purposes.

A distinction is made below between "outgoing equipment" and "incoming equipment". The "outgoing equipment" functions as the "master" equipment, and the "incoming equipment" as the "slave" equipment. When, as is likely, the equipments are identical, it should be possible by means of a switch to arrange them so that they can fulfil either function.

Measurement results will be recorded simultaneously at both ends of the circuit under test, by means of telegraph signals transmitted on that same circuit after each measurement. These results will be printed by a teleprinter associated with the equipment. It is left to national administrations, if they so wish, to arrange for their equipment to provide in addition a record of the results on punched tape.

2. *Kinds of measurement*

All measurements will be carried out for both directions of transmission. The following measurements will be made:

— noise measurement;

— transmission measurements at 400, 800 and 2800 Hz.

2.1 *Measurement of noise* [1]

The object of noise measurement will be to determine whether a circuit should be considered as "noisy" or "non-noisy".

The assessment of the noise value given by the noise-measuring equipment shall be in accordance with the value measured under similar conditions using a C.C.I.T.T. telephone circuit psophometer.

The threshold beyond which the circuit will be considered as noisy is expressed as a level referred to 0.775 volt. This threshold will not take account of the actual or nominal equivalent of the circuit. Without a knowledge of the equivalent of the circuit, the threshold cannot be expressed in the terms of a signal-to-noise ratio.

2.2 *Transmission measurements*

The automatic measuring equipment will be arranged to make either two-wire or four-wire measurements, depending on the switching system. If the switches have four-

[1] In this general specification, the expression "noise measurements" has been used throughout. Nevertheless, the automatic measuring equipment makes only a comparative assessment of noise to determine in a general way whether a circuit is noisy or non-noisy.

wire access to the circuits, suitable arrangements (attenuators, terminating unit) will be associated with the measuring equipment to ensure that the loss measurements can be within the range of 0 to 180 cNp.

For a circuit which has the designed loss the value indicated on the measuring equipment shall be 080 cNp. Such arrangements shall not affect the measuring accuracy.

2.3 *Test access*

So that measurement results obtained either manually or automatically (ATME) shall be compatible, it is thought to be essential for access in both instances to be provided to equivalent testing points, preferably via an equivalent access path. It is essential for the loss of the test access paths to be known, for the average loss to be compensated over the measuring frequency range and for the loss of the test access paths to be as stable as possible.

2.4 *Calibration*

The design of the measuring equipment shall be such that the specified measurement accuracy can be maintained over as long a period as possible without recalibration. Recalibration shall in any case not be necessary more often than once per week, but it is hoped that experience may show that longer intervals between recalibration may be possible.

3. *Operating principle of the automatic equipment*

The automatic measuring equipment shall be designed so that within a cycle, once each step in a cycle is concluded by one equipment, that equipment sends a suitable signal to the distant equipment so that the two equipments pass on to the next step in the cycle. This principle of "non-synchronous" operation has been adopted in preference to "synchronous" operation, in which each step is carried out in turn in accordance with a predetermined programme and in which each step would have a definite and constant duration.

"Non-synchronous" operation makes possible:

— a choice of measurement programme if desired;

— more rapid operation, if the measurement programme chosen is a shortened programme, because the equipment can be arranged to step-on in order to omit tests.

A choice of measurement programme in the outgoing station implies that the method of operation has to be *controlled* at the outgoing station and must use the principle in which backward signals only initiate the sending of the next forward signal but do not determine its nature, i.e. forward signals may be either "control" signals or "step-on programme" signals whereas backward signals may only be "step-on programme" signals.

3.1 *Preparation of the programme*

The general programme of a series of measurements (list of circuits to be measured and the kind of measurement to be carried out on each of them) will be prepared in advance (in the form of a perforated tape, for example) and introduced into the outgoing equipment.

3.2 *Measurement cycles*

For each circuit, there will be a choice between three measurement cycles:

cycle No. 1 = noise measurement, in each direction;

cycle No. 2 = level-measurement at 800 Hz, in each direction;

cycle No. 3 = level-measurement at 800 Hz, then at 400 Hz, then at 2800 Hz, in each direction alternately.

The cycles will be identified by transmission of a signalling pulse f_s, two signalling pulses f_s, and three signalling pulses f_s, respectively.

The following combinations will be possible:

— cycle No. 1 alone;
— cycle No. 2 alone;
— cycle No. 3 alone;
— cycle No. 1 followed by cycle No. 2;
— cycle No. 1 followed by cycle No. 3.

4. *Sequence of operation of a circuit being measured* (see Annex 1)

The operations take place in the following way:

— seizure of the circuit to be measured at the outgoing centre will take place in accordance with the specification for the signalling system in use;
— access to the automatic measuring equipment in the incoming centre;
— an exchange, by means of telegraph signals, of the circuit number and the codes of the centres;
— carrying out of one or more of the cycles laid down in the programme, including the printing of the results of each measurement;
— local printing of the date and time;
— release of the automatic equipment and the circuit.

4.1 *Sequence of operations within a measurement cycle* (see Annex 1)

Before a measurement cycle begins, one, two or three signal impulses f_s are sent as a start signal. These pulses last for 150 $\pm$ 30 ms, and any silent intervals between them will last for 100 $\pm$ 20 ms. The outgoing equipment, when it interprets its programme, transmits the f_s pulses indicating the measurement to be carried out.

The measurement cycle start signal causes local starting of the measurement operation, that is to say:

— for a noise measurement, it terminates the circuit with 600 ohms resistance within 150 ms;
— for level measurements at 400, 800 or 2800 Hz, it causes sending of the necessary frequency within 150 ms.

Reception of the signalling pulse (or pulses) f_s by the incoming equipment causes the measuring equipment (for level or for noise) to be connected after a delay of at least 150 ms.

When the measurement is finished, the result is translated into a telegraph signal, printed locally, and transmitted to the other end. The telegraph signal transmission is preceded by transmission of an f_s pulse of 150 $\pm$ 30 ms which causes the disconnection of the measuring equipment (generator, etc.). It is terminated by the sending of the "bell" signal which causes the appropriate equipment to be connected and the next (2nd) measurement of the cycle to begin (measurement in the other direction of transmission).

The same procedure takes place for the transmission of the result and, if necessary, for the third measurement of the cycle, etc.

When the cycle is finished, the outgoing equipment transmits the f_s pulses indicating the next cycle to be carried out.

4.2 *Guarding against instability*

If the circuit being measured ends in a two-wire termination, either normally during the measurements or during a particular phase of the measurement cycles, it shall be arranged that the two-wire end shall always be terminated with a resistance of 600 ohms. This resistance will only be disconnected when a measuring circuit of equivalent impedance is substituted for it.

4.3 *Conditions when changing from one measurement series to the next*

If for any reason the duration of a given series of measurements is extended, it could happen that the series is still not completed by the time another measurement series must be started.

Since the "master" equipment determines the measurement programme, it is in general desirable for this equipment to be able to start its measurement on time, whether the previous programme is completed or not. This should be borne in mind in drawing-up plans for overall test programmes.

Four cases can be distinguished:

a) the apparatus is in the process of carrying out a series of measurements in the capacity of "master" equipment at the time when it must begin another series of measurements. To avoid disturbing the measurement programme, it is desirable that the first series should not be continued to its conclusion and that the new measurements should commence on time;

b) the apparatus is carrying out a series of measurements in the capacity of "master" equipment at the time when it must serve as "slave" equipment for another series of measurements. In this case the measurements under way are interrupted and the apparatus is prepared for receiving incoming calls;

c) the apparatus is working as a "slave" equipment in a series of measurements at the time when it must start measurements as a "master" equipment. In this case, it is desirable to start the new series without completing the series under way;

d) the apparatus is working as "slave" equipment in a measurement series at the moment when it must be ready to serve as "slave" equipment for another measurement series. In this case, the condition of the measuring apparatus remains the same and the programme cannot be altered. It is a question of chance which measurements will take precedence.

5. *Print-out*

5.1 *Measurement results*

The results will be transmitted and recorded in centinepers, in the range —001 to —180 centinepers (the sign will be left out).

This range has been chosen rather than a range having 0 as a median value, because the automatic measuring equipment does not take account of the nominal value of overall loss. For a circuit having its designed loss, the result recorded by the automatic measuring equipment will be 080.

Received levels higher than —001 centinepers will be shown by the sign + + +;

Received levels lower than —180 centinepers will be shown by the sign — — —.

In the record of results, a noisy circuit shall be shown by the sign + and a non-noisy circuit by the sign —.

5.2 *Local symbols* (not to be transmitted)

Combinations 24, 22 and 2 of the "figures" series of international alphabet No. 2 will be used to indicate:

— circuit engaged;

— incoming equipment engaged;

— fault.

Combination 24 will indicate "circuit engaged". It will cause the sign / to be printed. This sign will always appear in the first column.

Combination 22 will indicate "equipment engaged". It will cause the sign = to be printed. This sign will always appear in the first column.

Combination 2 will indicate "fault". It will cause the sign ? to be printed. This sign may appear in any column of the results. If it has to indicate the absence of the return signal during hunting for the incoming equipment, it will be placed in the first column.

Administrations may use other symbols for print-out of local conditions particular to the station concerned.

The *date and time* (printed only locally and not transmitted) will be printed in the form of an 8-character block without spacing between the characters:

2 figures for the month
2 figures for the day
2 figures for the hour
2 figures for the minute

The time will be recorded in G.M.T.

6. *Telegraph requirements*

6.1 *Transmission between the two equipments*

This transmission will be carried out on the circuit being measured, using frequency modulated voice-frequency telegraph equipment in accordance with C.C.I.T.T. recommendations except as described below. The teleprinters placed at the ends will not need to be equipped with their transmitter mechanisms (the signals to be transmitted will come from the mechanisms of the automatic measuring equipment). The same telegraph frequency (f_t = 1500 Hz) will be used in both directions at a level of −1.67 neper or −14.5 dB at a zero relative level point on the telephone circuit. The teleprinter motor shall be kept running continuously throughout the measurement programme.

If the telephone circuit becomes disconnected the receiving equipment must assume the condition corresponding to the stop polarity and the modulator at the receiving end shall be made inoperative. The demodulator of the sending equipment shall have stop polarity on its output. Thereby the functions of the modulator at the sending end and demodulator at the receiving end shall be made operative in correspondence with the time sequence given in paragraph 6.5.

The characters should be transmitted as fast as possible in order to minimize the time spent on the measurement. The duration of one telegraph message must be sufficiently short so as to prevent time-out of the circuit (paragraph 6.4).

6.2 *Composition of the telegraph messages* (see Annex 3)

These messages will be composed solely of signals in the "figures" series in international alphabet No. 2.

The *circuit number* will be printed in the form 0XXX. The first digit 0 can be considered as a translation into digits of the prefix Z which identifies an automatic circuit. If, later, it is necessary to distinguish between semi-automatic and fully-automatic circuits, a digit other than 0 will provide the translation of the new identifying prefix to be allotted to fully-automatic circuits. Note that circuits Z1 will be read as 0001.

The *code of the centre* will be composed of the two-figure number indicating the country to which it belongs (under the C.C.I.T.T. code), followed by two or three figures (national exchange number of the centre in its own country).

The *results of each measurement* will be composed of four characters:

3 figures and a space for level measurements.

1 sign (+ or −) for noise measurements.

To ensure that only signs in the figure series are printed, the teleprinter will be mechanically blocked in position to print the figure series. The figure shift character (Signal No. 30) will not be sent and arrangements will be made to ensure the suppression of Signal No. 30 at the originating end.

6.3 *Bell signal*

The telegraph messages will end with the appropriate number of spaces, followed by Telegraph Signal No. 10 (bell) to indicate the end of message between teleprinters. Standardized teleprinters are so constructed that reception of this signal closes a contact. At each end of the circuit, the end of the telegraph message is indicated by the closing of this contact which may also start:

— either the measuring operation in the other transmission direction;

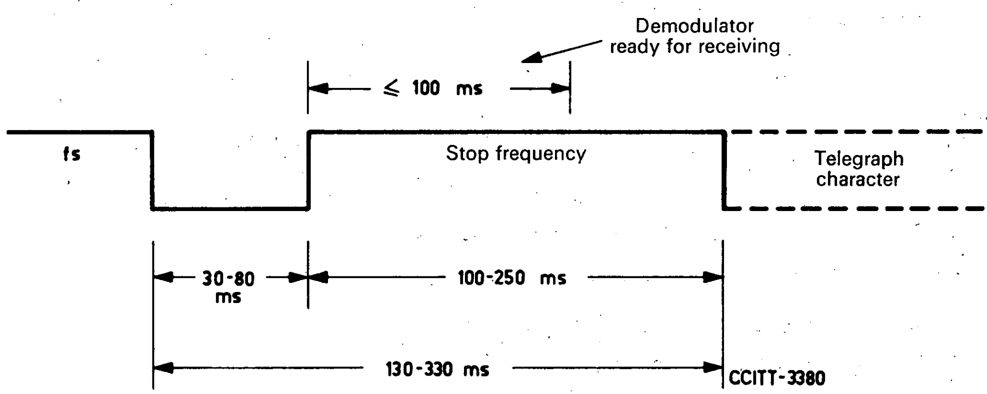
— or the following programme cycle.

On modern teleprinters, signal No. 10 causes the "Bell" sign to be printed and causes the carriage to move on. The printing of this sign could be suppressed but it would be difficult to suppress the carriage advance. On certain older teleprinters, signal No. 10 may not cause printing or carriage advance. The length of the lines printed on the result sheets will then be reduced.

6.4 *Occurrence of a fault during testing*

In the case of both equipments, independently of each other, if no new f_s signal is received or sent 15 $\pm$ 5 seconds after the last f_s signal sent or received (except if the latter is the "end-of-programme" or the "acknowledgement of receipt of end of programme" signal), an alarm shall be given and the fault sign ? printed, followed by the date and time and the return of the carriage. All the measuring and telegraph transmission equipments shall then be disconnected from the circuit, together with the automatic equipment itself (hanging-up).

If all the measurements in the programme have not been terminated, the outgoing equipment shall find the next circuit to be measured and the programme shall continue.



Connection and disconnection of demodulators

To ensure that the demodulator has adequate time to cancel the blocking of the telegraph relay, the stop frequency shall be connected to the line for a nominal period following cessation of the f_s signal. The limits are shown below and illustrated above and are intended to provide an adequate margin for ATME of different design and manufacture.

a) The telegraph character shall commence 130 ms-330 ms after the end of the preceding f_s signal.

b) Stop frequency, duration 100 ms-250 ms, shall precede the start signal of the first character and commence 30 ms-80 ms after the cessation of the f_s signal.

At the end of the telegraph message, stop frequency will be transmitted for 150 ms-180 ms following the time ("bell") signal.

7. *Specification of the measuring and signalling apparatus*

7.1 *Noise-measuring apparatus*

To simulate the assessment made by an observer reading the meter of a normal psophometer having a time-constant of 200 milliseconds, the noise-measuring equipment shall give the root-mean-square values of the instantaneous noise voltages over a period of 5 ± 1 seconds.

The noise-measuring equipment shall incorporate a weighting network in accordance with C.C.I.T.T. recommendations for the telephone circuit psophometer (see Supplement No. 3.2).

The noise-measuring equipment shall also conform to the other C.C.I.T.T. recommendations for the psophometer, in so far as they apply (pages 123-133, Volume V of the C.C.I.T.T. *Red Book*).

The noise measurement threshold of the automatic measuring equipment shall be capable of being set to any of the following values [1]:

—4 nepers or —35 decibels
—4.5 nepers or —39 decibels
—5 nepers or —43 decibels
—5.5 nepers or —48 decibels
—6 nepers or —52 decibels

The noise measurement shall be equivalent to a measurement of noise voltage made across a terminating impedance giving a return loss of at least 26 decibels against a resistance of 600 ohms.

The accuracy of the noise-measuring equipment relative to the calibration at 800 Hz shall be ± 0.35 nepers or ± 3 decibels.

During the noise measurement, the end of the circuit remote from the point where the measurement is being made shall be terminated by a resistance of 600 ohms.

7.2 *Transmission-measuring apparatus*

Sending equipment

The measurement frequencies shall be 400, 800 or 2800 Hz with an accuracy of ±1%. At these three measurement frequencies, the output impedance of the sending equipment shall give a return loss of at least 30 dB against a 600-ohm resistance. The output voltage from the sending equipment measured across a 600-ohm load resistance shall be 0.775 volt ± 0.008 volt (corresponding to 0 Nm ± 1 cNp).

Receiving equipment

At each of the three measurement frequencies, the input impedance of the receiving equipment shall give a return loss of at least 30 dB against a 600-ohm resistance.

The measurement accuracy over the level range from 0 Np to —1.8 Np shall be:

at 800 Hz . . . . absolute accuracy. . . . . . . ±2 cNp
at 400 Hz and 2800 Hz referred to the 800 Hz value . . . . ±2 cNp

[1] For the recommended value for maintenance purposes see Recommendation M.58.

7.3 *Signalling apparatus*

For signalling purposes (other than telegraph transmission), between the automatic measuring equipments at the two ends, the frequency transmitted shall be 1740 Hz ± 6 Hz.

Two lengths of pulse shall be used, namely 150 ± 30 ms and 600 ± 120 ms. These signals called f_s pulses shall be sent in accordance with the sequence of operations shown in Annex 1 and are measured at the outgoing end of the circuit.

These signals will be transmitted, with the durations mentioned above, at a level of −6 dB or −0.7 Np at a zero relative level point (with a tolerance of ± 1 dB or ± 0.1 Np).

7.4 The receiver of these signals must be able to operate even if the signal received is ±15 Hz away from its nominal value and the operate, non-operate levels and margin of the signal receiver should be as given below.

Range of level variation for correct operation of receiver, relative to nominal	±1.5 Np	±13.0 dB
Non-operative level, relative to nominal	−3.5 Np	−30.4 dB
Margin of uncertainty between lowest level of correct operation and non-operate level	2 Np	17.4 dB
Permissible leak during signalling period across possible static relay, relative to nominal level	−5.8 Np	−50.4 dB

The recognition time of f_s pulses will be 80 ± 20 ms for short signals and 375 ± 75 ms for long signals.

Since the receiver for the f_s pulses is permanently connected, it must not cause a tapping loss of more than 0.2 dB or 0.23 dNp.

8. *Optional facilities*

The additional facilities listed below could usefully be considered on an optional basis for incorporation in the ATME by administrations as they so wish.

8.1 *"Built-in" calibration*

The high accuracy of the existing ATME requires calibration equipment of laboratory type accuracy. These conditions are seldom satisfied by normal maintenance testing equipment available to repeater station staff. Hence it is considered that the provision of "built-in" calibration features is desirable in respect of ATME. Test signals, time pulses and other relevant technical features should also be accessible from control or calibration panels.

8.2 *Self-check*

It would be advantageous to incorporate a "built-in" self-check and programme-control feature. The arrangement could envisage the association of master and slave equipments on a "back-to-back" basis to ensure the correct operation of the programmed facilities.

8.3 *Automatic-start*

In the long term, the operation of the ATME without any attention by engineering personnel will be desirable. The addition of timed automatic-start facilities to the ATME is required when unattended operation of the ATME is intended.

8.4 *Automatic selection of nominated circuits*

The selection of a particular circuit or a number of circuits from various routes to check or examine certain transmission parameters—for example, noise at varying intervals of time during busy and non-busy hours—would be advantageous. The possibility of having automatic-selection devices permitting access to a suitable number of nominated circuits may be included in the ATME.

8.5 *Automatic repeat attempt*

Over long periods a re-test problem may arise due to the very large number of circuits involved.

A possible solution to this problem would be to incorporate an automatic repeating test facility for circuits which have been rejected as faulty due to transient faults, for example, noise burst, short interruption etc. The arrangement should permit:

i) an "automatic-repeat-attempt" of the relevant test cycle immediately following the first test;

ii) a complete test of the circuit, later, after some predetermined time interval acceptable to individual administrations.

8.6 *Telegraph receiver sensitivity adjustment*

The sensitivity of the telegraph receiver should preferably be the same as that of normal telegraph receiving equipment (see in Volume VII of the C.C.I.T.T. *Blue Book*, page 32, Recommendation R.35, paragraph 11).

If the noise level at the input to the telegraph receiver exceeds the normal threshold level of the telegraph receiver it shall be possible to reduce the sensitivity of the telegraph receiver by raising the threshold level to a value just below the lowest transmission measuring level (−1.80 Np) so that the threshold level will be at −2.67 Np relative to a zero level point.

If further discrimination against noise is required this can be made on a time basis, the timing element allowing unimpaired reception of the telegraph signals.

8.7 *Check of stability of the test signal*

When circuits are unstable (e.g. short duration interruptions) the test results may appear to be satisfactory and mask faults because only a transient condition was measured.

In such conditions it would be desirable to examine the received level over a period of say 500 ms. Failure of the loss to remain stable over this period should then result in a print-out giving the following information:

Interruption	9xx
Instability	8xx

A further refinement of the above could include an automatic repeat attempt of the relevant test cycle immediately following an indicated variation of loss. A complete test of the circuit should also be possible at any time if the ATME is arranged to select circuits for measurement by tape, card or other programme control technique.

ANNEX 1

Sequence of operations

	Function	Outgoing equipment	Incoming equipment
	1	2	3
1.	*Access to the circuit to be measured*	Hunting for the circuit to be measured via local access selectors. Sending of the "carriage return" signal followed by the "line-feed" signal to the teleprinter.	
1.1		*Circuit engaged:* The teleprinter prints the sign / in the first column followed by the number of the circuit, and the carriage returns. Example:	
	/ 0123		
		The equipment passes to the next circuit in accordance with its programme after having recorded the number of the engaged circuit, on an associated perforated tape, for example. The engaged circuit will be retested later.	
1.2		*Circuit free:* The following operations are carried out:	
2.	*Access to the incoming measuring equipment*	Transmission of the access code for access to the incoming measuring equipment (each incoming measuring equipment has its own code in the series 51, 52, 53, 54, 55). For example: (13) (12) 052 (15).	
		This transmission is made in accordance with the signalling system (code and frequency) used on the relation concerned.	
3.	*Seizing the incoming measuring equipment*		

	Function	Outgoing equipment	Incoming equipment
	1	2	3
3.1		Receipt of busy-flash signal. This causes the teleprinter to print the sign = in the first column followed by the circuit number, and the carriage returns. The circuit is then released. Example:	*The incoming equipment is engaged.* The switching centre sends back the busy-flash signal.
	= 0123		
3.2		No signal (busy-flash or answer) is received back. After 15 ± 5 seconds, an alarm is set off in the outgoing exchange and the sign ? indicating a fault is printed by the teleprinter followed by the circuit number, and the carriage returns. The circuit is then released. Example:	*Fault.*
	? 0123		
3.3			*The incoming equipment is free.* After seizing: — the "number received" signal is sent (if it exists in the signalling system concerned); — connection is made to the telegraph demodulator circuit; — the "carriage return" signal followed by the "line-feed signal" are sent to the local teleprinter; — the "called subscriber answer" signal is sent.
			Connection to the telegraph demodulator circuit. Sending of the "carriage return" signal followed by the "line-feed" signal to the local teleprinter.

	Function	Outgoing equipment	Incoming equipment
	1	2	3
4.	*Telegraphic exchange of information about the circuit and the centres*	Receipt of the number-received signal (possibly) and the answer signal.	
4.1		Receipt of this signal causes the connection of the telegraph modulator to the circuit, then local printing and sending to line of the telegraph sequence: — a space in the first column — circuit number (four figures) — a space — outgoing exchange number: 4 (or 5) figures — two (or one) spaces — the bell signal. Example:	Telegraph reception and printing of the sequence:
	.0123.5520 .. ⍾		
		After the end of the telegraph message, the telegraph modulator is disconnected from the circuit.	
4.2			Receipt of the bell signal causes: — the disconnection of the telegraph demodulator from the circuit — the connection of the telegraph modulator to the circuit — sending to line of the f_s signal (pulse of 150 ± 30 ms).
4.3		Receipt of the f_s signal causes the connection of the telegraph demodulator to the circuit. The teleprinter receives from the incoming centre the sequence: — incoming centre exchange number: 4 (or 5 figures) — 2 (or one) spaces — the bell signal Example:	After an interval of at least 130 ms from the end of the f_s signal, telegraph transmission commences: Local printing and transmission to line of the sequence:
		4691 .. ⍾	

	Function	Outgoing equipment	Incoming equipment
	1	2	3
			After the end of the telegraph message, the telegraph modulator is disconnected from the circuit.
4.4		Receipt of the bell signal causes: — the disconnection of the telegraph demodulator from the circuit — transmission of the f_s signal indicating the measurement cycle to be carried out in accordance with the programme.	
5.	*Test cycle 1 (noise)*		
5.1		An f_s signal (pulse of 150 ± 30 ms) is sent, then the circuit is terminated with a 600-ohm resistance within 150 ms.	Receipt of the f_s signal (one pulse) causes the connection of the noise-measuring device to the circuit after a delay of at least 150 ms.
5.2			When the test is terminated, the f_s signal (a pulse of 150 ± 30 ms) is sent, the noise-measuring device is disconnected from the circuit and the telegraph modulator is connected.
		Receipt of the f_s signal causes the disconnection of the 600-ohm resistance from the circuit and the connection of the telegraph demodulator.	After an interval of at least 130 ms from the end of the f_s signal, telegraph transmission of the result commences:
		The teleprinter receives from the incoming centre the sequence:	Local printing and transmission to line of the sequence:
		— a + or − signal (depending on the result) — three spaces — the bell signal.	
		Example:	
		+ . . .	

	Function	Outgoing equipment	Incoming equipment
	1	2	3
			After the end of the telegraph message, the telegraph modulator is disconnected from the circuit and the circuit is terminated with a 600-ohm resistance.
5.3		Receipt of the bell signal causes: — the disconnection of the telegraph demodulator from the circuit; — after a delay of at least 150 ms, the connection of the noise-measuring device to the circuit.	
5.4		When the test is terminated, the f_s signal (a pulse of 150 ± 30 ms) is transmitted, the noise-measuring device is disconnected from the circuit and the telegraph modulator is connected.	
		After a lapse of at least 130 ms from the end of the f_s signal, telegraph transmission of the result commences. Local printing and transmission to line of the sequence: — a + or — sign (depending on the result) — three spaces — the bell signal. Example:	Receipt of the f_s signal causes the disconnection of the 600-ohm resistance from the circuit and the connection of the telegraph demodulator. The teleprinter receives from the outgoing centre the sequence:
			— . . . ⍾
		After the end of the telegraph message, the telegraph modulator is disconnected from the circuit. The f_s signal indicating the next test cycle or, depending on the programme, the "end of programme", is sent.	Receipt of the bell signal causes the disconnection of the telegraph demodulator from the circuit.

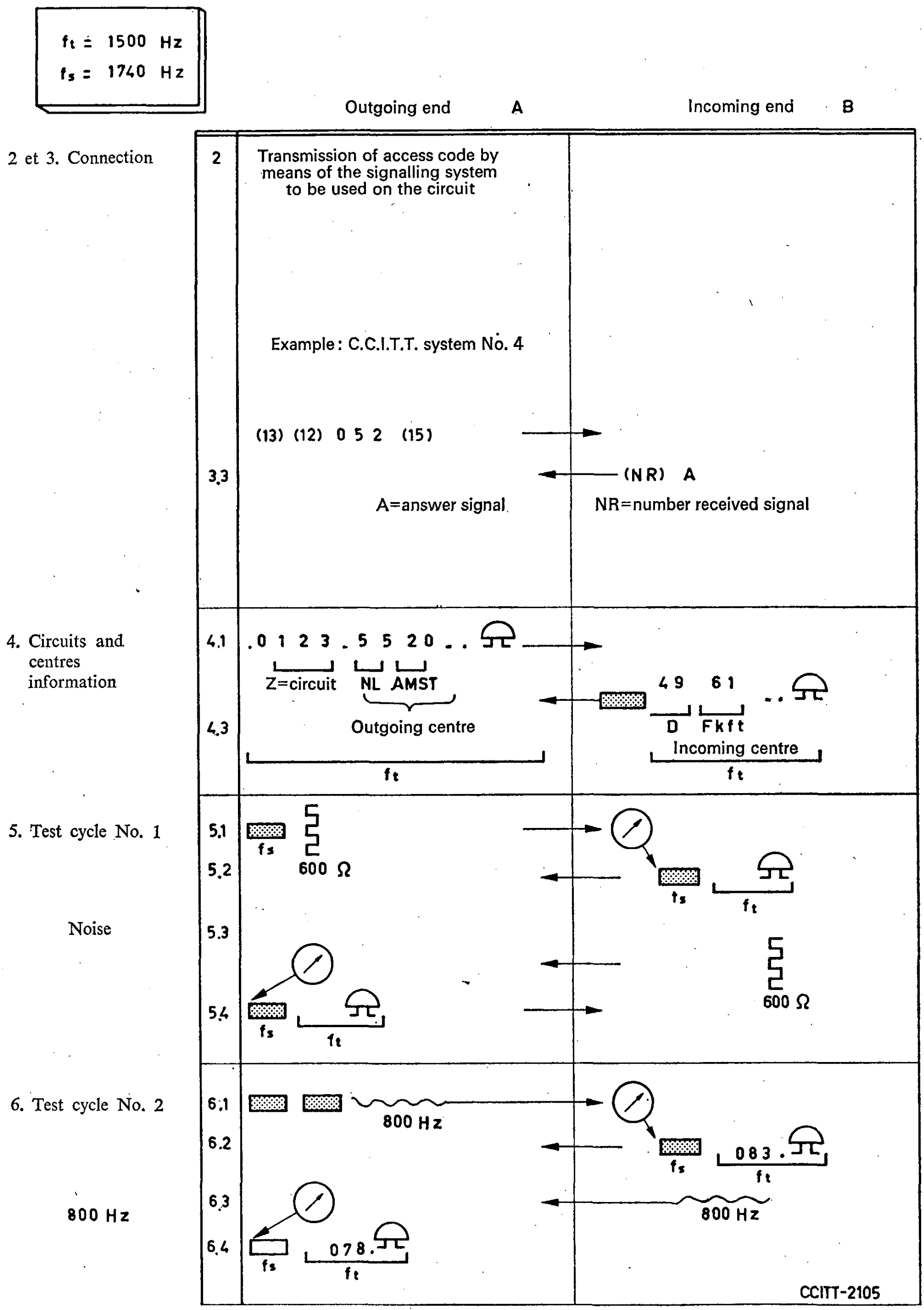
	Function	Outgoing equipment	Incoming equipment
	1	2	3
6.	*Test cycle 2*		
6.1	(800 Hz)	An f_s signal (two pulses of 150 ± 30 ms separated by an interval of 100 ± 20 ms) is sent, and then, within 150 ms, the 800-Hz signal generator is connected to the circuit.	Receipt of the f_s signal (two pulses) causes the connection of the level-measuring equipment to the circuit after a delay of at least 150 ms.
6.2		Receipt of the f_s signal (one pulse) causes the disconnection of the generator from the circuit and the connection of the telegraph demodulator.	At the end of the test, the f_s signal (a pulse of 150 ± 30 ms) is sent, the measuring equipment is disconnected from the circuit and the telegraph modulator is connected.
		The teleprinter receives from the incoming exchange the sequence: — result in centinepers (3 figures) — one space — the bell signal Example:	After an interval of at least 130 ms from the end of the f_s signal the telegraph transmission of the result of the test is carried out: Local printing and transmission to line of the sequence:
		083 ♫	
			After the end of the telegraph message, the telegraph modulator is disconnected from the circuit and within a delay of 150 ms the 800-Hz signal generator is connected.
6.3		Receipt of the bell signal causes the disconnection of the telegraph demodulator from the circuit and the connection of the level-measuring equipment.	

	Function	Outgoing equipment	Incoming equipment
	1	2	3
6.4		At the end of the test, the f_s signal (a pulse of 150 ± 30 ms), is sent, the measuring equipment is disconnected from the circuit and the telegraph modulator is connected. After an interval of at least 130 ms from the end of the f_s signal, telegraph transmission of the result of the test is carried out: Local printing and transmission to line of the sequence:	Receipt of the f_s signal causes the disconnection of the generator from the circuit and the connection of the telegraph demodulator. The teleprinter receives from the outgoing exchange the sequence:
		— result in centinepers (3 figures) — one space — the bell signal. Example:	
		078 ⍾	
		After the end of the telegraph message the telegraph modulator is disconnected from the circuit. The f_s signal indicating the end of the cycle is sent.	Receipt of the bell signal causes the disconnection of the telegraph demodulator from the circuit.
7.	*Test cycle 3* (800, 400 and 2800 Hz	An f_s signal (3 pulses of 150 ± 30 ms separated by intervals of 100 ± 20 ms) is sent, and then within 150 ms the 800-Hz signal generator is connected to the circuit.	Receipt of the f_s signal (3 pulses) causes the connection of the level-measuring equipment to the circuit after a delay of at least 150 ms.
	The cycle takes place as before, except for the last phase:		
		After the end of the telegraph message, the telegraph modulator is disconnected from the circuit and within 150 ms the 400-Hz signal generator is connected.	Receipt of the bell signal causes the disconnection of the telegraph demodulator from the circuit and the connection of the level-measuring equipment.

	Function	Outgoing equipment	Incoming equipment
	1	2	3
	Then the same sequence of operations is repeated for the 400-Hz test and finally for the 2800-Hz test. The final phase is:		
		After the end of the telegraph message, the modulator is disconnected from the circuit. The f_s signal indicating the end of programme is sent.	Receipt of the bell signal causes the disconnection of the telegraph demodulator from the circuit.
8. 8.1	*End and release*	The f_s end-of-programme signal (a long signal of 600 $\pm$ 120 ms) is sent, the teleprinter receives locally and prints the date and time, and the carriage returns.	Receipt of the f_s end-of-programme signal causes the local printing on the teleprinter of the date and time, after which the carriage returns.
8.2		Receipt of the "acknowledgement of receipt of end-of-programme" signal causes the disconnection of the equipment from the circuit (hanging-up by the calling subscriber).	The f_s signal, the "acknowledgement of receipt of end-of-programme" signal (a long signal of 600 $\pm$ 120 ms) is transmitted. After which, the equipment is disconnected from the circuit (hanging-up by the called subscriber).
8.3		This disconnection in its turn causes the transmission of the "clear-forward signal" by the switching centre.	
8.4			The receipt of the clear-forward signal by the switching centre causes the transmission back of the "release-guard" signal.
		The circuit is released at both ends.	
9.	*Occurrence of a fault during testing*	In the case of both equipments, independently of each other, if no new f_s signal is received or sent 15 $\pm$ 5 seconds after the receipt or sending of the answer signal or after the last f_s signal sent or received (except if the latter is the " end-of-programme " or the " acknowledgement of receipt of end-of-programme " signal), an alarm is given and the fault sign? is printed, followed by the date and time and the return of the carriage. All the measuring and telegraph transmission equipments are disconnected from the circuit, together with the automatic equipment itself (hanging-up). The circuit is then released. If all the tests in the programme have not been terminated the outgoing equipment finds the next circuit to be tested and the programme continues.	

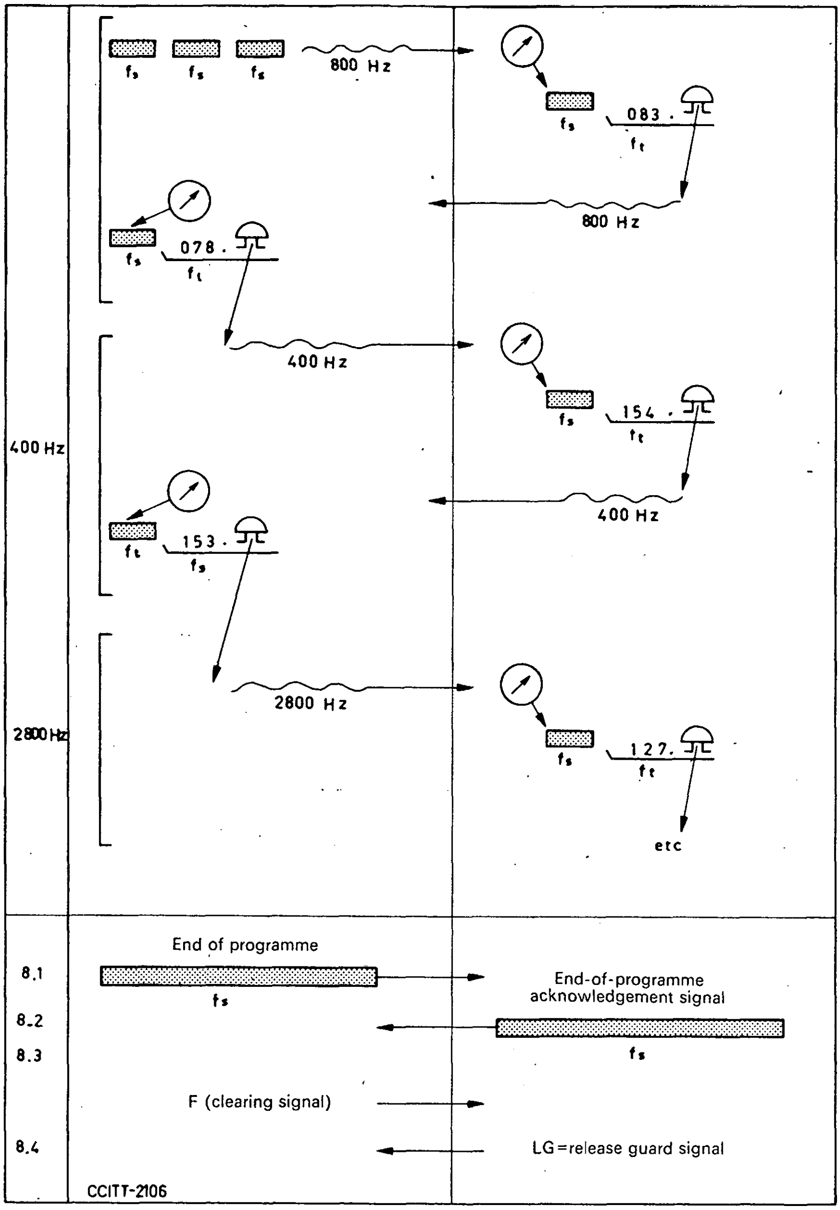
ANNEX 2

Signal sequence chart



7. Cycle 3 (possibly)

8. End and clear down



ANNEX 3

Examples of the printed teleprinter record for the various test cycles

PRINTING WITH A MODERN TELEPRINTER (which prints the bell sign)

```
          10        20        30        40        50        60      68

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

Example of recording for test cycles 1 and 3:

```
 0123 5520 🔔4961 🔔+ 🔔— 🔔083 🔔078 🔔154 🔔153 🔔127 🔔104 🔔09272317
/0125
 0127 5520 🔔4961 🔔— 🔔+ 🔔080 🔔093 🔔110 🔔116 🔔085 🔔094 🔔09272318
=0129
 0131 5520 🔔4961 🔔— 🔔— 🔔082 🔔078 🔔105 🔔115 🔔092 🔔096 🔔09272319
?0133
 0135 5520 🔔4961 🔔— 🔔— 🔔086 🔔?09272321
 0137 5520 🔔4961 🔔— 🔔— 🔔080 🔔075 🔔134 🔔117 🔔104 🔔098 🔔09272321
```

Example of recording for test cycle 1:

```
0123 5520 🔔4961 🔔+ 🔔— 🔔09272323
0125 5520 🔔4961 🔔— 🔔— 🔔09272324
0127 5520 🔔4961 🔔— 🔔+ 🔔09272324
0129 5520 🔔4961 🔔— 🔔— 🔔09272325
0131 5520 🔔4961 🔔— 🔔— 🔔09272326
```

Example of recording for test cycle 2:

```
0123 5520 🔔4961 🔔083 🔔078 🔔09272328
0125 5520 🔔4961 🔔084 🔔085 🔔09272329
0127 5520 🔔4961 🔔080 🔔093 🔔09272329
0129 5520 🔔4961 🔔086 🔔082 🔔09272330
0131 5520 🔔4961 🔔082 🔔078 🔔09272330
```

Example of recording for test cycles 1 and 2:

```
0123 5520 🔔4961 🔔+ 🔔— 🔔083 🔔078 🔔09272332
0125 5520 🔔4961 🔔— 🔔— 🔔084 🔔085 🔔09272333
0127 5520 🔔4961 🔔— 🔔+ 🔔080 🔔093 🔔09272334
0129 5520 🔔4961 🔔— 🔔— 🔔086 🔔082 🔔09272335
0131 5520 🔔4961 🔔— 🔔— 🔔082 🔔078 🔔09272336
```

```
          10        20        30        40        50        60      68

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

Printing with an old-type teleprinter

(which neither prints the bell-sign nor moves the carriage for the bell-combination)

10	20	30	40	50	60	68

. . . .

Example of recording for test cycles 1 and 3:

0123	5520	4961	+	—	083	078	154	153	127	104	09272317
/ 0125											
0127	5520	4961	—	+	080	093	110	116	085	094	09272318
=0129											
0131	5520	4961	—	—	082	078	105	115	092	096	09272319
? 0133											
0135	5520	4961	—	—	086	? 09272321					
0137	5520	4961	—	—	080	075	134	117	104	098	09272321

Example of recording for test cycle 1:

0123	5520	4961	+	—	09272323
0125	5520	4961	—	—	09272324
0127	5520	4961	—	+	09272324
0129	5520	4961	—	—	09272325
0131	5520	4961	—	—	09272326

Example of recording for test cycle 2:

0123	5520	4961	083	078	09272328
0125	5520	4961	084	085	09272329
0127	5520	4961	080	093	09272329
0129	5520	4961	086	082	09272330
0131	5520	4961	082	078	09272330

Example of recording for test cycles 1 and 2:

0123	5520	4961	+	—	083	078	09272332
0125	5520	4961	—	—	084	085	09272333
0127	5520	4961	—	+	080	093	09272334
0129	5520	4961	—	—	086	082	09272335
0131	5520	4961	—	—	082	078	09272336

10	20	30	40	50	60	68

. . . .

ANNEX 4

Basic principles of operation and interconnection of the various units comprising the automatic transmission measuring equipment No. 1

1. *Basic principles of operation*

The basic principles of operation are described below. The arrangement of the equipment is represented schematically in Figure 1.

2. *Measurements on outgoing circuits*

2.1 Information in an appropriate form (instructions on punched tape, etc.) concerning the particular circuits to be measured and the type of measurement to be made (the "measurement programme") will be inserted into the "control" equipment.

2.2 The access equipment selects the circuit to be measured, the transmission path is extended to the measurement selector, and subsequently a signal is sent back to the control equipment.

2.3 Locally generated signals identifying the selected circuit and showing the type of measurement required are sent to the control equipment, the function of which is to connect by means of the measurement selector, the required measurement equipment in the sequence required by the measurement programme.

2.4 The required measurements now proceed, the sequence of operations being explained in Annex 1.

2.5 At the end of the measurement, or when the circuit is found to be busy, or when the distant measurement equipment is not available, a signal is sent to the control equipment to initiate the selection of the next circuit to be measured.

2.6 During the progress of measurement on any group of circuits, the completion of a measurement on a particular circuit results in a record at the control equipment enabling further trials to be made on the same group of circuits. In this manner measurements can be made on circuits formerly busy or selected at times when the distant measurement equipment was not available.

3. *Manual control of measurements on outgoing circuits*

It will be necessary to provide facilities for the manual operation of the control equipment in order to select any particular circuit for measurement.

4. *Measurements on incoming circuits*

Receipt of the access codes (see Volume VI, *Blue Book*, page 188 et seq.) causes the access selector to extend the transmission path of the circuit to be measured to the measurement selector. In the "receiving condition" of the measuring equipment, the received signals are passed to the f_s receiver equipment to indicate the type of measuring equipment required and to cause the sequence of operations in Annex 1 to proceed.

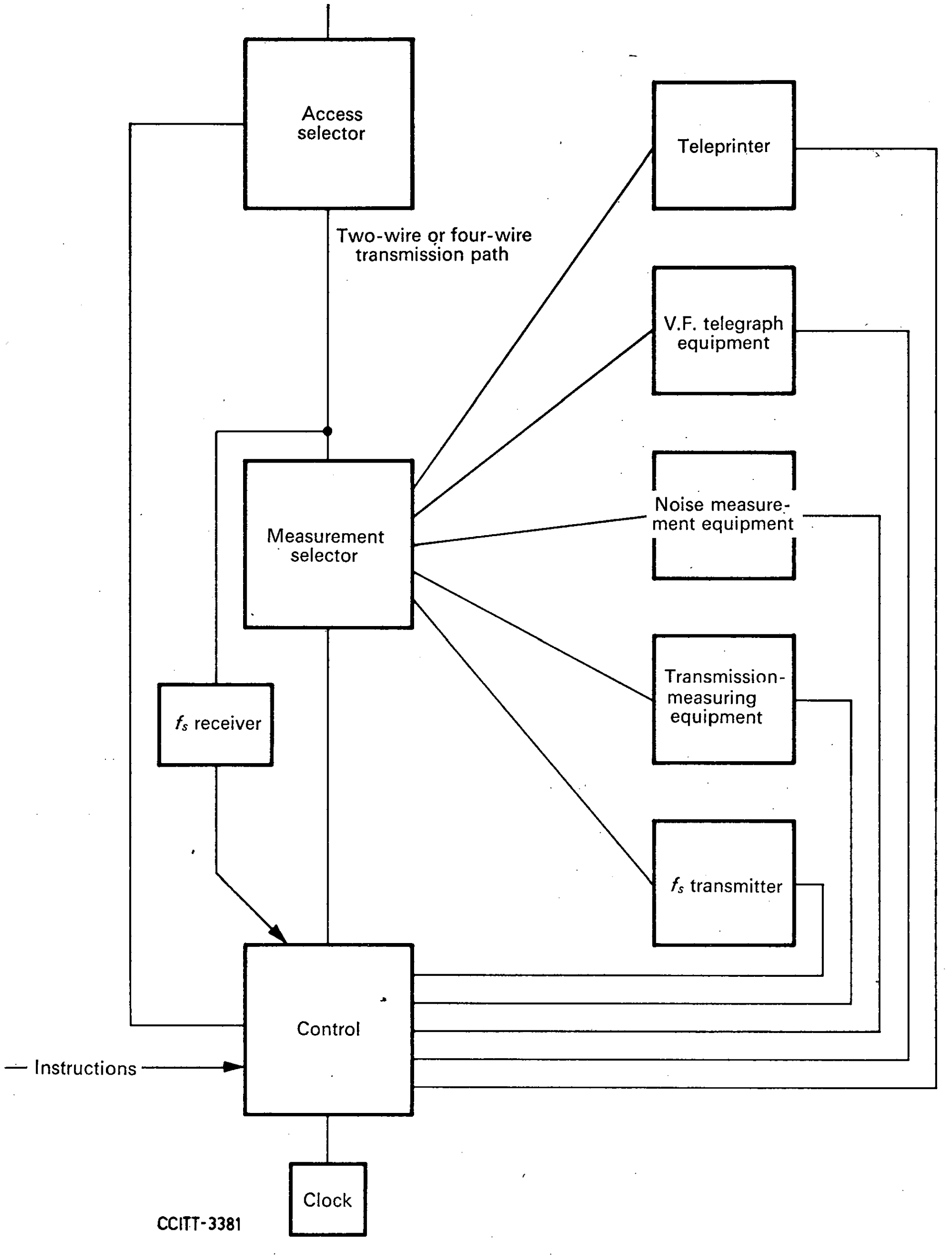


FIGURE 1. — **Schematic arrangement of the C.C.I.T.T. automatic transmission-measuring equipment No. 1**

SUPPLEMENT No. 4.1

RESULTS OF MEASUREMENTS AND OBSERVATIONS ON THE STABILITY OF THE OVERALL LOSS CIRCUITS IN THE INTERNATIONAL NETWORK [1]

(Analysis carried out by the French Administration)

1. *General*

As part of its continuing study of Question 1/IV, Study Group IV decided at its November 1966 meeting in Paris to publish an annual statistical analysis of the results of all routine maintenance measurements and to compile tables for comparison with the results in previous years.

Detailed analysis of the measurement results obtained in 1967 and 1968 are given in contributions COM IV—Nos. 185 and 186 (period 1964-1968) and COM IV—Nos. 15, 16, 17 and 18.

The work of the Rapporteur is based on the contributions submitted by the following countries:

Germany (Federal Republic), Denmark, France, United Kingdom, Italy, Norway, Netherlands, Poland, Sweden, Switzerland and Japan.

2. *Results for 1967 and 1968*

a) *Symbols used*

— N: number of results used in calculation of M and S,
— M: deviation of the mean value of loss measurement results from the nominal value in centinepers,
— S: standard deviation, in centinepers,
— HL: number of results which differ by more than ±62.5 cNp from the nominal value and which have not been taken into account.

b) *Classification of groups and supergroups*

— Class 1: category A groups (less than 2500 km in length), measurements made at regulator input,
— Class 2: category A groups, measurements made at regulator output,
— Class 3: category A groups without regulators,
— Class 4: category B groups (over 2500 km in length), measurements made at regulator input,
— Class 5: category B groups, measurements made at regulator output.

c) *Classification of results*

— Class 1: category A circuits routed on a single group with automatic regulation,
— Class 2: category A circuits routed on a single group without automatic regulation,
— Class 3: category A circuits not included in classes 1 and 2 above,

[1] In addition, an analysis of the results of the subscriber-to-subscriber tests carried out during April and June 1967 is published as an Annex to Question 4/XVI in Volume III of the *White Book*.

— Class 4: category B circuits routed on a single group,
— Class 5: category B circuits routed on two or more groups in tandem.

d) *Results obtained with reference to Recommendations M.16 and M.18*

To define the situation on the international network with reference to the objectives of Recommendation M.16 and the provisions of Recommendation M.18, information is given on the numbers of country-to-country relations which, judging from the results obtained, meet these requirements (taking each direction of transmission separately). It is to be noted that these Recommendations refer to the variations in time of an individual link (supergroup, group, circuit) whereas the values analysed refer to the variation in time of a series of links; the conclusions set forth below are therefore somewhat pessimistic.

e) *Results for 1967*

Nature	Results submitted by	Classification				
		1	2	3	4	5
Super-group pilots	France, United Kingdom, Italy, Norway	N =11 017 M =−10.63 S =21.16 HL=235	N =4025 M =0.00 S =4.17 HL=8	N =5849 M =−3.95 S =16.72 HL=74		
Relations meeting requirements of Recommendation M.18:			18 out of 19	2 out of 18		
Group pilots	Denmark, France, Italy, Norway, Netherlands, United Kingdom	N =86 122 M =−1.34 S =19.28 HL=1846	N =27 092 M=−0.51 S =2.67 HL=71	N =36 829 M =+0.80 S =15.51 HL=1253	N =1233 M =+4.01 S =12.36 HL=9	N =1168 M =−1.14 S =3.31 HL=0
Relations meeting requirements of Recommendation M.18:			36 out of 38	0 out of 26		1 out of 1
Circuits measured manually	(Germany (Federal Republic), Denmark, France, United Kingdom, Italy, Norway, Netherlands, Poland, Sweden, Switzerland, Japan	N =45 569 M =−1.09 S =9.98 HL=106	N =12 527 M =+0.06 S =11.31 HL=36	N =12 000 M =0.19 S =15.79 HL=266	N =1682 M =−1.52 S =15.36 HL=3	N =7860 M =−1.43 S =14.50 HL=60
Relations meeting requirements of Recommendation M.16:		80 out of 104	28 out of 56	73 out of 137	0 out of 2	17 out of 38
Circuits measured automatically	Germany (Federal Republic), France, United Kingdom, Norway, Poland	N =13 749 M =−6.43 S =14.36 HL=117	N =2004 M =−4.05 S =21.26 HL=22	N =331 M =−4.27 S =24.43 HL=20		

f) *Results for 1968*

Nature	Results submitted by	Classification 1	2	3	4	5
Super-group pilots	France, United Kingdom, Sweden, Norway	N =4755 M = −2.50 S =16.28 HL=18	N =4773 M =0.50 S =3.59 HL=6	N =4129 M = −0.03 S =12.94 HL=5		
Relations meeting requirements of Recommendation M.18:			13 out of 15	0 out of 18		
Group pilots	France, Norway, Netherlands, United Kingdom, Sweden	N =47 905 M = −1.35 S =16.90 HL=280	N′ =33 823 M = − 0.64 S =3.90 HL=34	N =21 946 M = −0.69 S =12.59 HL=84	N =894 M =6.55 S =10.31 HL=3	N =897 M= − 1.32 S =3.04 HL=0
Relations meeting requirements of Recommendation M.18:			37 out of 49	1 out of 18		2 out of 2
Circuits measured manually	Germany (Federal Republic), Denmark, France, United Kingdom, Italy, Norway, Netherlands, Poland, Sweden, Switzerland, Japan	N =44 051 M = −1.11 S =9.63 HL=114	N =14 854 M= −0.84 S =11.02 HL=50	N =12 074 M = −0.51 S =15.26 HL=313	N =1908 M =0.27 S =17.31 HL=38	N =4796 M = −0.63 S =13.26 HL=57
Relations meeting requirements of Recommendation M.16		74 out of 102	48 out of 74	90 out of 146	0 out of 4	13 out of 32
Circuits measured automatically	Germany (Federal Republic), France, Norway, Poland	N =2870 M = −3.07 S =16.23 HL=16	N =990 M =3.66 S =17.05 HL=9	N =233 M = +1.22 S =24.98 HL=12		
Relations meeting requirements of Recommendation M.16		4 out of 19	1 out of 5	0 out of 8		

3. *Comparisons*

a) *Group pilots*

From the study of certain relations it was concluded in the analysis for 1967 (Contributions COM IV—Nos. 185 and 186, 1964-1968) that the deterioration ascertained between the results for the first and second halves of the year was an overall phenomenon of a seasonal nature. On this basis, the results for 1968 should have been comparable to those for 1967 allowing for a certain general improvement. However, an examination of the tables for supergroup and group pilots invalidates this conclusion and suggests, on the contrary, a close relationship between the results for the first half of 1967 and those for the whole of 1968.

On checking it was found that the analysis for the two periods had covered the same relations, which was not the case for the second half of 1967.

b) *Telephone circuits*

The country-to-country relations examined for 1968 were more or less the same as for 1967; the deterioration observed in class 2 at the group level was not repeated at the circuit level in class 1, even when only one relation was examined.

Consideration of the values lying outside the established limits indicate that the improvement observed in nearly all classes is more apparent than real.

4. *Characteristics of observed distributions*

In the preceding paragraph, the values lying outside the established limits were also considered (i.e. absolute values above 62.5 cNp), which were not taken into account in previous analyses. If these values are taken honestly into account, they appear to provide a by no means negligible indication of network stability, in that they correct the over-optimistic impression given by the value of the standard deviation. The reason for this over-optimistic impression is one to which attention has often been drawn in previous reports or in contributions of the A. T. & T., namely, the non-normal character of the distributions.

Thus the standard deviation should be supplemented by other parameters which can characterize the non-Gaussian distributions of the attenuation. The most interesting parameter is the expression:

$$\mathrm{e} = \frac{E\,[x - E\,(x)]^4}{S^4} - 3,$$

(coefficient of kurtosis), which is zero for a normal distribution and increases in magnitude with that of the distribution " tails ".

In the above formulae, E= mathematical expectation

S= standard deviation

x= random variable whose realizations are experimental measurement results

e= coefficient of kurtosis

The coefficient of kurtosis was calculated by " relation " for 1967 and 1968. In many cases the improvement in the standard deviation S was accompanied by an increase in e, which indicates that the improvement affected the central part of the distribution but not the tails—this is a characteristic effect of automatic regulators.

The following tables give the values of M (mean) S (standard deviation) and e (coefficient of kurtosis) obtained for 1967 and 1968, taking all the measurement results into

S1	1967	1968
M	-11,57	-2,68
S	22,29	16,67
e	-0,09	0,74

S3	1967	1968
M	-4,43	-0,02
S	17,91	13,11
e	1,94	2,46

S2	1967	1968
M	-0,12	0,42
S	5,01	4,23
e	49,08	69,43

P1	1967	1968
M	-2,12	-1,57
S	21,05	16,53
e	1,02	1,55

P2	1967	1968
M	-0,68	-0,70
S	4,14	4,36
e	129,59	58,45

P3	1967	1968
M	-1,05	-0,67
S	18,99	13,14
e	2,97	5,14

C.C.I.T.T. 3164

C1	1967	1968
M	-1,19	-1,17
S	10,40	10,12
e	6,37	7,60

A1	1967	1968
M	-6,72	-3,23
S	15,27	16,81
e	3,21	1,61

C2	1967	1968
M	0,05	-0,92
S	11,78	11,58
e	5,09	6,70

A2	1967	1968
M	-4,57	4,07
S	22,02	17,89
e	0,06	1,79

P4	1967	1968
M	4,13	6,32
S	13,56	11,04
e	5,76	11,58

P5	1967	1968
M	-1,14	-1,32
S	3,31	3,04
e	-0,46	-0,41

C4	1967	1968
M	-1,62	0,07
S	15,56	19,24
e	2,42	2,02

C3	1967	1968
M	-0,21	-1,12
S	18,13	18,02
e	3,39	3,79

A3	1967	1968
M	-6,17	0,14
S	27,66	28,05
e	0,15	-0,20

C5	1967	1968
M	-1,53	-1,15
S	15,43	14,79
e	3,29	4,72

C.C.I.T.T. 3165

consideration and not only those lying within ± 62.5 cNp from the nominal value. For the purposes of the calculation, the results of measurements lying outside these limits were taken as being equal to

$$+62.5 \text{ cNp or } -62.5 \text{ cNp}$$

depending on which side of the nominal value they lay. Thus this probably still provides an optimistic view of the situation.

The letters in the top left-hand box of each table denote the following:

S = measurements of supergroup pilots
P = measurements of group pilots
C = manual circuit measurements
A = measurements of circuits made with automatic equipment

The figures 1 to 5 following letters S, P, C or A indicate the class in accordance with paragraphs 2 b) and c).

5. *General remarks*

a) *Transmission of results to the Rapporteur*

There was no increase in the number of measurement results submitted to the Rapporteur for analysis in 1968 as compared with 1967.

It is highly desirable that the results submitted by administrations for each traffic relation considered should refer to circuits, groups and supergroups. This will make it easier to determine the relative incidence of modulation equipment and of inaccuracies in measurement.

b) *Remarks on some of the results*

Some of the results shown in the Tables included in paragraphs 2 e) and 2 f) above may be found surprising because of the fact that the standard deviation of the measurement results for circuits carried by a single non-regulated group is less than that for the measurement results for the pilots of such groups. Two explanations have been put forward in this connection:

1) The group pilot and the circuit measurements are not carried out on the same series of relations;

2) The groups are measured first and re-regulated and then the circuit measurements are made. Consequently, the measurements are made on circuits of which some, at least, have already been indirectly re-regulated. It would be desirable, therefore, to measure the circuits before re-regulating the routes in order to obtain a truer picture of the situation before any re-regulation is carried out.

c) *Automatic measurements*

In an effort to evaluate the influence on the standard deviation of the variations in the channel-translating equipments together with the influence of errors in manual circuit measurements, a figure of 7.5 cNp was arrived at for the joint effect of all these factors, which is in good agreement with a value previously put forward in Annex 1, point 2.1, in the *Blue Book*, Volume IV, Supplement 10.

This is quite a high figure. To reduce it appreciably the use of automatic transmission measurement equipment will have to be developed. The results obtained by certain countries with experience of this technique is very encouraging.

SUPPLEMENT No. 4.2

RESULTS AND ANALYSIS OF THE 8th SERIES OF TEST OF SHORT BREAKS IN TRANSMISSION

1. *Introduction*

This supplement reproduces the results of the 8th series (1964-1968) of test of short breaks in transmission on the international network.

Tables 1 to 4 at the end of this supplement summarize the results obtained in the course of this series of tests classified as follows:

— general constitution of the circuits, distribution of numbers of isolated breaks;

— regrouping of isolated breaks and mean time between breaks;

— comparison between the 7th and 8th series of test of short breaks in transmission, and

— analysis of the causes of breaks.

2. *Representation of test results*

2.1 *Distribution of numbers of isolated breaks (Table 1)*

Table 1 shows the distribution of numbers of isolated breaks for each time interval and each direction of transmission of each circuit in the test network. The composition of each circuit and the number of sections involved through-connected on a voice frequency basis is also given for the purpose of comparison with the 7th test series (see *Blue Book*, Volume IV, p. 309). The division of the measurement results into the two directions of transmissions has been done because telegraph transmissions are unidirectional.

Even though recordings of breaks were carried out these numbers are not included in Table 1 because of the incidental character of this type of break. These series of breaks should in most cases be regarded as a complete breakdown of the circuit.

Isolated breaks of less than 5 ms have also been inserted in Table 1 but not been taken into account for the subsequent calculations because electronic recording equipment capable of measuring very short breaks, i.e. <5 ms, was only partly available so that results on only four directions are shown in the table.

2.2 *New grouping of the isolated breaks and means time between breaks (MTBF)* [1] *(Table 2)*

In evaluating the distribution of breaks, a grouping of the recorded time intervals slightly different from that outlined in the rules adopted before the series of test was

[1] Although we are dealing here with the mean time between two successive *breaks* the abbreviation MTBF should be used, being well established in the calculation of electric component reliability.

embarked upon has been made. Originally three groups of breaks were proposed, namely 0.5-20 ms, 20-300 ms and > 300 ms. These distributions had been proposed as being significant for data, v.f. telegraphy and telephone transmission respectively.

Results expressed with a single range of break duration of 0.5 ms to 20 ms may not sufficiently distinguish breaks that are significant for data transmission from those that are significant for telegraph transmission. This range was therefore divided into two, giving 0.5 ms to 5 ms and 5 ms to 20 ms, resulting in four classes of break in all, as shown below. The general effects assumed for each type of transmission and each class of break duration are as shown in Table A below.

TABLE A

Type of transmission	Duration of break			
	0.5–5 ms	5–20 ms	20–300 ms	300 ms–1 min
Data transmission and C.C.I.T.T. signalling system No. 6	Possible loss of information	Loss of information. Possible loss of synchronization	Loss of information. Loss of synchronization	Interruption of transmission
Telegraphy		Possible fault in character (ref. M.81 item 10.1)	One or more faulty characters	Release of circuit (Telex) or run open
Telephony			Switching error. Disturbance in conversation (clipping)	Call may be lost or the subscriber may abandon it

In Table 2 the distribution of the number of breaks for each of these four categories has been shown separately for the two directions of transmission for each circuit in the test.

In addition the distribution of the total number of breaks is given for each circuit and for each direction of transmission in the classes 5-300 ms and 5 ms-1 min.

2.3 *Mean time between two successive failures (breaks in transmission)*

In an effort to establish a criterion for the reliability of a circuit with respect to the various types of service one factor will have a predominant influence on the performance of a circuit: the mean time between two successive isolated breaks (MTBF). These values have also been calculated in Table 2, and are shown for the two categories mentioned under 2.2 applying to the total of the test network.

2.4 *Make-up of the test network, average test circuit (Table 3)*

Table 3 shows the make-up of the actual test network of the 8th series of tests compared with that of the preceding series. As can be seen from this table the radio-relay link portion has increased by a factor 2 whereas the cable portions are much the same as before.

By summing the circuit lengths of the total test network and dividing by the number of circuits involved an average length of the test circuit was determined and compared with the corresponding length for the 7th series of tests.

As can be seen from Table 3 the average circuit length has slightly increased.

The measurement results have not been referred to any given length of reference circuit, because the total amount of equipment involved is of greater importance with respect to the number of breaks than the circuit length itself. Nevertheless the actual length and make-up of the circuits tested should be kept in mind when making any comparison with previous measurements.

2.5 *Analysis of the causes of breaks (Table 4)*

Table 4 gives the analysis of the main causes of the breaks. The total number of isolated breaks is grouped into two categories, namely:

5-300 ms

>300 ms

A third category gives the total of the " series of breaks ".

3. *Comments on the summary of results*

3.1 Table 3 contains the respective MTBF values for the 7th and 8th series of tests divided into the basic categories. A 5th category comprising 5 ms to 1 min has been added and likewise evaluated.

The requirement for telegraph transmission for the number of permitted faults is 3 per 10^5 characters (see Volume VII, Recommendation R.54); 1 fault per 10^5 characters is allocated to line transmission. This means for the 50-baud telegraph service 1 fault in 4.2 h continuous telegraph service or 320 faults in an 8-week period. It should be remembered that short breaks in transmission contribute only a portion of the faults introduced by a link. Other factors which add to such faults are noise and phase shift. Therefore, short breaks can only contribute to a portion of the allowed time between faults. The MTBF being 4.2 h could thus be compared with the figures evaluated in Tables 2 and 3.

This has been done for the telegraph service for only one of the directions and for the telephone service using both directions of transmission.

In the 7th series of tests, it was found that only three of the circuits tested met the requirement of one fault per 10^5 characters.

In the 8th series of tests, only a few of the circuits tested did not meet this requirement.

In both instances, the figures for MTBF were calculated on the basis of the effect of isolated breaks only, no account being taken of the possible effect of noise and phase shift.

In the analysis of short breaks in transmission the expression MTBF (mean time between failures) is used and it seems necessary to give some guidance as to the use of the values in this document.

a) If M is the MTBF calculated from

$$\frac{\text{time of observation}}{\text{number of failures}}$$

there will be 63% (and not 50%) of TBF (time between two successive failures or interruptions) which will be smaller than the value M. The 50% value will be at 0.7 M.

b) The spread of the individual values will be big. Anyhow there will be 5% of the TBFs smaller than 0.05 M; 10% smaller than 0.1 M but also 5% higher than 3 M.

c) The number of observed failures (or breaks in transmission) is of primary importance for the spread of the individual TBFs found in actual service conditions. It is therefore very important to define a "confidence level" (90% or 95%). Take an example: MTBF = 10 h. The confidence level should be 95% and the number of failures in the observation time was only 3. The 95% confidence limits are then 3.4 hours and 50 hours.

For the same value of MTBF but based on 10, 30 or 100 failures the appropriate 95% confidence level limits will be 5.5/21, 7/15 and 8/12.2 hours respectively.

d) With this general guidance the interpretation of the values of MTBF given in this document will give more realistic figures for actual service conditions.

The MTBF values stated in Table 2 for the individual circuits should be interpreted cautiously in cases where the number of breaks shown is very low.

3.2 Comparing the results given in Table 4 with the corresponding results (Table 2, *Blue Book*, Volume IV, page 313) from the 7th series of tests of short breaks in transmission the following should in particular be noticed:

a) Taking into account the number and length of the test circuits in the two series of tests, the total number of breaks has dropped considerably.

b) The number of breaks caused by power supplies has diminished remarkably, e.g. from approximately 20% to 7% of all breaks. However, in this connection it should be remembered that at the time of the 7th series, there was a very hard winter with snow storms in Europe, resulting in breakdowns in primary power stations with a consequent effect on repeater stations etc.

Nevertheless, it may be expected that since 1963 the further introduction of no-break power supply equipment in repeater stations, according to Recommendation M.16, has also improved the general situation.

c) The percentage of breaks registered in the category "faults" dropped from 40% to nearly 20%.

d) The percentage of breaks caused by maintenance work remained nearly the same as in the 7th series of measurements.

3.3 *Relationship between observed breaks on the circuits tested and the associated group pilots*

Correlation between observed breaks on the circuit under test and the associated group pilot can be a useful means of helping to determine the basic cause of a break. However, such observations must be evaluated with care as the character of the observed breaks on the pilot may be very different from the actual break in the circuit. This is due to the very narrow bandwidth of the pilot filters. These filters may, in the case of very short breaks (app. < 20 ms), cause the break to be unobserved and in other cases change the length of the observed break.

Three administrations made observations of the pilot and the correlation of observed breaks varied from 40 to 90%. This wide spread in correlation is explained when the length of break is examined. In the case of 40% correlation there were relatively large numbers of very short breaks and in the 90% case the longer were by far the largest number.

TABLE 1

Circuit A→B		Constitution: Total length (km)	Symm. cable pairs	Sub-marine cable	Land coax. cable	Radio link	No. of v.f. sect.	Isolated breaks (in ms): 0.5 <— 1	1 — 2	2 — 5	5 — 10	10 — 20	20 — 40	40 — 80	80 — 150	150 — 300	300 1 min	Duration of tests (weeks)
København - Wsw	A-B																	5
	B-A	936	600	336			2			45	82	23	8	4	10	9	55	
Ldn - Rt											15	6		5	3	2	31	8
		487	170	154	163		3				22	4		4	9	2	38	
Ldn - Bxl											11	2	6	4	7	9	35	8
		376		88	288		2				30	1	8	5	10		31	
Brn - Prs											55	90	22	10	12	1	21	8
		712	7		332	373	1				14	12	7	14	6	8	38	
FfM - Prs											56	43	11	5	12	35	44	8
		749	7			742	1	15	7	15	6	12	13	6	3	11	38	
FfM - Zürich											28	14	9	16	16	11	32	8
		425	8		226	191	1	20	6	9	3	1	3	2	53	1	8	
Oslo - Sthm											4	4	5	8	4	5	49	8
		751			544	207	1		459	209	46	21	9	15	19	13	46	

TABLE 1 (*contd.*)

Circuit A ⟶ B	Constitution: Total length (km)	Constitution: Symm. cable pairs	Constitution: Sub-marine cable	Constitution: Land coax. cable	Constitution: Radio link	Constitution: No. of v.f. sect.	Isolated breaks (in ms): 0.5 <— 1	1 — 2	2 — 5	5 — 10	10 — 20	20 — 40	40 — 80	80 — 150	150 — 300	300 1 min	Duration of tests (weeks)
København - Sthm										13	5	3	4	2	6	44	8
	700		30	302	368	1											
FfM - Pha										124	196	120	3	7	15	15	8
	513	165			348	2					20	6	3	1		29	
Bxl - Rt										9	2		2			5	8
	156	156				1				12			1	1		8	
Total	5805	1113	608	1855	2229	15	35	472	278	530	456	230	111	175	128	567	

TABLE 2

Circuit	Direction →		Isolated breaks <5 ms	5-20 ms	20-300 ms	300 ms-1 min	Total 5-300 ms	MTBF/Tg h	Total 5 ms-1 min	MTBF/Tg h	Total 20 ms - 1 min	MTBF/Tg h	MTBF/Tph h
Købn - Wsw	A	B											
	B	A	144	105	31	55	136	6.2	191	4.4	86	9.8	
Ldn - Rt	A	B		21	10	31	31	43.5	62	21.7	41	32.8	14.3
	B	A		26	15	38	41	32.7	79	17.0	53	25.4	
Ldn - Bxl	A	B		13	26	35	39	34.5	74	18.2	61	22.0	11.7
	B	A		31	23	31	54	24.9	85	15.9	54	25.0	
Brn - Prs	A	B		145	45	21	190	7.1	221	6.4	66	20.4	9.7
	B	A		26	35	38	61	22.0	99	13.6	73	18.5	
FfM - Prs	A	B		99	63	44	162	8.3	206	6.5	107	12.6	7.6
	B	A	37	18	33	38	51	26.4	89	15.2	71	18.9	
FfM - Zürich	A	B		42	52	32	94	14.3	126	10.7	84	16.0	8.9
	B	A	35	4	59	8	63	21.3	71	19.0	67	20.0	
Oslo - Sthm	A	B		8	22	49	30	44.8	79	15.4	71	18.9	7.8
	B	A	668	67	56	46	123	10.9	169	7.1	102	13.2	
Købn - Sthm	A	B		18	15	44	33	40.7	77	13.2	59	22.8	
	B	A											

TABLE 2 *(contd.)*

Circuit	Direction →	Isolated breaks										
		<5 ms	5-20 ms	20-300 ms	300 ms-1 min	Total 5-300 ms	MTBF/Tg h	Total 5 ms-1 min	MTBF/Tg h	Total 20 ms-1 min	MTBF/Tg h	MTBF/Tph h
FfM - Pha	A B		320	145	15	465	2.9	480	2.8	160	8.4	6.8
	B A		20	10	29	30	44.8	59	23.0	39	34.5	
Bxl - Rt	A B		11	2	5	13	103.0	18	75.0	7	192.0	79.0
	B A		12	2	8	14	96.0	22	61.0	10	134.4	
A → B		884	986	644	567	1630	15.0	2197	11.0	1211	20.0	10.0

TABLE 3

Test series	Total length of circuit	Number of circuits	Number of circuit sec-tions	Composition of the average circuit length in km				MTBF for the different categ. of breaks in h				MTBF for the different categories of breaks and services [1]		
												Telegraphy		Telephony
				Sym. pairs	Sub-marine cable	Land coax. cable	Radio link	< 5 ms	5-20 ms	20-300 ms	300 ms-1 min	5 ms-1 min	20 ms-1 min	20 ms-1 min
7	4038 km	8	?	105	62	246	92			10 h (16 directions)	17.7 h (8 circuits)	6.26 h (16 directions)	11.9 h (16 directions)	5.95 h (8 circuits)
8	5805 km	10	15	111	60	186	223	6.1 h (4 directions)	24.5 h (18 directions)	37 h (18 directions)	21.5 h (9 circuits)	11 h (18 directions)	20 h (18 directions)	10 h (8 circuits)

[1] In the calculation of the MTBF all faults having a duration of either < 5 ms or > 1 min are excluded.

Note 1. — It should be remembered that the threshold in the 7th and 8th series of tests was different, being 0.7 Np/6 dB, 1.1 Np/10 dB respectively.

Note 2. — In the calculation of the MTBF values the use of the circuits was assumed to be unidirectional (for v.f. telegraphy) or bidirectional (for telephony). The number of directions or circuits used for calculation is shown in brackets.

TABLE 4

Total breaks day and night of all circuits

Cause of short breaks in transmission		Isolated breaks 5-300 ms		Isolated breaks 300 ms-1 min		Series of breaks	
		Number	%	Number	%	Number	%
Faults	Power supplies	58	3	44	8	34	15
	Cables	17	1	14	2	33	14
	Radio-link fading	146	9	27	5	6	2
	Terminal equipment	16	1	23	4	6	2
	Frequency generating equipment	14	1	7	1	7	3
	Carrier line equipment	9	1	9	2	18	8
	Total faults	260	16	124	22	104	44
Maintenance	Power supplies	20	1	3	1		
	Terminal equipment	37	2	26	5	7	3
	Frequency generating equipment	38	2	8	1		
	Line	71	5	36	6	36	15
	Total maintenance	166	10	73	13	43	18
Work	Power supplies	25	1	19	3	6	2
	Cables	14	1	22	4	2	1
	Other	11	1	29	4	4	2
	The station	29	2	57	11	16	7
		79	5	127	22	28	12
Cause unknown		1125	69	243	43	62	26
Total		1630	100	567	100	237	100

SUPPLEMENT No. 4.3

CHARACTERISTICS OF LEASED INTERNATIONAL TELEPHONE-TYPE CIRCUITS

The following characteristics are likely to be exhibited by an international point-to-point private circuit having the least favourable values for all the permissible limits. For circuits of less complicated structure the relevant quantities can in many cases be modified by using a suitable proportionality factor.

1. *Attenuation distortion*

In order to make a reliable estimate of the attenuation distortion likely to be encountered in practice on a maximum world-wide private circuit from renter to renter it is necessary to know, or estimate, the distortion contributed by the principal components of such a maximum circuit. These components are as follows:

1.1 *Two subscribers' lines*

The average length of a subscriber's line is probably between ½ to 1½ miles (0.8 to 2.4 km) routed on unloaded cable pairs, often of mixed gauge and introducing an attenuation of, say, 4 to 5 dB (4.6 to 5.8 dNp) at 1600 Hz. The maximum amount of unloaded cable pair is typically such as will introduce an attenuation of 10 dB (12 dNp) at, say, 1600 Hz. Longer lengths will probably be loaded.

1.2 *Two junction circuits*

These circuits connect the local exchange to the trunk centre and typically are routed on loaded or unloaded cable pairs, each introducing attenuation in the range 3 to 6 dB (3.5 to 7 dNp) at 1600 Hz. In some connections these junctions will be provided on short-haul f.d.m. or p.c.m. line transmission systems.

Figure 1 shows the insertion loss-frequency characteristic between 600-ohm resistances of an unloaded cable pair dimensioned to introduce 19 dB (22 dNp) at 1600 Hz. The 19 dB (22 dNp) is composed as follows:

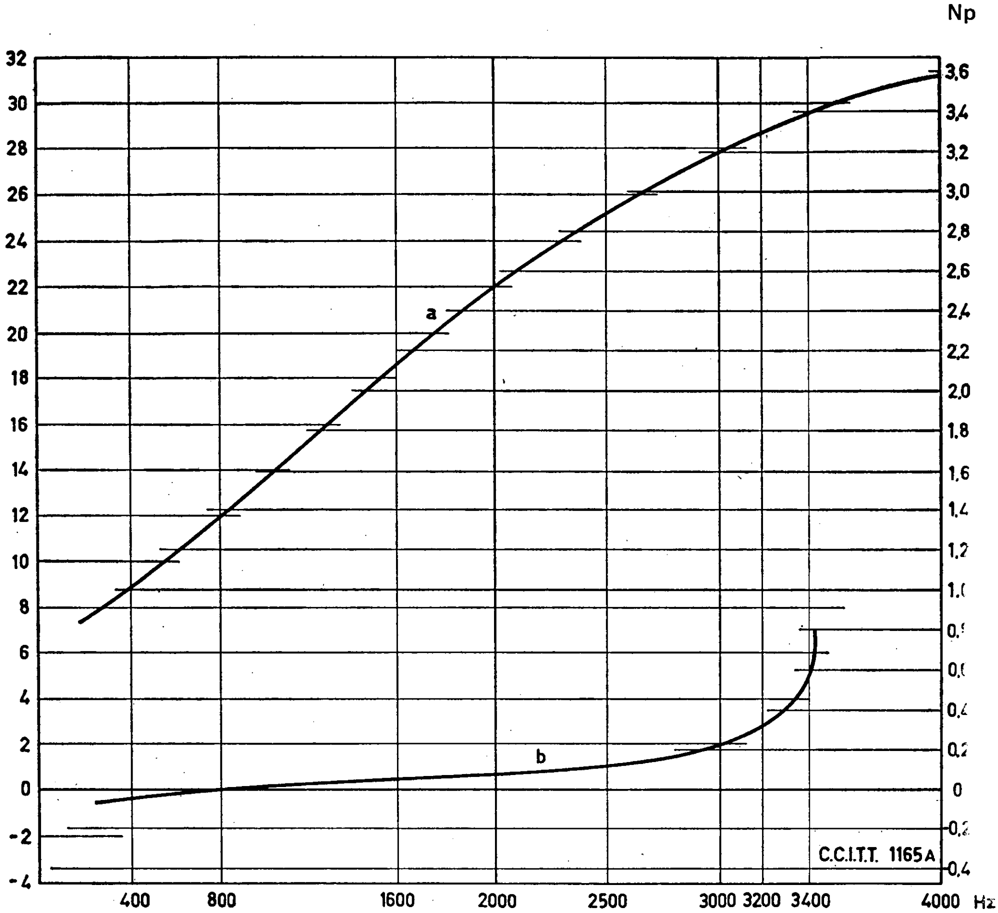
— two average subscribers' lines, 4.5 dB each = 9 dB,

— two average junction circuits, 5 dB each = 10 dB.

Figure 1 also shows the unequalized attenuation-distortion of 50 miles (80 km) of loaded cable (20 lb, 19 gauge, 0.9 mm, 88 mH, 2000 yards, 1.818 km, 0.066 μF/mile, 41 nF/km).

1.3 *A four-wire chain of 12-carrier circuit-sections*

Study Group XV has expressed the opinion that the likely limits of the attenuation-frequency characteristic of a chain of twelve carrier circuit-sections each with one pair of 4-kHz channel equipments conforming to Recommendation G.232 will be as follows:



a = Twice the insertion loss between 600-ohm resistances of 14 000 yards (12.8 km) of unloaded cable (20 lb; 19 gauge; 0.9 mm) the attenuation at 1600 Hz being 19 dB (22 dNp).

b = Unequalized attenuation of 50 miles (80 km) of loaded cable relative to the attenuation at 800 Hz (88 mH, 2000 yards, 1.818 km, 20 lb; 19 gauge, 0.9 mm; 0.066 μF/mile, 41 nF/km).

FIGURE 1. — **Characteristics of circuit sections routed on loaded and unloaded cables**

Frequency range (Hz)	Range of loss relative to that at 800 Hz
Less than 400	Not less than −2.2 dB (−2.5 dNp) Otherwise unspecified
400-600	+4.3 to −2.2 dB (+5 to −2.5 dNp)
600-2400	+2.2 to −2.2 dB (+2.5 to −2.5 dNp)
2400-3000	+4.3 to −2.2 dB (+5 to −2.5 dNp)
3000-3200	+8.7 to −2.2 dB (+10 to −2.5 dNp)
Greater than 3200	Not less than −2.2 dB (−2.5 dNp) Otherwise unspecified

Some long international circuit-sections use 3-kHz-spaced channel equipment, so there will be no signal transmitted above about 3100 Hz on circuits incorporating such a section. Furthermore, such circuit-sections sometimes have three pairs of channel-translating equipments.

The nominal loss at 800 Hz of the chain of 12 sections between the two-wire points of the terminating sets at the terminating trunk exchanges is not specified, but could be of the order of 10 dB (12 dNp); the standard deviation will be of the order of 3 to 4 dB (3.5 to 4.6 dNp).

2. *Group delay and group-delay distortion*

Study Group XV has estimated the combined group delay characteristic of the channel-translating equipments in a chain composed of twelve carrier circuit-sections using typical figures supplied by administrations.

This characteristic together with the corresponding characteristic for 50 miles (80 km) of loaded cable is given in the table below.

Frequency (Hz)	Group delay (ms) 12 pairs of channel-translating equipments	50 miles (80 km) of loaded cable [1]
300	50	4.5
400	35	4
2000	14	4
3000	22	5.5
3400	41	6

[1] 20 lb, 19 American wire gauge 0.9 mm; 88 mH/2000 yards, 1.818 km; 0,066 μF/mile, 41 nF/km.

The group-delay distortion introduced by unloaded cable pairs is generally negligible compared with group delays of the magnitude shown in the table.

Hence the group-delay distortion of a world-wide private circuit is likely to be of the order of 36-38 ms at 300 Hz and between 27-35 ms at 3400 Hz, the higher figures being taken if there is 200 miles (320 km) or so of unequalized loaded cable in the circuit.

The absolute group delay at a frequency of 800 Hz or so can be estimated for a particular connection from the following:

National systems

The group delay to the most distant renter is unlikely to exceed:

$12 + (0.0064 \times \text{distance in statute miles})$ ms

$12 + (0.004 \times \text{distance in kilometres})$ ms

International circuits

1) Terrestrial, including submarine, cables: assume a velocity of propagation of 100 statute miles/ms (160 km/ms).

2) *Satellites* (single hop)

Medium-altitude satellite — mean altitude 8750 miles (14 000 km): 110 ms
High-altitude satellite — mean altitude 22 500 miles (36 000 km): 260 ms.

3. *Magnitude of echoes accompanying the data signal*

In Annex I of the *Blue Book*, Volume III, an estimate is made of the stability of the four-wire chain of circuits of a world-wide connection. The method of calculation described in that annex can be used to estimate the magnitude of the first listener echo accompanying the signal at the data receiver on a private circuit having two-wire extension to the renters' premises. As a first approximation the ratio of the signal to first listener echo at the terminal trunk exchange serving the data receiver is twice the stability [1] of the four-wire chain assuming substantially equal balance return losses at the two terminating sets and also assuming that they are the principal echo sources.

The attenuation distortion suffered by the echo signal is not now a function solely of the transmission losses of the circuit-sections but also of the balance return loss characteristics presented at the terminating sets. In this regard it is important to note that the worst values of balance return loss usually occur at the edges of the telephone band, outside the likely band of interest for data transmission. Hence, the value of balance return loss may be assumed to be greater than the stability balance return loss, perhaps approaching the value of echo balance return loss, although this latter is more strictly related to the subjective effect of echo on telephone users.

4. *Thermal and intermodulation noise* (hissing) [2]

The objectives for the noise power at a zero relative level point on international hypothetical reference carrier circuit 2500 km long on a cable or radio-relay systems are given in Recommendation G.222. Other noise objectives are given for circuits on open-wire lines, tropospheric forward-scatter systems and communication satellite systems in Recommendations G.311, G.444 and G.445 respectively.

Objectives are given for hourly-mean, the one-minute-mean, and the 5 ms-integrated noise powers. The one-minute-mean and the 5 ms-integrated noise objectives apply particularly to radio-relay systems whereas cable f.d.m. systems are adequately described by the hourly-mean alone.

It must be noted that the durations mentioned (hour, minute, 5 ms) refer to the method of measurement or calculation. They do not in any way purport to describe the characteristics of the noise being measured. In the particular case of radio-relay systems the C.C.I.R.

[1] The quantity " twice the stability " is numerically equal to the quantity referred to as " loop loss " (symbol M) in Annex 1 of the *Blue Book*, Volume III.

[2] The references in this section 4 are to Volume III of the *Blue Book*.

is of the opinion that high-level noise attributable to propagation phenomena (e.g. fading) is characterized by duration of the order of seconds or tens of seconds and that high-level noise from other sources (e.g. clicks from power supplies and switching apparatus) is reduced to negligible proportions by suitable design of the radio-relay system.

For circuits less than 2500 km, one may assume without serious error that the magnitudes of the hourly-mean and the one-minute-mean noise powers are directly proportional to length. In the case of the 5 ms-integrated noise power it is the incidence which may be considered to be proportional to length (i.e. the percentage of the month or hour).

Provisional noise objectives for very short circuits on carrier systems are given in Recommendation G.125, and those for circuits much longer than 2500 km are given in Recommendation G.153. These objectives are being studied by Special Study Group C.

It may be of interest to note that the objectives given in Recommendation G.222 are suitable for existing systems of telephone signalling and also for frequency-modulated voice-frequency telegraphy at 50 bauds. Amplitude-modulated voice-frequency telegraphy at 50 bauds is more susceptible to noise and Recommendation G.442 gives a more stringent objective for the 5 ms-integrated noise power.

5. *Impulsive noise* (clicks and bangs)

Little is known quantitatively about impulsive noise on international circuit-sections. Special Study Group C has recently specified a suitable instrument to measure impulsive noise. For information, impulses equalling the peak value of a sinusoid with a power level of −30 dBm0 (35 dNm0) are not uncommon on channels of modern carrier systems. Impulses at lower levels are correspondingly more numerous.

6. *Spurious signals at discrete frequencies* (whistles)

When 16-channel groups are routed on group links provided by f.d.m. systems based on 4-kHz-spaced virtual carrier frequencies it sometimes requires special effort to reduce the 1-kHz and 2-kHz whistles to an acceptable level.

7. *Short interruptions*

Supplement No. 4.2 to Volume IV of the *White Book* gives the results of the recent series of measurements of interruptions on international circuits. As a first approximation the incidence of the interruptions can be assumed to be proportional to circuit length. However, there cannot reasonably be interruptions of this type on that part of a circuit or connection provided on undersea plant or satellite paths.

8. *Sudden phase changes*

In f.d.m. systems these often occur when carrier supplies are changed over. Any phase-change from 0° to 180° can be expected. It is doubtful if such phase changes ever occur unaccompanied by a short break or indeed if they are even distinguishable from them.

9. *Unwanted side-frequencies derived from power supplies* (hum-modulation)

One cause of this is the presence of spurious signals on the carrier supply at the power supply frequency (and its harmonics and subharmonics). Values of signal-to-side frequency ratios lie typically in the range 45 to 55 dB (52 to 63 dNp) per circuit, although much lower ratios have been encountered. This topic is to be investigated in the current study period.

10. *Frequency error*

A circuit comprising 12-circuit sections each routed on carrier group is estimated to introduce a frequency error with a mean value of 0 Hz and a standard deviation from the mean of 1.1 Hz. If a normal distribution of errors is assumed the chance of any particular value of error can be estimated.

Less complicated circuits can be reasonably expected to introduce less chance of frequency error. For a circuit with no more than three circuit-sections routed on carrier systems the maximum error should not exceed $\pm$ 2 Hz.

11. *Non-linear distortion*

11.1 *F.d.m. systems*

Cross modulation products generated within the transmitted band of f.d.m. systems are usually at an insignificantly low level, provided the total power level of the compound signal is sufficiently below the overload point of the channels.

11.2 *P.c.m. systems*

It is inherent in p.c.m. line transmission that sinusoidal signals will be accompanied by intermodulation products which are somewhat higher in level than those generated in a conventional f.d.m. carrier circuit and of course considerably higher in level than those in a physical audio pair circuit. The actual signal/distortion ratio for a particular p.c.m. system is a function of the number of coding digits, the companding law and the signal level. For systems currently in operation, or being studied, a maximum signal/distortion ratio of about 30 dB (35 dNp) could be attained over a range of signal levels from 0 to

30 dBm0 (0 to 35 dNm0). At levels above or below this range, the signal/distortion ratio falls fairly rapidly to, typically, 10 dB (12 dNp). The distortion products are of the type 2A, A + B and 2A-B. On international private circuits there would be two such circuits and, more exceptionally, four unless special routing instructions are given to avoid their inclusion.

SUPPLEMENT No. 4.4

RESULTS OF MEASUREMENTS MADE ON INTERNATIONAL CIRCUITS, CHAINS OF INTERNATIONAL CIRCUITS AND INTERNATIONAL EXCHANGES DURING 1964-1968

1. In 1965 a few measurements organized by Study Group IV were made on international circuits and chains of circuits. The following annex is a summary.

2. Additional information can be found in the following 1964-1968 documents:

COM IV—146 (Australia): Chains of circuits

COM XVI—75 (Australia): International exchange

COM XVI—76 (Japan): International exchange

ANNEX

Measurements of international circuits

(Figure 1 and Graphs 1 and 2)

Limits are sought by Study Group IV for international circuits and Study Group XVI asked for a comparison to be made between measurements on switched connections and measurements on *circuits*. The results illustrated in Graphs 1 and 2 are relative to circuits and accordingly represent information of use and interest to Study Groups IV, XV and XVI.

These are *mean* values so that some circuits were outside the boundaries on the two graphs.

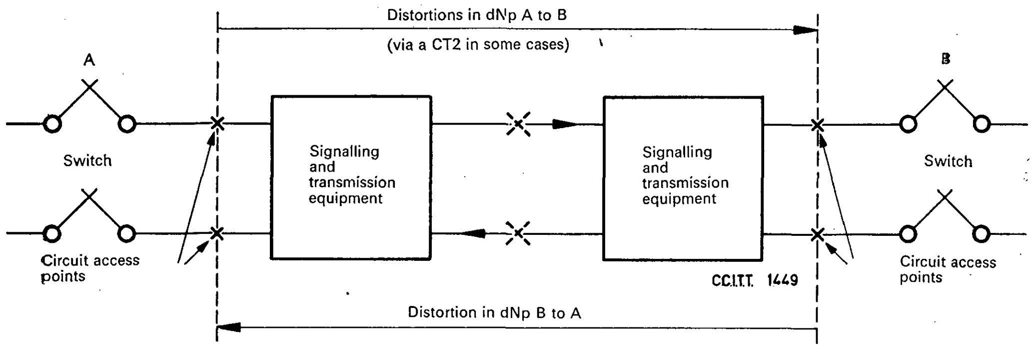
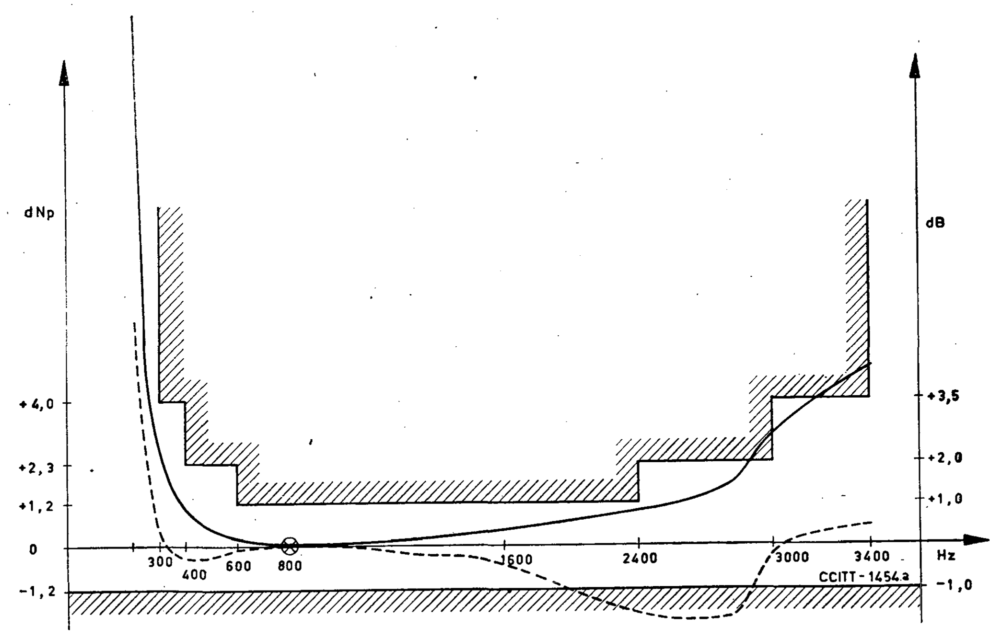
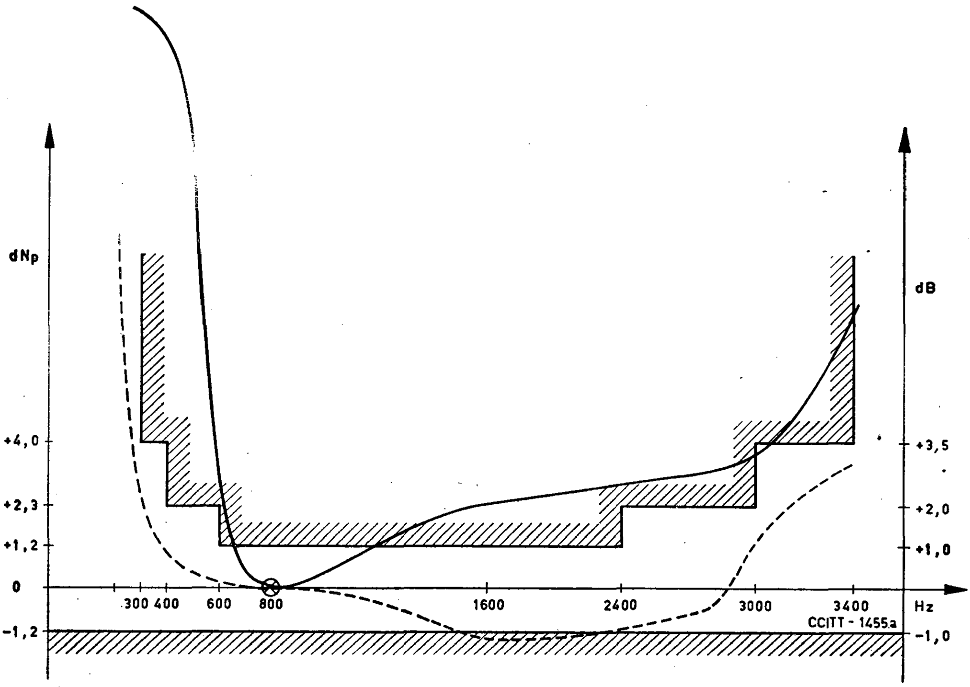


FIGURE 1. — **Schematic diagram showing the measurements concerned in the establishment of Graphs 1 and 2 following**



1965-mean values only
All the recorded values fall within boundary lines
(Recommendation M.58 — Table A (M.58))

GRAPH 1. — **Range of mean distortion for one 4-kHz category A international circuit between circuit test access points**



1965-mean values only
All recorded values fall within the boundary lines
(Recommendation M.58 — Table A (M.58))

GRAPH 2. — **Range of mean distortion for two 4-kHz category A international circuits between circuits test access points at the terminal centres**

SUPPLEMENT No. 4.5

INSTRUCTIONS FOR MAKING FUTURE MEASUREMENTS OF THE TRANSMISSION QUALITY OF COMPLETE CONNECTIONS AND FOR RECORDING THE RESULTS OF THE MEASUREMENTS

1. *Setting up the connections*

a) The connections should be set up preferably between service telephone instruments situated in local exchanges. In this way the length of subscriber's local line is reduced to a minimum and the necessity to refund call-charges is avoided. When the connection has been established the telephone instruments are disconnected and their place taken by the appropriate measuring instrument. (See section 7 for a possible arrangement of testing apparatus.)

b) The connections should be set up at the time of test in precisely the same fashion as they would be for ordinary calls. For example, on semi-automatic routes an operator is required. When this is the case then the test call should be made in exactly the same way using the normal operating procedures appropriate for the administration.

The characteristics of connections between test desks, repeater station test-jack panels etc. are of little use and are not required.

c) Sometimes when an operator is required in order to set up an outgoing international call, the calling subscriber is requested to replace his receiver and the outgoing operator recalls him when she has established the connection forward to the called subscriber. This means that on the established connection part (or whole) of the national extension of the outgoing country comprises national routes operated in an incoming direction. Such calls are termed " reverted calls " and an indication is required when this occurs (see section 6).

d) Some connections may be established via an alternative route or an overflow route which includes intermediate *international* exchanges through which the call does not pass on the direct route. However, this is not likely to occur so often as to seriously jeopardize the accuracy of any subsequent analysis if it were undetected. In consequence there is no need to ascertain whether it has occurred.

e) It should be possible to set up one or two teams (perhaps having some knowledge of foreign languages) travelling around the country making international test calls. There are obvious advantages if such travelling teams make outgoing calls to one or two selected service numbers in the objective countries. This will obviate the need to set up elaborate permanent arrangements to give international co-operation from a variety of national locations.

f) Once communication has been established between a travelling team making the outgoing call and the stations specially equipped to receive incoming calls, the telephone number of the travelling team can be made known to the fixed team and measurements can readily be made on connections set up in the reverse direction. In this way there is no need to publish the telephone numbers to be used by the travelling teams beforehand.

g) There is no need to involve the personnel of the international centre or repeater station. However, their role as language interpreters should not be overlooked. It might prove useful to establish communication with the international centre separately when their assistance is required. Accordingly international centres should be informed when these tests on complete connections are being made so that they may be prepared to co-operate when asked. Ordinarily there should be no need for the international centre to intervene on the connection being measured unless there is some fault condition.

h) Administrations willing to receive incoming test calls should enter into direct negotiation with administrations with which they can co-operate conveniently (common language of communication, identity or convenience of time zone, convenience of circuits and relations). In these negotiations, they will need to make known the national numbers of a selection of service installations, which will be equipped with the requisite measuring apparatus, and from which co-operation will be given during agreed working hours. The exchanges at which the service installations are selected should if possible each have a different complexity of routing to the international exchange. In this way a sample of the major classes of national extension can be obtained. The period over which a co-ordinated programme of test calls will be made will be notified by Study Group IV.

This does not affect similar tests that administrations may wish to carry out between themselves at any time, but the results of such tests will *not* be sent to the rapporteur. If desired, an analysis only can be sent to the C.C.I.T.T. Secretariat for transmission to the particular Study Group concerned.

i) If possible, samples of complete connections involving various numbers of national circuits ranging from the minimum number to the maximum national extensions should be measured.

j) For the various types and numbers of each complexity of connection tested, there is no need to take any account of the pattern of traffic incidence.

2. *Fault conditions*

When a gross fault condition has been clearly established on a connection that has been set up, the outgoing country should record the fault on the form for outgoing calls. Steps should, of course, be taken to clear such faults as soon as possible.

3. *Speech concentrators*

Connections established over international circuits provided by a speech concentrator (e.g. CELTIC, TASI) introduce varying amounts of loss as the speech concentrator reassigns connection channels.

In order to prevent this happening special arrangements and procedures (described in section 8) are necessary.

In order to provide some information on the magnitude of this effect on the measured loss at 800 Hz, opportunity should be taken on one or two occasions to observe and record the effect of deliberately interrupting both test tone and guard tone (see section 8). Of course, this will only be effective during the busy period of the international route involved.

4. *Impedance of measuring apparatus*

The impedance of the measuring instruments should be that normally used by the administration.

Where the impedance used by the administration is other than 600 ohms, the administration should furnish the results as measured with the normal test arrangements. Tests have shown that, in practice, the effect of having different nominal impedances is negligible.

The other administration co-operating in the tests should be advised of the terminating impedance involved in the measurements.

5. *Quantities to be measured or calculated*

The following quantities are to be measured or calculated:

a) the transmission loss in both directions of transmission at as many of the following frequencies as possible: 200, 300, 400, 600, 800, 1000, 1400, 2000, 2400, 3000, 3400 Hz;

b) the group delay distortion wherever possible. This can only be done if both administrations have compatible group-delay distortion measuring sets;

and at both ends of the connection:

c) the value of unweighted (flat) noise *power* level;

d) the value of psophometrically-weighted noise *power* level (the value of the psophometric *e.m.f.* is not required).

e) the band-limited noise power level, using a filter having the following characteristics:

Insertion loss between 600 ohms of the auxiliary filter to be used in conjunction with the voltmeter portion of a psophometer (see Note 1 below) *in order to limit the band when measuring noise*

Frequency range (Hz)	Insertion loss relative to that at 800 Hz (see Note 2 below)
Below 600	To increase (as frequency decreases from 600 Hz) at approximately 18 dB/octave
600	3 dB (nominal)
600-750	Uniformly decreasing, otherwise unspecified
750-2300	0 ± 1 dB
2300-3000	Uniformly increasing, otherwise unspecified
3000	3 dB nominal
Above 3000	To increase (as frequency increases from 3000 Hz) at approximately 18 dB/octave

Note 1. — When a psophometer is not used the voltmeter portion of the national noise-measuring instrument should be used.

Note 2. — The insertion loss should be between impedances equal to the nominal impedance of measuring instruments used in the local network. In some countries this is other than 600 ohms, for example, 900 ohms.

f) wherever possible, impulsive noise levels should be measured for 15 minutes with the measurement instrument specified in Recommendation V.55 and a threshold setting of −18 dBm0, i.e. 18 dB below the received level when the normal generator is applied on the transmit side to the reference frequency (800 Hz or 1000 Hz). The instrument shall be used in the " flat " bandwidth condition with a nominal, dead-time of 125 ms.

6. *How the measurements should be made and the results presented*

a) *Units*

On the assumption that the rapporteur has a computer available to analyse the results, the measurement results sent to the rapporteur may be expressed in any of the units indicated below provided it is clearly indicated which units are used. Units other than those given below should not be used.

— measurement signals: dBm, dNm, Nm;
— unweighted (flat) and band limited noise: dBm, dNm, Nm, mV(pd), dBrn;
— psophometrically weighted noise: dBmp, dNmp, Nmp, mVp(pd), dBrnC.

(In the case of values expressed in mV(pd) and MVp(pd)', the impedance of the measuring instrument must be stated.

It is recommended that the measurement results be expressed in dBm instead of dNp or mV (see Recommendation B.4, *White Book*, Volume I).

The levels of measurement signals should be recorded to three significant figures and noise power to two significant figures.

Group delay distortion should be in milliseconds.

Distances should be in kilometres.

b) *Measuring points*

The only signal levels to be recorded are those injected or measured at the test locations at the end of the complete connection.

c) *Quantities recorded*

The noise power levels actually measured at the specified points should be submitted. No attempts should be made to refer them to any other points.

d) *Interchange of information*

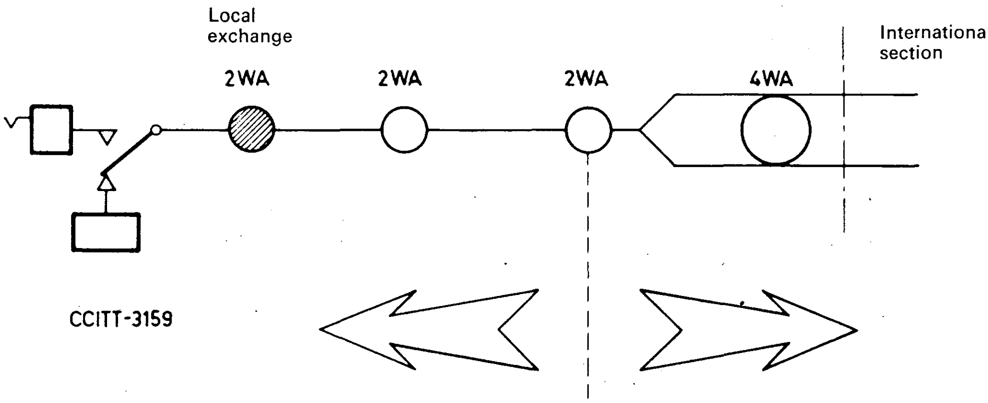
At the time of the measurement, all parties if possible should exchange the results of measurements among themselves. This will naturally be done in terms of the units in which they are measured. It follows that each person should have copies of the appropriate form with the same layout as the C.C.I.T.T. form which permits the use of a variety of units.

e) *Routing information*

The sketch associated with the test form should be completed for each test call. There is no need to give details of the structure of the national extension, such as the number of the circuit used between national exchanges. However, the general routing structure must be known, e.g. that the connection was routed through a two-wire switched primary centre and then into a four-wire switched secondary centre. The letters A and M should be used to indicate automatic or manual telephone exchange. Any information concerning the nature of the transmission systems involved which is readily available should be given though it is appreciated that this will not normally be possible.

f) *Reverted calls*

These should be indicated on the forms by arrows as shown in the example below which indicates that in this case the call was reverted at an intermediate two-wire manual board.



g) *More than one test call between same locations*

If more than one test call is made between the same locations the results for each should be submitted separately. However, such calls should be distinguished from one another by a serial number. For example:

London (GB) 4323891–Milan (I) 867433
Call No. 2 of three calls

To identify the countries concerned, the codes given in the *Routine maintenance programme* should be used in all cases.

h) *Responsibility for submitting the results to the rapporteur*

The country initiating a particular call should submit the measurement results for both directions of transmission in the units permitted under point a) above on an " outgoing " form. The routing sketch should be completed showing the national section and the international section including any international transit exchanges.

The country receiving this call will submit an " incoming " form with its own national section of the routing sketch completed, the measurement results for both directions of transmission should also be included. These will provide a valuable check of any obvious errors in the results submitted on outgoing forms, resulting from, perhaps, language difficulties between the technicians carrying out the tests.

It would be of great help to the rapporteur if " outgoing forms " were printed on white paper and " incoming forms " on coloured paper. Outgoing forms should have the name of the country printed in the top right-hand corner—see forms below. Incoming forms should also have a space into which the name of the outgoing country can be inserted—see forms below.

The date, universal time (G.M.T.) and local time is information of the greatest importance to the rapporteur in correctly associating the pair of forms from each connection tested.

It is essential that the forms sent to the rapporteur by each country be identical in the layout and sequence of the measured results and similar forms to those shown below should be used. When layouts are identical the rapporteur is able to deal with forms in foreign languages and translation is then not necessary. There is no provision on the forms for recording group delay distortion measurement results. Those countries able to make such measurements should associate a record of them with the outgoing (or incoming) form and mark them with a cross-reference to the test-call. The reference frequency of the group delay distortion measurement should be clearly indicated.

7. *Example of a suitable test arrangement*

Figure 1 shows a suitable arrangement that can be used for testing switched connections. The components marked " only if required " concern connections likely to encounter speech concentrators for which special arrangements and procedures are required.

8. *Special apparatus and procedures for connections likely to encounter speech concentrators*

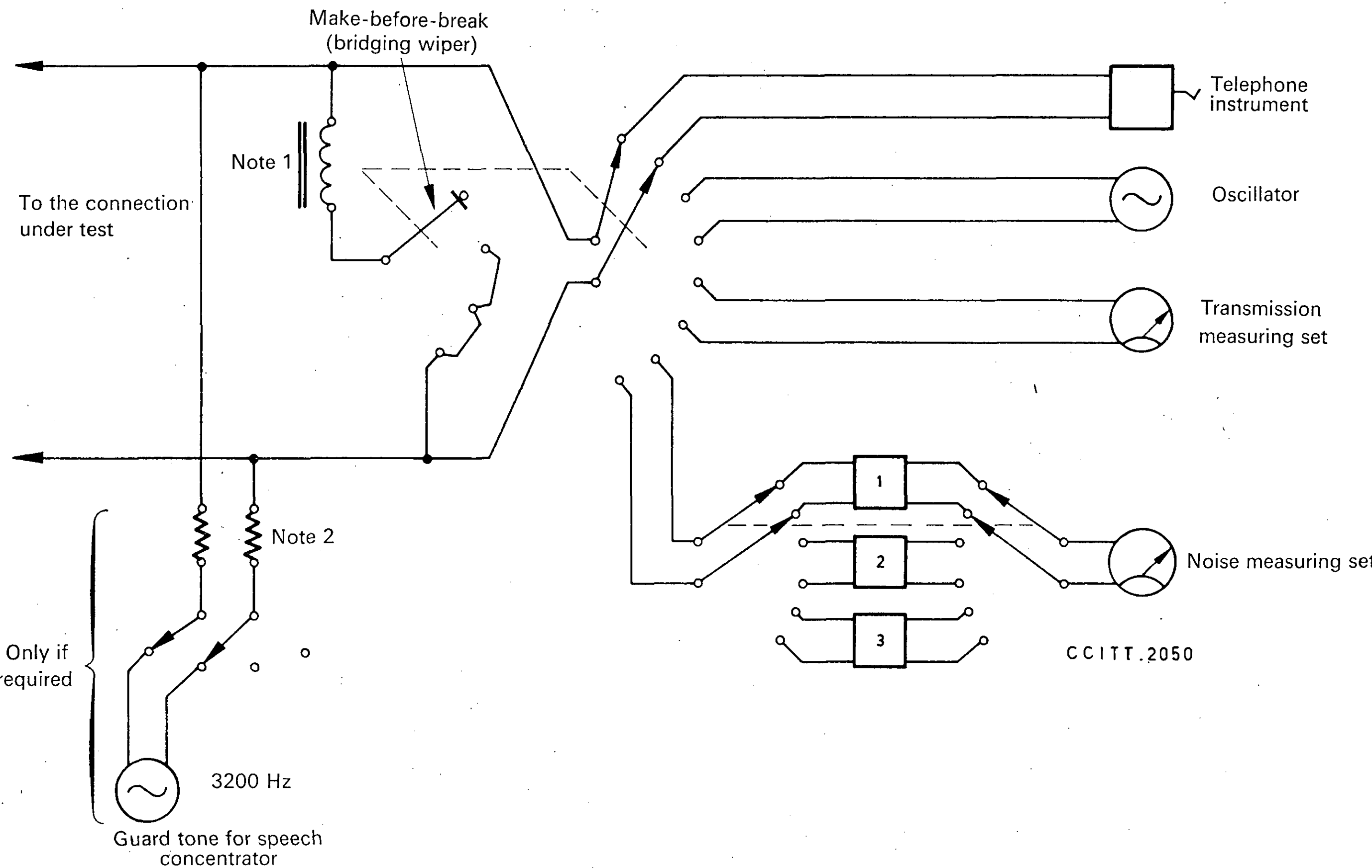
a) In order to prevent a speech concentrator from reassigning a connection channel during the tests a high-frequency (for example 3200 Hz), low-level (for example approximately —30 dBm or —35 dNm at the end of the complete connection) guard tone may be used to ensure that the connection channel is retained. The optional components in Figure 1 show how this can be done.

b) In practice the presence of the guard tone injected at one end has no effect on the accuracy of received signal or noise levels measured at the other end. This is because at the present time (1967) connection channels for speech concentrators are provided on 3-kHz-spaced channel equipments so that a guard tone of 3.2 kHz, although reaching the speech concentrator terminal, will not be transmitted by the connection channel. A useful consequence of this circumstance is that when the guard tone is transmitted over the whole of the connection it may be fairly assumed that there is no speech concentrator in the connection, so that in this case the guard tone can be removed and the tests made in the usual way.

c) The presence of the locally-injected guard tone, however, can seriously affect the local noise measurements and a special procedure is necessary as follows:

i) when the connection has been established the guard tone is injected first at one end and then at the other. If neither end can hear the guard tone a speech concentrater has probably been encountered. If the guard tone can be heard no speech concentrator is likely to be involved.

ii) end A with guard tone ON and end B with guard tone OFF, the noise at B and the loss A to B can be measured, the guard tone from A ensuring continuity of the channel A to B;



Note 1. — High-impedance hold coil. For example 4000 ohms, 4.2 henrys, the impedance being maintained in the presence of an appropriate direct current, for example 90 mA.

Note 2. — The value of these resistors and the output level of the 3200-Hz oscillator should be chosen so that approximately −30 dBm (−35 dNm) is delivered to the connection being tested and furthermore so that the accuracy of the measurement of received signals and noise is not affected by undue tapping loss.

Weighting networks 1 = flat   2 = telephone (message) weighting   3 = band-limiting

FIGURE 1. — **Example of a suitable test arrangement**

iii) end A with guard tone OFF and end B with guard tone ON, the noise at A and the loss B to A is measured, the guard tone from B ensuring continuity of the channel B to A. This is not necessarily the same channel as was used when the connection was first established but this is of no importance.

9. *Forms to be used to record the results*

a) It should be remembered that technicians not necessarily used to international working may be making the tests. As a result they may not be familiar with the transmission units used in other countries. Furthermore, they themselves may only have national testing apparatus available. It follows that the instructions concerning how to record the results must be as clear and unambiguous as possible and there follows an example of such an instruction sheet.

b) It is likewise important that both ends have forms laid out in a similar fashion and the " outgoing form " and " incoming form " are shown below.

c) The same kind of forms can also be sent to the rapporteur, one "outgoing form" printed on white paper for each outgoing call and one " incoming form " printed on coloured paper for each incoming call.

Because the rapporteur is able to convert the various measurement units in the analysis, the actual forms [1] used by the technicians carrying out the tests may be sent to the rapporteur. It may be necessary for headquarters staff to complete some of the information on the outgoing forms, such as the length and routing of the international section.

ANNEX

Specimen instruction sheet for staff carrying out tests

1. Universal time G.M.T., LOCAL TIME AND DATE must be carefully and accurately given.

2. Use a white OUTGOING FORM (on which you will be Country A) for each outgoing call you establish (whether it is reverted or not). Use a coloured INCOMING FORM for each incoming call you receive. On this form you will be Country B. On the INCOMING FORM, write, in the space provided at the top right-hand corner, the name of the country making the call.

[1] Or copies, but not photocopies, so that the valuable distinction of colour of an incoming form can be retained.

3. Indicate the type of call on the OUTGOING FORM, for example, manual, semi-automatic (operator-dialled) or automatic (customer-dialled).

4. Indicate your reference frequency (800 Hz, 1000 Hz for example) and obtain that used by the other end.

5. Indicate the impedance of your test apparatus (600 ohms, 900 ohms for example). Obtain that used by the other end.

6. If when measuring the loss at various frequencies you operate intermediate signalling apparatus with a particular frequency choose some frequency as close as possible and amend the table. If this is not possible omit the measurement at the frequency.

7. To measure noise first verify that the connection is still established, then both A and B measure the noise at the same time (so that the connection is terminated) using a noise-measuring instrument (psophometer) in the following ways:

— without any filter or weighting network. This is termed a " flat measurement ";

— with a telephone (message) weighting network. This is termed a " weighted measurement ";

— with the filter specially provided for these tests, the telephone (message) weighting network being out of circuit. This is termed the " band-limited measurement ".

State the units used very clearly, e.g. mV(pd), dBrnc, Nmp, dBmp, etc. and ascertain what unit the other end uses as well. Remember, noise in dBrnc is a positive number (e.g. +30 dBrnc) whereas noise in dBmp and Nmp is usually a negative number (e.g. −60 dBmp, −5.2 Nmp).

" Flat " and " band-limited " measurements are recorded in mV(pd), dBrn, dBm, Nm, etc. " Weighted " measurements are recorded in mVp(pd), dBrnc, dBmp, Nmp, etc.

The p indicates " psophometrically-weighted " whereas the c in dBrnc indicates " c-message weighting ".

8. If there is likely to be a speech concentrator (you will have been informed of this possibility) the following procedure should be followed:

"i) When the connection has been established the guard tone is injected first at one end, with the other end listening and then vice versa. (If neither end can hear the guard tone a speech concentrator [1] has probably been encountered. If the guard tone can be heard no speech concentrator is likely to be involved.)

ii) End A with guard tone ON and End B with guard tone OFF the noise at B and the loss at A to B can be measured, the guard tone from A ensuring continuity of the channel A to B.

iii) End A with guard tone OFF and End B with guard tone ON the noise at A and the loss B to A is measured, the guard tone from B ensuring continuity of the channel B to A. This

[1] Or an international circuit with 3-kHz-spaced channel modulating equipment. You will have been informed of this possibility.

is not necessarily the same channel as was used when the connection was first established but this is of no importance."

9. Sketch-in the general routing structure, if possible, by indicating whether four-wire or two-wire switching and whether manual or automatic exchange. Use abbreviations 4 WA, 2 WM, etc. Indicate the approximate total length of the national portion of the connection. Indicate type and length of transmission systems where this can *easily* be done. Indicate a reverted call with arrows.

10. In the space for comments indicate any peculiarities observed, for example variation, high noise level, etc. If a speech concentrator (CELTIC, TASI, etc.) is involved record here the effect of interrupting the test tone at 800 Hz. The guard tone must be disconnected and the test should be done during the busy-hour of the international route.

11. To measure group delay distortion ... (Here the Administration should give instructions concerning measuring and recording group delay distortion in accordance with section 6 h).

OUTGOING FROM NETHERLANDS[1]

Universal time (G.M.T.) .... Local time .... Date ....

A. Netherlands [1] exchange and number B. Terminating country exchange and number

Call No.................................... of .... calls

Set up during attempt number ....

Type of call: manual/semi-automatic (operator-dialled)/ automatic (customer-dialled)

Any faults detected:

Measurement of transmission loss

When a result is not available or not required a horizontal stroke should be marked in the relevant space.

Transmission direction Send level — 0 dBm — 0 Nm — 1 mW	Record the actual measured values at the ends of the connection dBm, Nm, etc. State the units used at each end Wherever possible include a measurement at 800 Hz											Impedance of test equipment	
	200	300	400	600	800	1000	1400	2000	2400[2]	3000	3400	A	B
A ——▶ B													
B ——▶ A													

Reference frequencies: A ------------ Hz B ------------ Hz

Measurement of noise power level

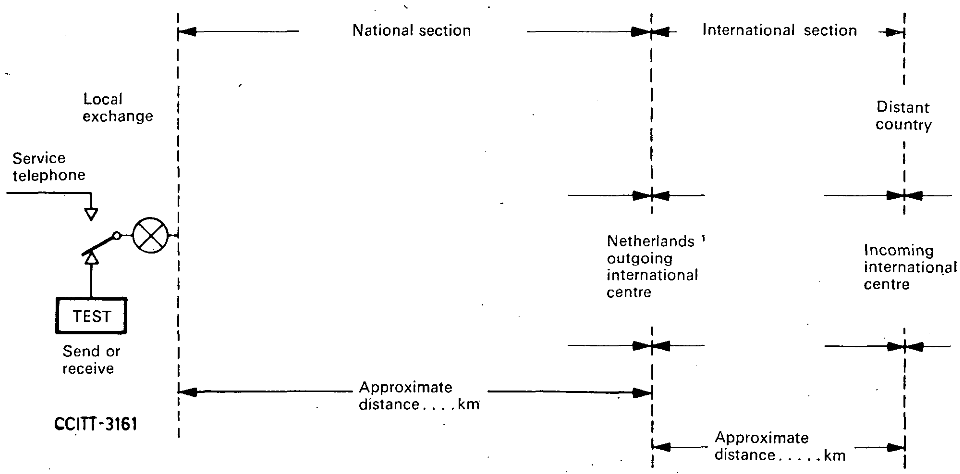
Flat measurement A ------------ B ------------

Weighted measurements A ------------ B ------------

Band-limited measurement A ------------ B ------------

Measurement of impulsive noise (optional)

Number of noise peaks exceeding −18 dBm0 in 15 minutes: A ------------ B ------------



[1] This is only an example.

[2] If it is not possible to use this frequency, measurements should be carried out on an adjacent frequency, e.g. 2500 Hz.

(To be printed on coloured paper) INCOMING TO NETHERLANDS [1]

Universal time (G.M.T.) .... Local time .... Date ....

A. Originating country exchange and number B. Netherlands [1] exchange and number

Call No................................... of.............................. calls

Measurement of transmission loss

When a result is not available or not required a horizontal stroke should be marked in the relevant space.

Transmission direction Send level — 0 dBm — 0 Nm — 1 mW	Record the actual measured values at the ends of the connection. dBm, Nm, etc. State the units used at each end Wherever possible include a measurement at 800 Hz										Impedance of test equipment	
	200	300	400	600	800	1000	1400	2000	2400 [2]	3000	3400	A	B
A ——▶ B													
B ——▶ A													

Reference frequencies: A ----------- Hz B ----------- Hz

Measurement of noise power level

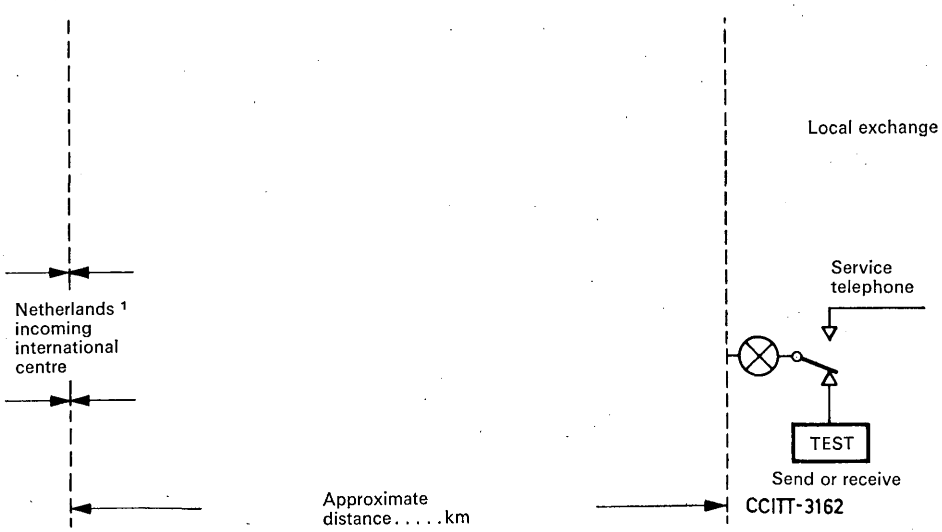
Flat measurement A ----------- B -----------

Weighted measurements A ----------- B -----------

Band-limited measurement A ----------- B -----------

Measurement of impulsive noise (optional)

Number of noise peaks exceeding -18 dBm0 in 15 minutes: A ----------- B -----------



[1] This is only an example.

[2] If it is not possible to use this frequency, measurements should be carried out on an adjacent frequency, e.g. 2500 Hz.

SUPPLEMENT No. 4.6

INSTRUCTIONS FOR MAKING FUTURE MEASUREMENTS OF THE TRANSMISSION QUALITY OF NATIONAL EXTENSIONS (EXCLUDING SUBSCRIBERS' LOCAL LINES) AND FOR RECORDING THE RESULTS OF THE MEASUREMENTS

1. *General*

a) This is solely a national matter not requiring international co-operation.

b) It is not essential to know the precise routing details, merely the general routing structure of the extension.

c) The presentation must be related to the pattern of traffic incidence. Examples are given in section 6.

d) Incoming and outgoing national extensions to and from the same national subscriber's location could provide a useful insight into the effect (very often substantial) that traffic direction has on transmission. This is particularly true when subscribers have recently been accorded the facility of making their own long-distance calls automatically. The outgoing centre (or outgoing portion of the existing centre) very often incorporates the new exchange equipment required and often additional (sometimes new) outgoing circuits are provided, whereas the incoming centre (or incoming portion of the centre) is the existing one using the existing network and incoming equipment which have not been changed. On national calls this is probably of no great consequence, because both incoming and outgoing centres are in the same country. However, this is not the case for international calls.

e) It is also of interest to make measurements on a connection established by semi-automatic means (with the aid of an operator) even when direct subscriber dialling is available. Sometimes these operators are located at a point from which several local exchanges are served and it is useful to observe how sometimes this arrangement introduces additional loss and distortion. In principle, for an assistance call, the transmission should be the best possible.

f) The effect of echo suppressors on some national circuits should not be overlooked when making measurements of the transmission loss of the path a-t-b (see Figure 1 and section 2).

2. *Quantities to be measured or calculated*

These are:

— transmission loss and attenuation distortion of the paths A-b and a-A (see Figure 1);

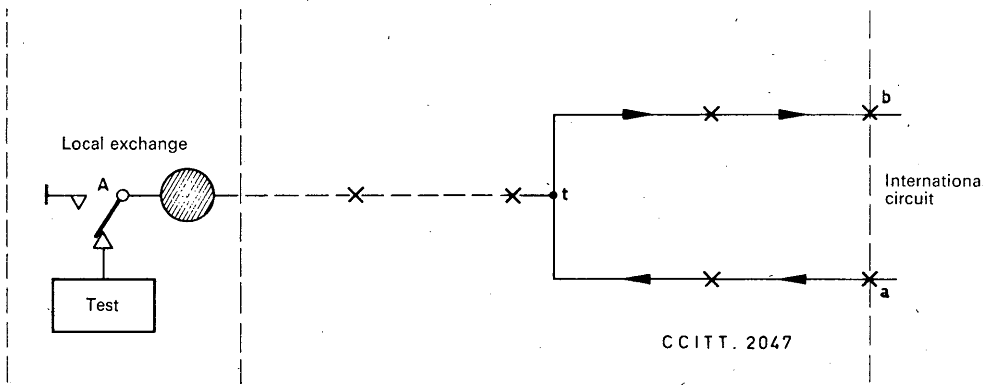
— the difference in transmission loss at 800 Hz of the paths A-b and a-A;

— group-delay distortion (if possible) of the paths A-b and a-A;

— insertion loss of the path a-t-b (see Figure 1) from the point of view of both stability and echo;

— the random noise power levels at A and b, unweighted (flat) telephone (message) weighted and band-limited using the filter specified in Supplement No. 4.5;

— the impulsive noise at A and b using the impulsive noise counter specified in Recommendation V.55 where possible for 15 minutes with the operating threshold set at −18 dBm0. The instrument shall be used in the "flat" bandwidth condition with a nominal " dead-time " of 125 ms.



A is a service installation located preferably in the local exchange so that the subscriber's line is as short as possible, and the question of refunding call-charges is avoided.

a and b are the receive and send virtual switching points respectively of an international circuit. These points and the path a-t-b are defined in Recommendation G.122, A, a) of Volume III of the *Blue Book*.

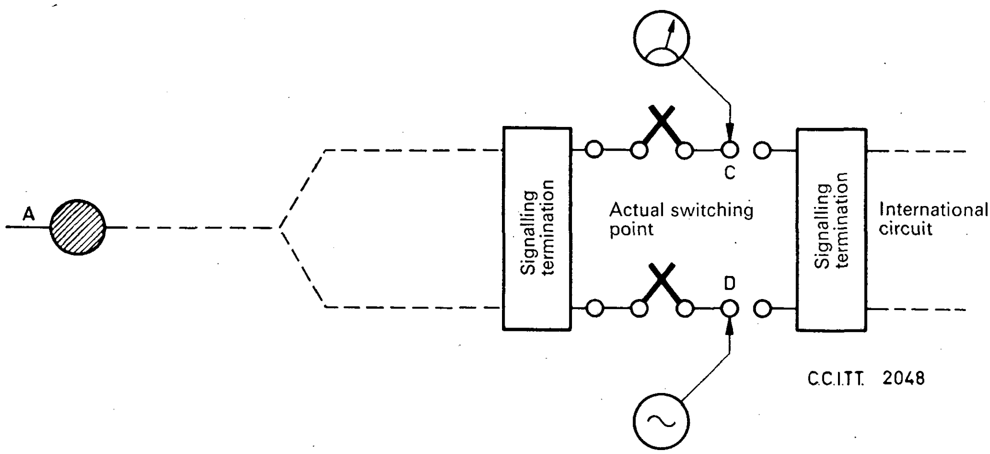
FIGURE 1

3. *Referring measured quantities to virtual switching points*

The measurements at the international centre should if possible be made at the circuit test and measurement access points of an international circuit, the location of the test access points being such as to include as much of the permanently connected apparatus proper to the circuit as possible. (See Recommendations M.64 and M.70.)

These points are shown in Figure 2.

Transmission losses from the receive virtual switching point to national locations, from the national location to the send virtual switching point, and of the path a-t-b between virtual switching points, are obtained from a consideration of the nominal relative levels assigned to the circuit test and measurement access points on the international circuit at the international centre and the actual measured or sent levels at those circuit test and measurement access points and at the service location in the following way:



C and D are the circuit test access points of an international circuit.

FIGURE 2

Insertion loss from A to send virtual switching point (A-b)

Insertion loss A-b = send level at A − measured level at C + nominal relative level at C + 3.5 dB.

Example : Send level at A = 0 dBm
Measured level at C = −8.3 dBm
Nominal relative level at C = −3.5 dBr

Insertion loss A-b is:

$0 - (-8.3) + (-3.5) + 3.5 = 8.3$ dB

Insertion loss from receive virtual switching point to A (a-A)

Insertion loss a-A = send level at D − measured level at A − nominal relative level at D − 4 dB.

Example : Send level at D = −3 dBm
Measured level at A = −14.8 dBm
Relative level at D = −2 dBr

Insertion loss from a-A is:

$(-3) - (-14.8) - (-2) - 4 = 9.8$ dB

Insertion loss of the path a-t-b between virtual switching points

Insertion loss a-t-b = send level at D − measured level at C − nominal relative level at D + nominal relative level at C −0.5 dB.

Example :	Send level at D	= −3 dBm
	Actual measured level at C	= −16.2 dBm
	Nominal relative level at D	= −2 dBr
	Nominal relative level at C	= −3.5 dBr

The insertion loss a-t-b is:

$(-3) - (-16.2) - (-2) + (-3.5) - 0.5 = 11.2$ dB

The method of calculation above makes no assumption concerning the relative level of any reference point in the national network.

No attempt should be made to refer the power levels actually measured at the specified points A, C and D to any other points except in the way described in the explanatory notes above.

4. *Treatment and presentation of results*

a) The measurement results sent to the C.C.I.T.T. should be expressed in the following units:

— insertion losses, preferably in dB or, failing that, in dNp;

— noise power levels in dBmp (or dNmp) for psophometrically weighted noise, in dBm (or dNm) for flat and band-limited noise;

— Group delay distortion in milliseconds.

— Distances should be in kilometres.

b) All results should be weighted in accordance with the traffic incidence.

Routes should be chosen in accordance with the pattern of the international traffic incidence as far as possible.

c) The various quantities should be presented graphically as cumulated-frequency distribution curves. The mean and standard deviation may also be quoted. However, the mean and standard deviation should not be quoted unaccompanied by some description of the distribution of the variate. Some examples are given in section 6.

5. *Measuring and calculating the loss of the path a-t-b from the point of view of stability and of echo*

a) *Measuring the loss a-t-b*

When measuring the transmission loss of the path a-t-b, point A is connected to the telephone left in the speaking condition. If it is not convenient to replace the microphone capsule by resistor of appropriate nominal value it will suffice if the mouthpiece is muffled and the handset placed upon a soft surface, e.g. a cushion. The room must also be quiet. If the room is not very quiet, the handset could be placed between two cushions. The frequency band should be explored with a continuously variable oscillator—a sweep measuring set with an oscilloscope display is particularly useful. The sending level must be constant.

For incoming calls to the local exchange the loss a-t-b can be measured without the need for a technician at the local exchange. The calls could be made to service personnel who would be understanding and co-operative concerning muffling the mouthpiece etc.

b) *Calculating the loss from the point of view of stability*

When a continuously variable oscillator is used in conjunction with an oscilloscope display, the minimum value in the band 300 to 3400 Hz should be recorded and these values (duly weighted in accordance with the incidence of traffic) should be used as the data from which to construct the weighted cumulative distribution curve. If it is possible to cover a wider band this should be done. No attempt need be made to measure stability loss in other than the speaking condition.

c) *Calculating the loss from the point of view of echo*

When a continuously-variable oscillator is used in conjunction with an oscilloscope display, a smooth mean curve should be drawn through the display and the values at 500, 1000, 1500, 2000 and 2500 Hz on the mean curve recorded. After having expressed these values as power ratios, the loss of the path a-t-b from the point of view of echo for a particular connection can now be characterized by a single figure as follows:

1) Sum the following quantities

½ × the mean power ratio at 500 Hz
the ,, ,, ,, ,, 1000 Hz
the ,, ,, ,, ,, 1500 Hz
the ,, ,, ,, ,, 2000 Hz
½ × the ,, ,, ,, ,, 2500 Hz

2) Divide the sum by 4.

3) Express the resultant power ratio in transmission units.

Example :

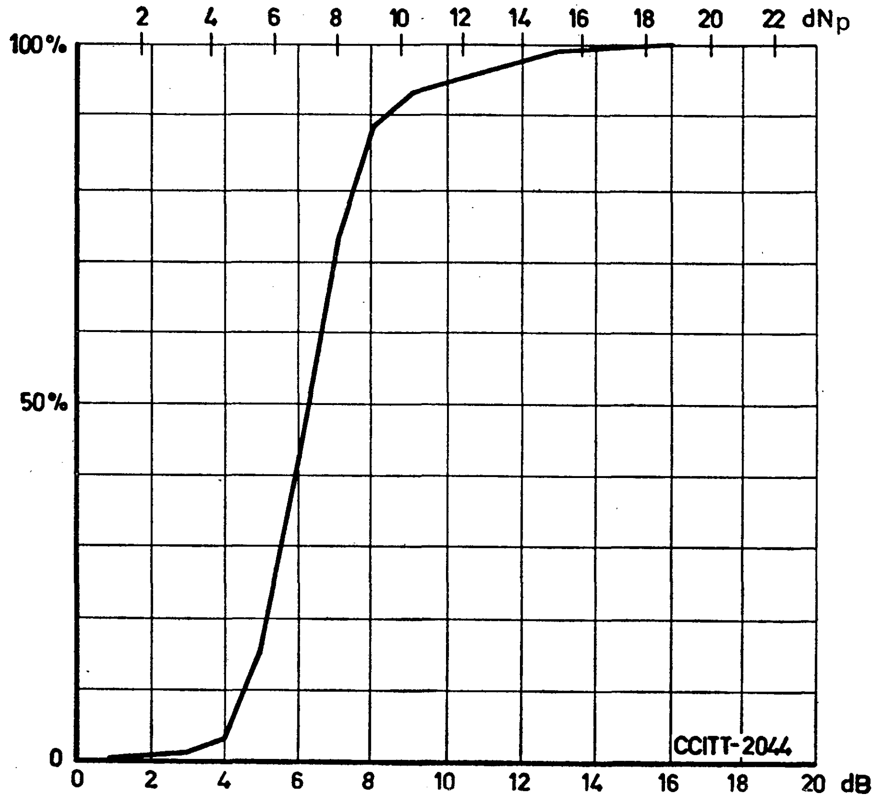
Hz	Transmission loss read from smooth curve (dB)	Corresponding power ratio	Sum
500	10	0.1	0.0500
1000	12	0.0631	0.0631
1500	12	0.0631	0.0631
2000	13	0.0501	0.0501
2500	15	0.0316	0.0158
			0.2421

Mean echo power ratio = 0.2421/4 = 0.0605 corresponding to 12.2 dB (13.9 dNp)

A sample from each major class of connections should be measured, each class being characterized by a single decibel (or decineper) figure. The values for each major class of connection when weighted in accordance with the traffic incidence can then be used to construct a weighted cumulated-frequency distribution curve.

Further study will be needed to decide if the method outlined above is sufficiently informative.

6. *Examples of how to submit the results*

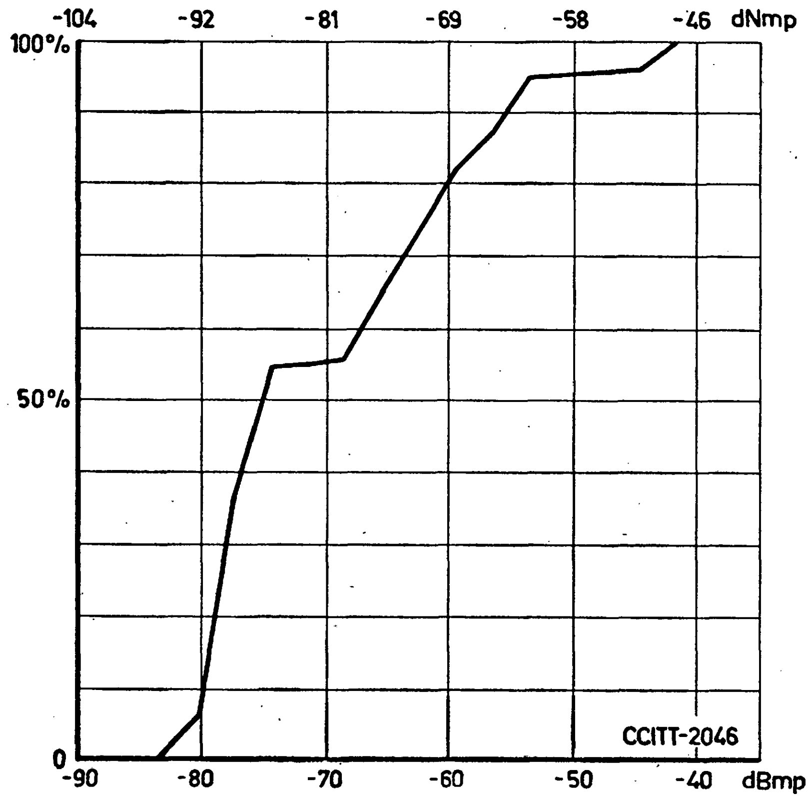


Frequency: 800 Hz
Mean: 6.6 dB (7.5 dNp)
Standard deviation: 1.9 dB (2.2 dNp)
Sample size: 100% = 930

The results of measurements of the loss A-a and also of the difference between the two directions of transmission at 800 Hz should be submitted in a similar fashion.

Similar curves should be established showing the loss relative to the loss at 800 Hz for each of the frequencies 200, 300, 400, 600, 1000, 1400, 2000, 2400, 3000 and 3400 Hz, for the paths A-a and b-A.

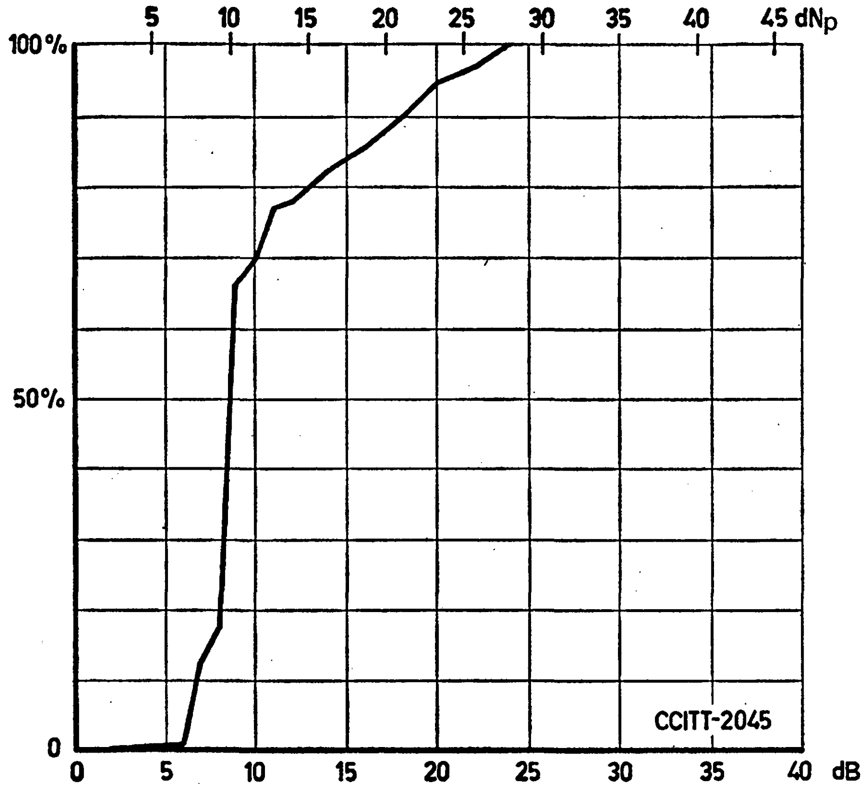
EXAMPLE 1. — **Distribution of the transmission loss at 800 Hz b-A (from the receive virtual switching point to the local exchange)**



Mean: −70.5 dBmp (−81 dNmp)
Standard deviation: 10.4 dB (12.1 dNp)
Sample size: 100% = 1020

The measurement results for flat and band-limited noise power levels measured at the send virtual switching point and also for noise power levels measured at the local exchange should be submitted in a similar fashion.

EXAMPLE 3. — **Distribution of psophometrically weighted noise power levels measured at the send virtual switching point**



Mean: 11.0 dB
Standard deviation: 4.4 dB (5.1 dNp)
Sample size: 100% = 137

The results of measurement of transmission loss a-t-b from the point of view of echo should be submitted in a similar fashion.

EXAMPLE 4. — **Distribution of transmission loss of the path a-t-b from the point of view of stability**

SUPPLEMENT No. 4.7

INSTRUCTIONS FOR MAKING FUTURE MEASUREMENTS OF THE TRANSMISSION QUALITY OF INTERNATIONAL CIRCUITS, CHAINS OF CIRCUITS AND INTERNATIONAL CENTRES AND FOR RECORDING THE RESULTS OF THE MEASUREMENTS

1. *Measurements on international circuits*

a) Much of this work will eventually be taken over by automatic transmission measuring equipment operating at the circuit test-access points. However, those administrations which have provided " circuit access points " in accordance with Recommendation M.64 should measure perhaps 20% of a route or 12 circuits, whichever is the greater. The results should be expressed in similar terms to those outlined in Supplement No. 4.6 for national extensions if there is a large enough sample.

b) Measurements will be required of attenuation-frequency distortion, noise and, if possible, group-delay distortion. (Measurement of the transmission loss at 800 Hz is adequately covered by the normal work of Study Group IV in its continuing study of Q.1/IV.)

If possible, measurements of impulsive noise should be made, and the number of noise peaks that exceed a noise threshold set at −21 dBm0 for a period of 15 minutes should be determined.

Measurements should also be made of flat, weighted and band-limited noise as described in Supplement No. 4.5.

c) The measurement results should be submitted to the C.C.I.T.T. by the administrations controlling the circuit, on Form 1 (see below). No sketch is required.

2. *Measurements on chains of international circuits*

If it is *not* possible to make measurements at intermediate international centres then only attenuation-distortion, noise (and group-delay-distortion if possible) need be measured, and the results submitted by the administrations setting up the call on the form, suitably annotated, used for single international circuits (see Form 1 below).

3. *Verifying the transmission plan of international circuits and international centres*

This matter concerns international centres only, there being no need to include national extensions. However, this is probably the most difficult to organize. If, as is preferable, it is desired to set up connections through a transit centre in the same way as they are normally established, i.e. from and to other international centres, then at least three groups of people are involved. These groups must identify the particular circuits, measure at several frequencies in two directions of transmission on at least four points and probably interchange the results amongst themselves.

FORM 1: *Distortion and noise on international circuits between circuit test-access points*

Connections set up from	Measurement made at	Noise power level			Number of noise peaks > −21 dBm0 in 15′	Distortion * (in) relative to the loss at 800 Hz (— sign indicates relative gain)									
		Weighted * ( )	Flat * ( )	Band-limited * ( )		200	300	400	800	1000	1400	2000	2400	3000	3400
A	B								0.0						
	A								0.0						
A	B								0.0						
	A								0.0						
A	B								0.0						
	A								0.0						
A	B								0.0						
	A								0.0						
A	B								0.0						
	A								0.0						
A	B								0.0						
	A								0.0						

* Give transmission unit used.

If there are added to this language difficulties and substantial time-differences, so that at least one I.M.C. is also trying to do its day-to-day work, the affair becomes extremely complicated, tedious and prone to error.

In view of these difficulties the C.C.I.T.T. does not feel that it can recommend that such measurements be made though it would urge administrations to make the attempt if possible. Perhaps those with the least language difficulties and without a great time-difference could contemplate doing this. For the information of such administrations the way in which the measured results can be manipulated to reveal the transmission plan is given in section B below.

A. *Local tests*

a) The alternative approach is to set up connections through the international transit centre locally and to measure the insertion loss between the back-to-back circuit test access points, applying the formula quoted in Recommendation G.142, B (*Blue Book*, Volume III). This formula states that the insertion loss introduced by the exchange should be equal to $R\text{-}S + T$, where R is the nominal relative level assigned to the receive circuit test-access point, S is the nominal relative level assigned to send circuit test-access point and T is the nominal insertion loss of the international circuit, i.e. 0.5 dB or 0.6 dNp.

The difference between the measured loss and the nominal loss calculated from the formula is termed the net switching loss. It should, of course, be zero.

b) This procedure is perhaps not so satisfactory as setting-up genuine connections but it is so very much more simple that the C.C.I.T.T. can recommend that it be done. Care must be taken to avoid successively selecting the same path through the exchange when making these tests in a period of light traffic.

c) Opportunity could be taken to measure the net switching loss introduced on connections established with the assistance of an operator. Very frequently in these cases additional apparatus is used in the switching centre and it is enlightening to measure their transmission performance.

d) The exchange noise (unweighted, weighted, band-limited and impulsive noise with a threshold of −21 dBm0 for 15 minutes) could also be measured during these local tests. Impulsive-noise shall be measured with the instrument specified in Recommendation V.55 set to the " flat " bandwidth condition with a nominal " dead-time " of 125 ms.

B. *Tests involving three international centres*

a) *Measuring points*

The measurements should be made at the circuit test and measurement access points as defined in Recommendation M.64 (part B, 1 b), so that as much as possible of the permanently associated equipment is on the international line side of the test point. The nominal relative level assigned to the circuit test-access points must be made known to the administration making the calculations.

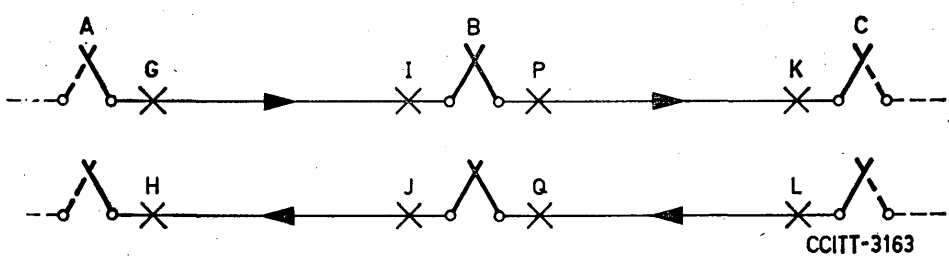
Terminated level measurements should be made at the circuit test-access points. It should be noted that making a terminated-level measurement at an intermediate exchange on a switched connection interrupts the test signal passed on to the succeeding circuit. This circumstance could provoke a re-operation of any speech concentrator that may be ncluded in the succeeding circuit.

b) *Relative and measured levels*

A careful and accurate distinction should be made and preserved between assigned nominal relative levels and measured actual levels.

This care is necessary if the departures from nominal of the losses of lines and transit centres are to be discovered. If such departures cannot be ascertained the 0.5 dB (0.6 dNp) inominal insertion loss of international circuits will not become apparent.

c) *Example of the necessary calculations* (referring to the sketch below)



G, H; I, J; P, Q; and K, L are circuit test-access points. The connection has been established from A to C via B. G and L are energized at appropriate levels (e.g. if the nominal relative level assigned to point G is −16 dBr then an appropriate level would be one not exceeding −16 dBm, that is not exceeding 0 dBm0). The actual sending level used must be stated. At IPK and QJH terminated-level measurements are made. The nominal relative level assigned to these points is used in the calculations.

The pairs of measured levels at GI, PK, IQ and JH provide information concerning international circuits. The pairs of measured levels at IP and QJ provide information concerning the net switching loss at exchange B.

The way in which the measured levels can be manipulated to give the results in the required form is given in the following example.

Let the following data be available for the G to K direction of transmission. Sending level at G = −20 dBm.

	G	I	P	K	
Nominal relative levels (dBr)	−16	+10	−12	+8	
Actual measured levels (dBm)	−20	+ 5.7	−17.2	+4.9	800 Hz
	−20	+ 3.2	−19.9	−1.1	3400 Hz

The following quantities may now be derived.

1. *Insertion losses at 800 Hz in excess of nominal loss*

a) *Channel GI*

Excess loss = (measured loss) — (nominal loss).

Noting that measured loss = (input measured level) — (output measured level) and nominal insertion loss = (input nominal relative level) — (output nominal relative level), gives:

$$\begin{aligned}\text{Excess loss} &= [(-20) - (+5.7)] - [(-16) - (+10)] \\ &= (-25.7) - (-26) \\ &= +0.3 \text{ dB}\end{aligned}$$

b) *Channel PK*

$$\begin{aligned}\textit{Channel PK} &= [(-17.2) - (+4.9)] - [(-12) - (+8)] \\ &= (-22.1) - (-20) \\ &= -2.1 \text{ dB (i.e. 2.1 dB gain)}\end{aligned}$$

c) *Net switching loss*

From the formula given in Recommendation G.142B (*Blue Book*, Volume III) the nominal switching loss of exchange B in the example should be $R - S + T$, where:

R = nominal relative level at the receive circuit test access point = +10 dB;

S = nominal relative level at the send circuit test access point = −12 dB;

T = nominal loss of the international circuit AB = 0.5 dB.

i.e. nominal insertion exchange loss = (+10) — (−12) + (0.5) = 22.5 dB

Actual insertion exchange loss + (+5.7) — (−17.2) (at 800 Hz) = 22.9 dB

The net switching loss = actual insertion loss nominal loss = +0.4 dB

2. *Distortions at 3400 Hz relative to insertion loss at 800 Hz*

In terms of loss this is defined as (insertion loss at 3400 Hz) – (insertion loss at 800 Hz) so that as before a negative answer indicates a relative gain.

As before, insertion loss is defined as (input level – output level).

This enables the following quantities to be derived from appropriate pairs of measured values:

Distortion of channel GI = [(–20) – (+3.2)] – [(–20) – (+5.7)] = +2.5 dB
Distortion of channel PK = [(–19.9) – (1.1)] – [(–17.2) – (+4.9)] = +3.3 dB
Distortion of switching path IP = [(+3.2) – (–19.9)] – [(+5.7) – (–17.2)] = +0.2 dB.

The corresponding quantities at other frequencies and for the other direction of transmission can be derived in a similar way. The results for the departure from nominal loss and distortions relative to the loss at 800 Hz for the circuits can be entered on Form 1 (adding a column for departures from nominal).

The results for net switching loss and the distortions thereof can be entered on Form 2 as shown below.

The exchange noise can be measured at J and P with the circuits disconnected at I and Q, their place being taken by 600-ohm resistors. The noise should be measured psophometrically weighted, unweighted and if possible with the filter specified in Supplement No. 4.5.

Notes

As can be seen from the sample calculations, in practice there is no need to involve the nominal levels of the virtual switching points (–3.5 dB, –4.0 dB) for circuits and only their difference (0.5 dB) is involved when calculating net switching loss.

The differences derived in the example between the measured loss (or gain) of circuits and exchanges and the nominal loss required by the plan, could be regarded as " errors " in circuits or switching equipments. It should be noted that these so-called errors are likely to be due to a variety of causes such as circuit variations, speech concentrator switching, impedance mismatches, measuring instrument errors, etc. However, it is to be hoped that sometimes an assignable fault can be discovered and cleared.

FORM 2

Net switching losses at . . . . (B)

Direction of transmission	Net switching loss at 800 Hz *( )	Distortion * (in) relative to the insertion loss at 800 Hz (– sign indicates a relative gain)										
		200	300	400	600	800	1000	1400	2000	2400	3000	3400
I to P						0.0						
Q to J						0.0						
I_1 to P_1						0.0						
Q_1 to J_1						0.0						
I_2 to P_2						0.0						
Q_2 to J_2						0.0						
I_3 to P_3						0.0						
Q_3 to J_3						0.0						
I_4 to P_4						0.0						
Q_4 to J_4						0.0						
I_5 to P_5						0.0						
Q_5 to J_5						0.0						

* = transmission unit used
(B) = name of transit centre
I = receive virtual switching point of incoming circuit (AB)
J = send virtual switching point of incoming circuit (AB)
P = send virtual switching point of outgoing circuit (BC)
Q = receive virtual switching point of outgoing circuit (BC)

SUPPLEMENT No. 5.1

(For the convenience of users of Volume IV of the C.C.I.T.T., *White Book* this Supplement is reproduced from C.C.I.R. Recommendation 421-1 (Oslo, 1966). See subsequent publications of the C.C.I.R. for the latest version of the recommendation).

REQUIREMENTS FOR THE TRANSMISSION OF TELEVISION SIGNALS OVER LONG DISTANCES (SYSTEM I EXCEPTED)

The C.C.I.R., (1959—1963—1966)

CONSIDERING

the agreement reached by the Joint C.C.I.R./C.C.I.T.T. Committee for television transmissions (C.M.T.T.), on a draft Recommendation concerning television transmissions over long distances, common to the C.C.I.R. and the C.C.I.T.T.,

UNANIMOUSLY RECOMMENDS

that, taking account of the definitions in § 1, television transmissions over long distances should satisfy the requirements laid down in §§ 2 and 3 and their Annexes.

1. Definitions

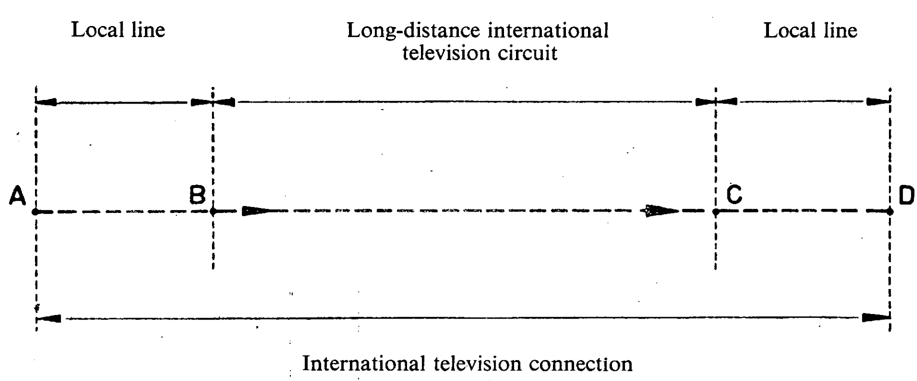


FIGURE 1

1.1 *Definition of a long-distance international television connection (see Fig. 1)*

1.1.1 Point A, to be considered as the sending end of the international television connection, may be the point at which the programme originates (studio or outside location), a switching centre or the location of a standards converter.

1.1.2 Point *D*, to be considered as the receiving end of the international television connection, may be a programme mixing or recording centre, a broadcasting station, a switching centre or the location of a standards converter.

1.1.3 The local line *AB* connects point *A* to the sending terminal station, point *B*, of the international television circuit.

1.1.4 The long-distance international television circuit, *BC*, comprises a chain of national and international television links. The precise locations (e.g. within buildings), to be regarded as the points *B* and *C*, will be nominated by the authorities concerned.

1.1.5 The local line *CD* connects point *C*, the receiving terminal station of the long-distance international television circuit, to point *D*.

1.1.6 The combination *AD*, of the long-distance international television circuit, *BC*, and the local lines *AB* and *CD*, constitutes the *international television connection*.

The requirements given in §§ 2 and 3 refer to the performance of long-distance international television circuits only; no requirements have been laid down for the local lines, *AB* and *CD*.

1.2 *Definition of the hypothetical reference circuit*

The main features of the television hypothetical reference circuit, which is an example of a long-distance international television circuit (*BC* in Fig. 1) and which may be of either radio or coaxial-cable type, are:

— the overall length between video terminal points is 2500 km (about 1600 miles).

— two intermediate video points divide the circuit into three sections of equal length.

— the three sections are lined up individually and then interconnected without any form of overall adjustment or correction.

— the circuit does not contain a standards converter or a synchronizing-pulse regenerator.

Note 1. — The concept of the hypothetical reference circuit serves to provide a basis for the planning and design of transmission systems. Such a circuit has a length which is reasonably but not excessively long and, for a television circuit, a defined number of video-to-video sections. It is appreciated that, at the present time, international television circuits usually contain more than three video-to-video links in a length of 2500 km, but it is expected that the number will be reduced in the course of time. Annex IV gives a provisional indication of the characteristics of circuits with more or fewer video sections than the hypothetical reference circuit.

Note 2. — In Canada and the U.S.A., objectives are normally specified for circuits 6400 km long. The limits given in this Recommendation for 2500-km circuits for the 525-line system in Canada and the U.S.A. are therefore chosen to give an adequate performance in a 2500-km portion of a 6400-km circuit.

2. Requirements at video interconnection points

In this section the requirements apply at the video terminals of any long-distance television circuit, whatever its length.

2.1 *Impedance*

At video interconnection points, the input and output impedance of each circuit should be unbalanced to earth, with a nominal value of 75 Ω resistive and a return loss of at least 24 dB relative to 75 Ω. (The return loss, relative to 75 Ω, of an impedance Z is

$$20 \log_{10} \left| \frac{75 + Z}{75 - Z} \right| \text{ (dB).)}$$

Note 1. — In Canada and the U.S.A., the impedance at video interconnection points should be either 124 Ω balanced to earth or 75 Ω unbalanced to earth, with a return loss of at least 30 dB.

Note 2. — In some countries, impedance is specified in term of " waveform return loss " (see Docs. CMTT/9 (O.I.R.T.), 1963-1966 and Recommendation 451).

2.2 *Polarity and d.c. component*

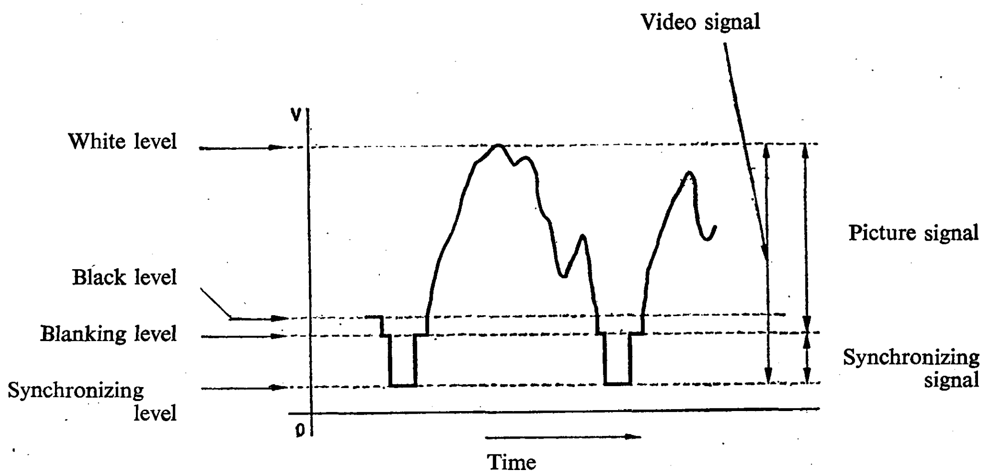
At video interconnection points, the polarity of the signal should be *positive*, i.e. such that black-to-white transitions are positive-going.

The useful d.c. component, which is related to the average luminance of the picture, may or may not be contained in the video signal and need not be transmitted, or delivered at the output.

Any non-useful d.c. component unrelated to the video signal (e.g. the component due to d.c. valve supplies) should not cause more than 0·5 W to be dissipated in the 75-Ω load impedance. If the load impedance is disconnected, the voltage of this component should not exceed 60 V.

2.3 *Signal amplitude*

At video interconnection points, the blanking level taken as the reference level, the nominal amplitude of the picture signal, measured from the blanking level to the white level should be 0·7 V (0·714 V in Canada and the U.S.A.), while the nominal amplitude of the synchronizing signal, measured from the blanking level to the tips of the synchronizing pulses should be 0·3 V (0·286 V in Canada and the U.S.A.), so that the nominal peak-to-peak amplitude of the video signal should be 1·0 V (see Fig. 2).



V = Difference in potential between the terminal (not at earth potential) of the input (or output) impedance and earth (difference of potential positive in an upward direction).

FIGURE 2

Theoretically, the amplitude should be measured with the useful d.c. component of the video signal restored, but in practice this is not necessary.

Note 1. — In the design of equipment, account should be taken of the losses in interconnecting cables when the video interconnection points are at some distance from the terminals of the modulating and demodulating equipment.

Note 2. — For colour in system *M* (Japan), the above specification applies to the luminance and synchronizing signals. For the chrominance signal, further study is required.

3. Transmission performance of the hypothetical reference circuit

In this section, the performance requirements are to be taken as design objectives applying to the hypothetical reference circuit as defined in § 1.2.

It should be emphasized that the material of this section constitutes only a first step towards the solution of the general problem of determining methods of measuring and specifying the performance of television circuits of any length or degree of complexity.

3.1 *Insertion gain*

A long-distance international circuit, having the form of the hypothetical reference circuit should, at the time of setting up, have an insertion gain of 0 dB ± 1 dB (± 0·5 dB in Canada and the U.S.A.).

The insertion gain should be measured, using Test Signal No. 2 (described in Annex I) and is defined as the ratio, in decibels, of the amplitude of the bar (from black level to white level) at the output to the nominal amplitude of the bar at the input.

The measurement should be made under the following conditions:

A generator producing Test Signal No. 2, with an internal impedance of 75 Ω (resistive), is adjusted so that, if connected directly to a 75 Ω resistance, it would produce a line-synchronizing signal of 0·3 V combined with a picture signal of 0·7 V which may include 0·05 V of pedestal. At the receiving end, the voltage between the black level and the white level (bar amplitude) is measured, using an oscilloscope connected across a resistance of 75 Ω. The ratio of this voltage to 0·65 V if pedestal is used, or 0·7 V if it is not (in decibels) is the insertion gain of the television circuit.

Note. — In Canada and the U.S.A. somewhat different methods are used, but similar results are obtained.

3.2 *Variations of insertion gain*

The variations of insertion gain with time in the hypothetical reference circuit should not exceed the following limits:

— short-period (e.g. 1 s) variations: ± 0·3 dB (± 0·2 dB in Canada and the U.S.A.),
— medium-period (e.g. 1 hr) variations: ± 1·0 dB.

3.3 *Noise*

3.3.1 *Continuous random noise*

The signal-to-noise ratio for continuous random noise is defined as the ratio, in decibels, of the peak-to-peak amplitude of the picture signal (see Fig. 2) to the r.m.s.* amplitude of the noise, within the range between 10 kHz and the nominal upper limit of the video frequency band of the system, f_c. The purpose of the lower frequency limit is to enable power supply hum and microphonic noise to be excluded from practical measurements.

TABLE I

System (See Report 308-1)	*M* (Canada and USA)	*M* (Japan) monochrome and colour	*B, C, G, H*	*D, K, L*	*F*	*E*
Number of lines	525	525	625	625	819	819
Nominal upper limit of video frequency band f_c (MHz)	4	4	5	6	5	10
Signal-to-weighted-noise ratio X (dB)	56	52	52	57	52	50

* Administrations measuring the quasi-peak-to-peak amplitude of the noise are asked to establish the crest factor appropriate to their method of measurement and to express the results in terms of r.m.s. amplitude.

For the hypothetical reference circuit, the signal-to-noise ratio should be not less than the values X given in Table I when measured with the appropriate low-pass filter, described in Annex II, the appropriate weighting network described in Annex III, and an instrument having an " effective time constant " or " integrating time " in terms of power of 1 s (0·4 s in Canada and the U.S.A.).

Note 1. — To obtain satisfactory transmission performance, television specialists believe that the signal-to-weighted-noise ratio should fall neither below X dB for more than 1 % of any month, nor below $(X - 8)$ dB for more than 0·1 % of any month.

Note 2. — For the routine measurement of signal-to-noise ratio on real circuits, the noise can be measured with sufficient accuracy in the absence of the video signal. The error introduced by this method will not, in general, exceed 2 dB. More accurate devices and methods for measuring signal-to-weighted-noise ratio when transmitting test signals, are described in Docs. XI/25, Moscow, 1958, CMTT/23, Monte Carlo, 1958, and CMTT/3, Paris, 1962, presented by the U.S.S.R.

TABLE II

System	*M* (Canada and U.S.A.)	*M* (Japan)	*B, C, G, H*	*D, K, L*	*F*	*E*
Number of lines	525	525	625	625	819	819
Nominal upper limit of video frequency band f_c (MHz)	4	4	5	6	5	10
Signal-to-noise ratio (dB) for power-supply hum (including the fundamental frequency and lower-order harmonics) (¹)	35	30	30	30	30	30
Signal-to-noise ratio (dB) for single-frequency noise between 1 kHz and 1 MHz	59 (²)	50	50	50	50	50 (³)
Value (dB) to which the signal-to-noise ratio for single-frequency noise may decrease linearly between 1 MHz and f_c	43 (⁴)	30 (⁶)	30	30	30	30 (⁵)

(¹) These figures apply only to hum added to the signal and not to hum which in transmission has modulated the amplitude of the signal and cannot be removed by clamping. The measurement should be made without clamping.

(²) This limit applies between 1 kHz and 2 MHz.

(³) For system E for frequencies below 1 kHz excluding power-supply hum (including both the fundamental frequency and lower-order harmonics), the signal-to-noise ratio may decrease linearly between the values 50 dB at 1 kHz and 45 dB at 100 Hz and between the values 45 dB at 100 Hz and 30 dB at 50 Hz.

(⁴) Value to which the signal-to-noise ratio may decrease, according to a linear function on a chart having a linear decibel scale and a logarithmic frequency scale, for frequencies between 2 MHz and f_c.

(⁵) For system E this figure is reached at a frequency of 7 MHz and remains constant between 7 MHz and f_c (10 MHz)

(⁶) For colour in system M (Japan), the signal-to-noise ratio should not be less than 50 dB at 3.6 MHz.

3.3.2 *Periodic noise*

The signal-to-noise ratio for periodic noise is defined as the ratio, in decibels, of the peak-to-peak amplitude of the picture signal (see Fig. 2) to the peak-to-peak amplitude of the noise.

Note. — This definition has so far been used in specification clauses dealing with single-frequency noises and with power-supply hum (including the fundamental frequency and lower-order harmonics), but it may also prove to be useful for any case in which two or more sinusoidal components are in harmonic relationship.

The signal-to-noise ratio in the hypothetical reference circuit should not be less than the value given in Table II.

3.3.3 *Impulsive noise*

The signal-to-noise ratio for impulsive noise is defined as the ratio, in decibels, of the peak-to-peak amplitude of the picture signal (see Fig. 2) to the peak-to-peak amplitude of the noise.

Provisionally, for the hypothetical reference circuit, a minimum signal-to-noise ratio of 25 dB for impulsive noise of a sporadic or infrequently occurring nature has been proposed for all systems, except system *M* (Canada and the U.S.A.), for which the requirement is 11 dB.

3.3.4 *Crosstalk*

This matter is still under study.

3.4 *Non-linearity distortion*

Non-linearity distortion affects both the picture and the synchronizing signals.

Non-linearity distortions of the picture signal may be classified under three headings*, namely:

— field-time non-linearity distortion,
— line-time non-linearity distortion,
— short-time non-linearity distortion.

3.4.1 *Field-time non-linearity distortion of the picture signal*

This matter is still under study.

3.4.2 *Line-time non-linearity distortion of the picture signal*

Non-linearity of the picture signal is measured with Test Signal No. 3 (described in Annex I), using a superimposed sine-wave at a frequency $0 \cdot 2 f_c$.

The magnitude of the distortion is indicated by the ratio of the minimum peak-to-peak amplitude of the sine-wave to the maximum amplitude along the saw-tooth.

The sine-wave may be displayed on an oscilloscope with the time base running at line frequency by using a band-pass filter to separate the sine-wave from the rest

* The corresponding terms in French are respectively: distorsion de non-linéarité aux fréquences très basses, aux fréquences moyennes, aux fréquences élevées.

of the signal. The display then has the form indicated in Fig. 3 and the line-time non-linearity distortion is indicated by changes in amplitude across the display.

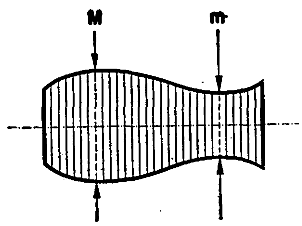


FIGURE 3

The non-linearity distortion should be expressed as a percentage, in the form $(1\text{-}m/M) \times 100$ and should not be more than 20% for the hypothetical reference circuit.

Alternatively, the result may, if desired, be expressed in dB in the form $(20 \log_{10} M/m)$ and for the hypothetical reference circuits should not exceed 2 dB.

For system *M* (Canada and the U.S.A.), the non-linearity distortion is measured with a superimposed sine-wave of 0·143 V peak-to-peak at 3·6 MHz and the results are expressed either as a percentage or in dB and should not be more than 13% or 1·2 dB respectively. For colour in system *M* (Japan), using the same test signal, the differential gain should not exceed 10%, and the differential phase should not exceed 5°.

3.4.3 *Short-time non-linearity distortion of the picture signal*

This matter is still under study *.

In Canada and the U.S.A., the short-time non-linearity distortion requirement is covered by the non-linearity distortion requirement given in § 3.4.2.

3.4.4 *Non-linearity distortion of the synchronizing signal*

For the hypothetical reference circuit, when the gain of the circuit is 0 dB, the amplitude, *S*, of the line-synchronizing signal, measured with Test Signal No. 3, should lie between the limits of 0·21 V and 0·33 V (0·26 V and 0·31 V for Canada and the U.S.A.), irrespective of whether the intermediate lines are at black level, S_a, or at white level, S_b.

3.5 *Linear waveform distortion*

3.5.1 *Field-time waveform distortion*

3.5.1.1 Systems *B, C, D, E, F, G, H, K, L*

For the hypothetical reference circuit, using Test Signal No. 1 (described in Annex I) the received waveform displayed on an oscilloscope should

* In several countries, such measurements are at present being made using Test Signal No. 3 with a higher value than $0 \cdot 2\, f_c$ for the frequency of the superimposed sine-wave (see Doc. CMTT/41, Monte Carlo, 1958—Chairman's report).

lie within the limits of the mask shown in Fig. 4, provided that the oscilloscope is adjusted so that the half-amplitude points of the bar transitions coincide with M_1 and M_2, and the mid-points of the " black " and " white " portions coincide with A and B respectively.

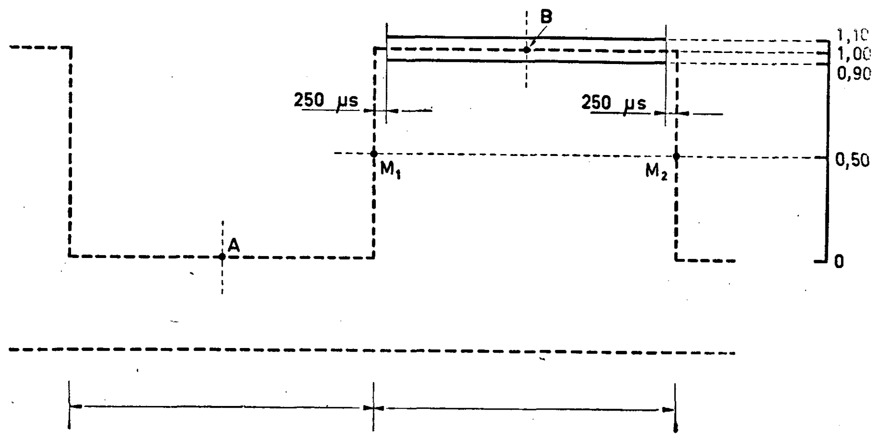


FIGURE 4

Waveform response to Test Signal No. 1

3.5.1.2 System M

In Canada and the U.S.A., with Test Signal No. 1, the variations about the level B should not exceed $\pm$ 5% when the signal is unclamped, or $\pm$ 1% when the signal is clamped.
In Japan, with Test Signal No. 1, the tolerances are the same as for the 625- and 819-line systems.

3.5.2 *Line-time waveform distortion*

3.5.2.1 System M

In Canada and the U.S.A., for the hypothetical reference circuit, using Test Signal No. 2 (described in Annex I), with a rise-time of $2T$ ($0 \cdot 25\mu s$), the received waveforms displayed on an oscilloscope should lie within the limits of the corresponding mask, similar to that shown in Fig. 5, but with a permitted variation about the level B of $\pm$ 1%, provided that the oscilloscope is adjusted so that the half-amplitude points of the bar transitions coincide with M_1 and M_2, and the mid-points of the " black " and " white " portions coincide with A and B respectively.
In Japan, the conditions described below for the 625- and 819-line systems apply.

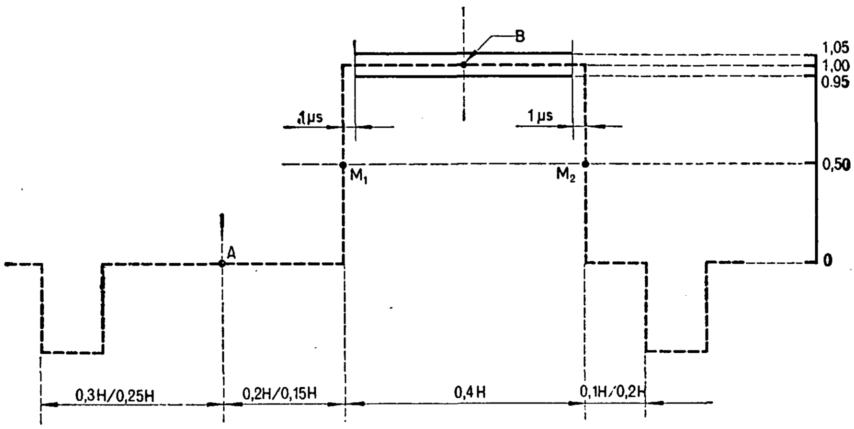


FIGURE 5

Waveform response to Test Signal No. 2

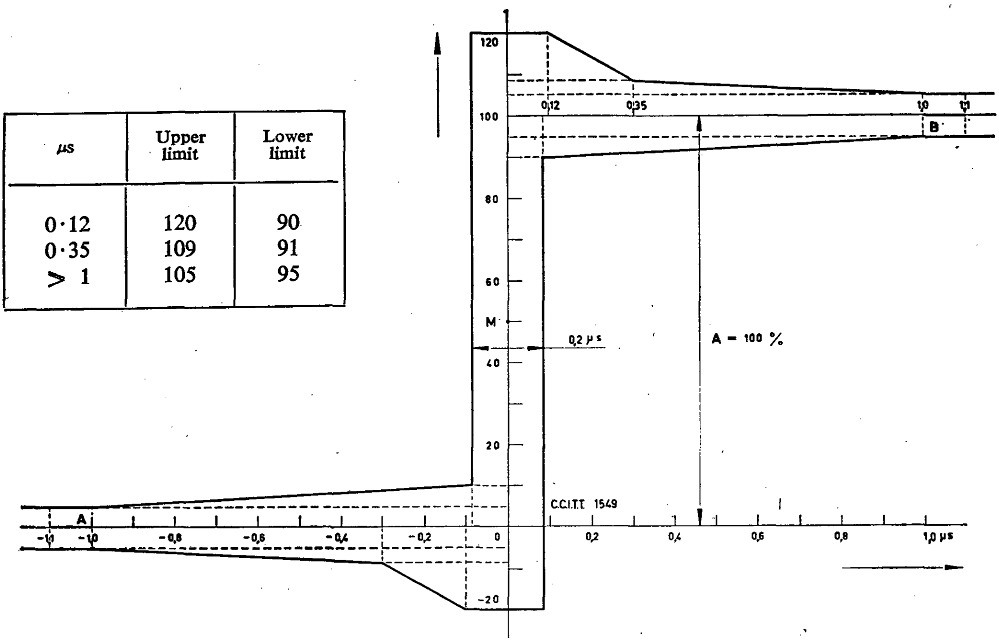
3.5.2.2 Systems *B, C, D, E, F, G, H, K, L*

For the hypothetical reference circuit, using Test Signal No. 2 (described in Annex I), with a rise-time of T (it may be necessary to use a rise-time of $2T$ for circuits which cut off sharply close to the nominal upper video-frequency limit), the received waveform displayed on an oscilloscope should lie within the limits of the mask shown in Fig. 5, provided that the oscilloscope is adjusted so that the half-amplitude points of the bar transitions coincide with M_1 and M_2, and the mid-points of the " black " and " white " portions coincide with A and B respectively.

3.5.3 *Short-time waveform distortion*

3.5.3.1 System *M*

In Canada and the U.S.A., where a test signal comprising a sine-squared pulse of half-amplitude duration $1/(2\ f_c)$ *s* is used, the output signal should have a first-overshoot amplitude (negative), leading or trailing, not greater than 13% of the peak amplitude of the pulse.
In Japan, the test procedure is the same as that described for systems *B, C, D, E, F, G, H, K, L*, the response being observed by means of the mask shown in Fig. 6. For the chrominance channel, further study is required.



µs	Upper limit	Lower limit
0·12	120	90
0·35	109	91
> 1	105	95

FIGURE 6

Mask for waveform response to Test Signal No. 2 for system M (Japan)

3.5.3.2 Systems *B, C, D, E, F, G, H, K, L*

Test Signal No. 2 is used, with a rise-time of $T = 1/2f_c$).

The response is observed by means of one of the masks shown in Figs. 7 and 8, the oscilloscope being adjusted so that *M* coincides with the middle of the rise, and the black and white levels coincide with the segments *A* and *B*.

If ringing is present in the regions *A* and *B*, the peaks of the oscillations should be set symmetrically with respect to *A* and *B*.

For the hypothetical reference circuit, the response should be within the limits of the appropriate mask as follows:

— Fig. 7 for systems *D, K.*

— Fig. 8 for systems *B, C, E, F, G, H* (see Note).

Note. — For system *L*, the mask for the waveform response to Test Signal No. 2 is provisionally the mask of Fig. 8 corresponding to the 819-line system $E(f_c = 10$ MHz).

3.6 *Steady-state characteristics*

3.6.1 System *M*

In Canada and the U.S.A., the design-objective limits are shown by the lines B in Figs. 10 and 11, the lowest frequency to which these limits apply being $0 \cdot 0025 f_c$.

µs	Upper limit	Lower limit
0·08	120	90
0·28	109	91
⩾ 1	105	95

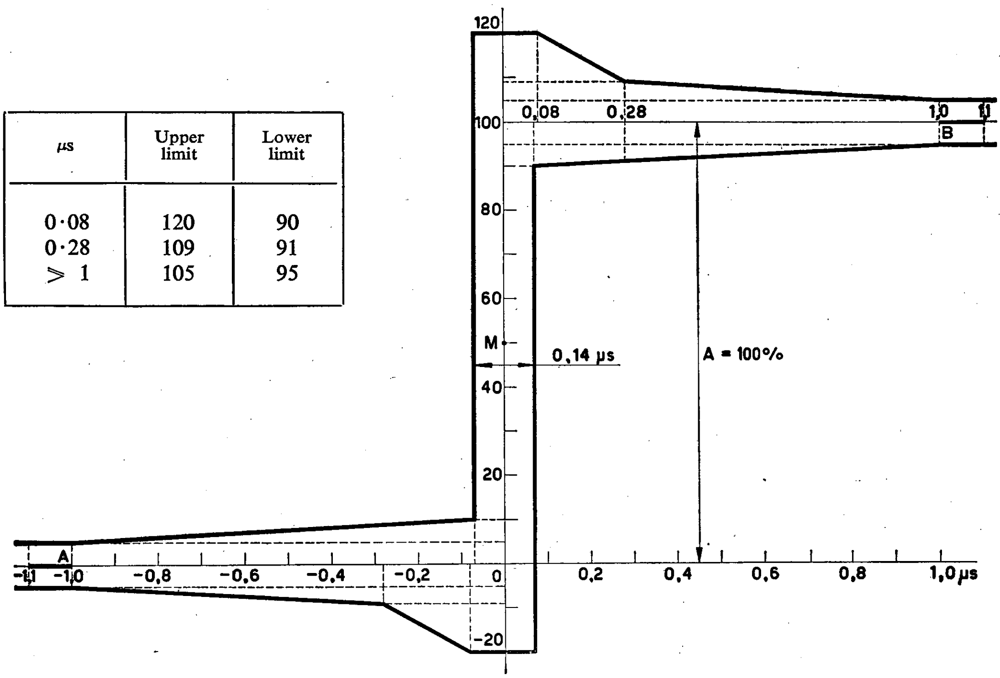
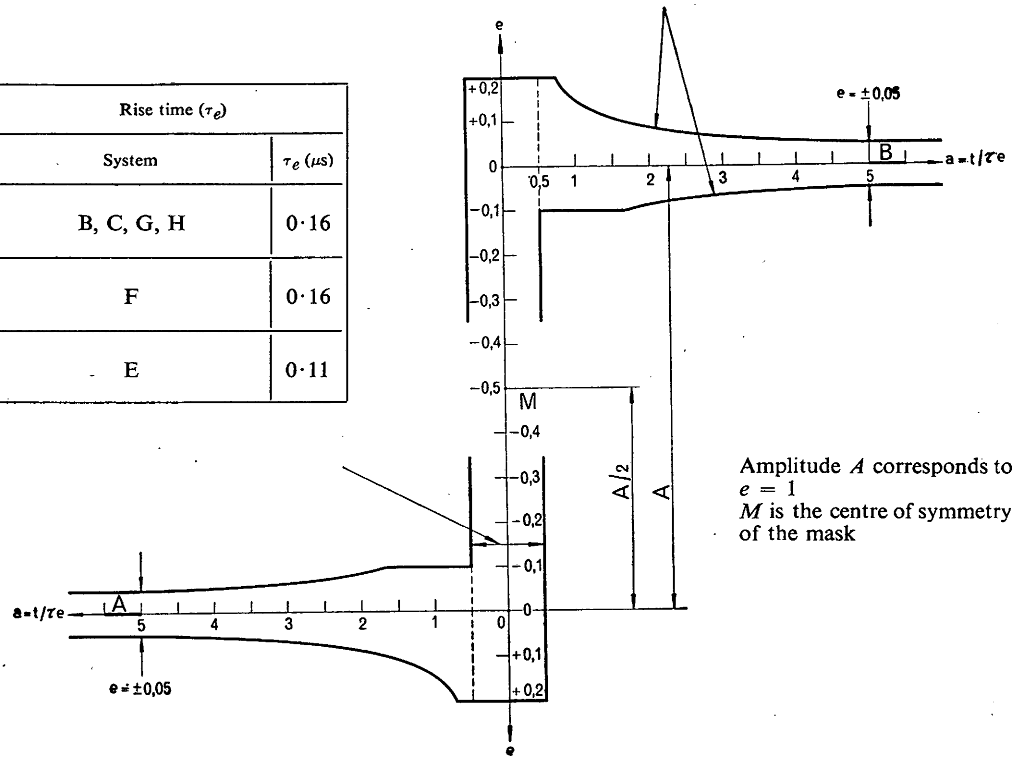


FIGURE 7

Provisional mask for waveform response to Test Signal No. 2 for systems D, K

Mask formed by a part of the curve defined by: $\pm e = 1/8a + 0{\cdot}025$ within the limits: $e = +0{\cdot}2$ and $e = -0{\cdot}1$ on the one hand, and $e = \pm 0{\cdot}05$ up to $t = 1$ μs on the other hand

Rise time (τ_e)	
System	τ_e (μs)
B, C, G, H	0·16
F	0·16
E	0·11



Amplitude A corresponds to $e = 1$
M is the centre of symmetry of the mask

FIGURE 8

Mask for waveform response to Test Signal No. 2 of systems B, C, E, F, G, H

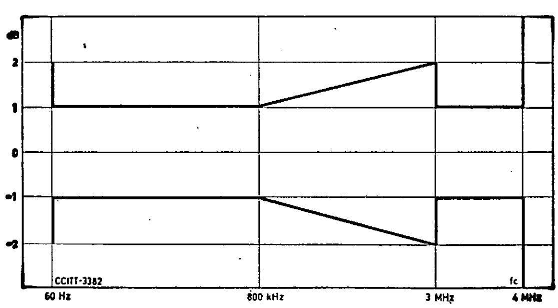


FIGURE 9

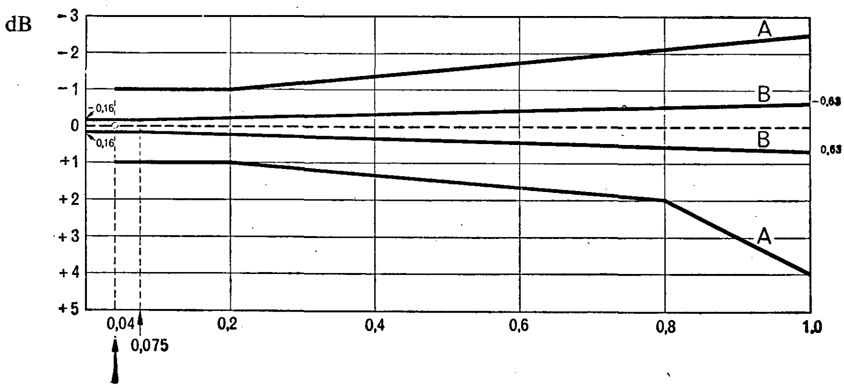
Limit for the attenuation/frequency characteristics of System M for colour television (Japan)

f_c: nominal upper limit of video-frequency band

In Japan the limits are as indicated below for the 625-line and 819-line systems, the appropriate value of f_c being 4 MHz. For colour, the attenuation/frequency limits are indicated in Fig. 9; the envelope-delay/frequency limits require further study.

3.6.2 Systems *B, C, D, E, F, G, H, K, L*

For the hypothetical reference circuit, the limits of the attenuation/frequency and envelope-delay/frequency characteristics given in Figs. 10 and 11 may be found useful by designers. In these figures, the abscissae show a single parameter which is the ratio between the frequency and the nominal upper video frequency, f_c, of the system considered (normalized frequency).



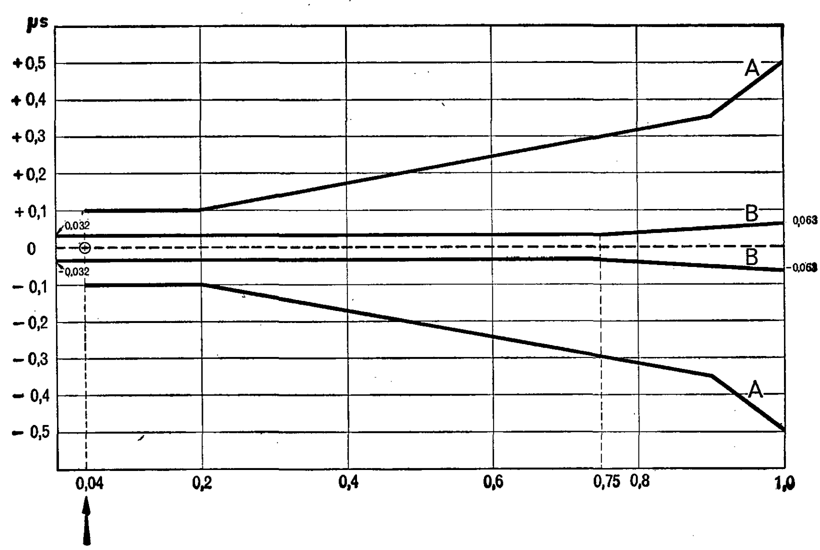
Reference frequency

FIGURE 10

Limits for the attenuation/normalized-frequency characteristic for television systems

Curves *A*: With nominal upper limits of the video-frequency band f_c = 4 MHz, system *M* (Japan); 5 MHz, systems *B, C, F, G, H*; 6 MHz, systems *D, K, L*; 10 MHz, system *E*.

Curves *B*: For system *M* (Canada and the U.S.A.), f_c = 4 MHz.



Reference frequency

FIGURE 11

Limits for the envelope-delay/normalized-frequency characteristic for television systems

Curves *A*: With nominal upper limits of the video-frequency band f_c = 4 MHz, system *M* (Japan); 5 MHz, systems *B, C, F, G, H*; 6 MHz, systems *D, K, L*: 10 MHz, system *E*.

Curves *B*: For system *M* (Canada and the U.S.A.), f_c = 4 MHz.

ANNEX I

TEST SIGNALS

1. Test signal No. 1

Test signal No. 1 is used in the measurement of field-time waveform distortion. As shown in Fig. 12 below, it comprises a square wave of field frequency superimposed upon line-synchronizing and blanking pulses. If desired, a field-synchronizing signal may be included and the pedestal may be omitted.

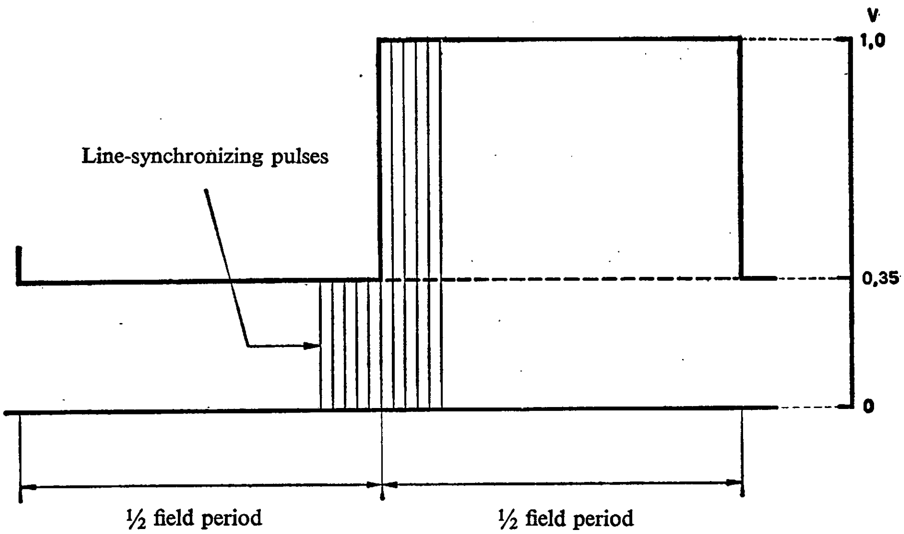


FIGURE 12

Test signal No. 1

2. Test signal No. 2 *

Test signal No. 2 is used in the measurement of insertion gain, line-time waveform distortion and short-time waveform distortion. As shown in Fig. 13, it comprises a half-line bar associated with line-synchronizing pulses. If desired, a field-synchronizing signal may be included. The interval between the half-line bar and the succeeding synchronizing pulse may be either 0.1 H or 0.2 H, where H is the line period. The pedestal may be omitted if desired.

The precise shape and rise-time of each transition of the half-line bar may be determined by means of a shaping network, the design of which is based on " Solution 3 " in a paper by W. E. Thomson (Proc. I.E.E., Part III, **99**, 373 (1952)). Two alternative networks may be used giving rise-times of T and 2 T, where $T = 1/(2 f_c)$, and f_c is the nominal upper video-frequency limit of the system. (Annex IV of the paper by Thomson contains a description of the appropriate network.)

If desired, an additional feature such as a sine-squared pulse, of shape and half-amplitude duration determined by the above-mentioned shaping networks, or a high-frequency burst, can be added in the space marked A. For systems D and K, a sine-squared pulse of half-amplitude duration T or 2 T is used.

* Considerable errors in measurement occur when using Test signals Nos. 2 and 3, if the signal-to-noise ratio is less than 30 dB (see Doc. CMTT/2, Paris, 1962).

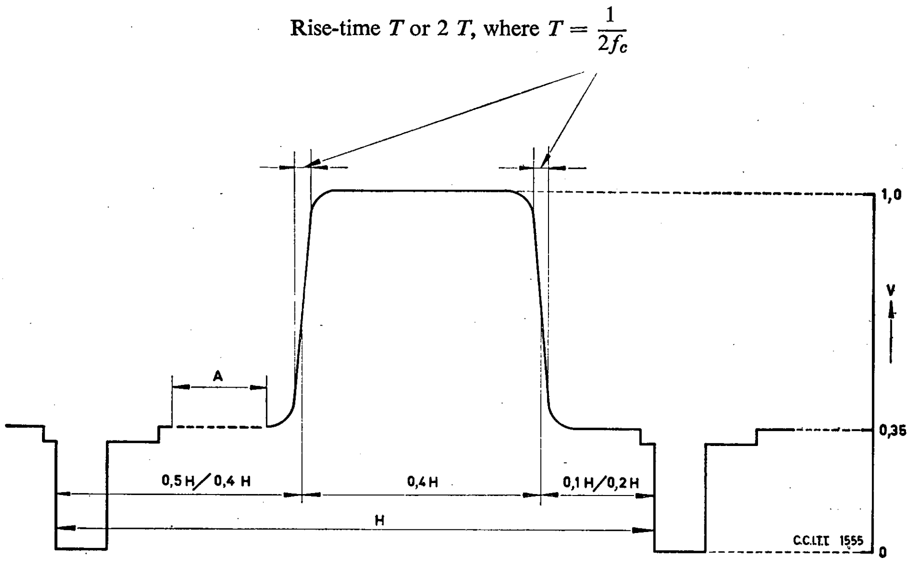
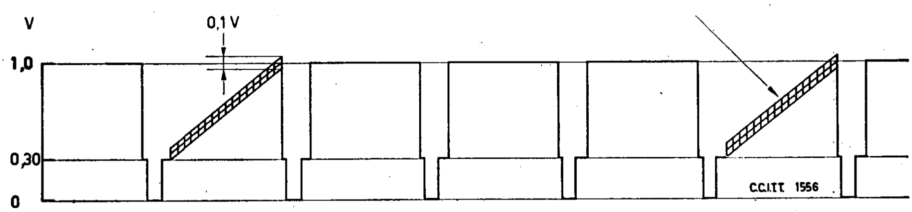


FIGURE 13

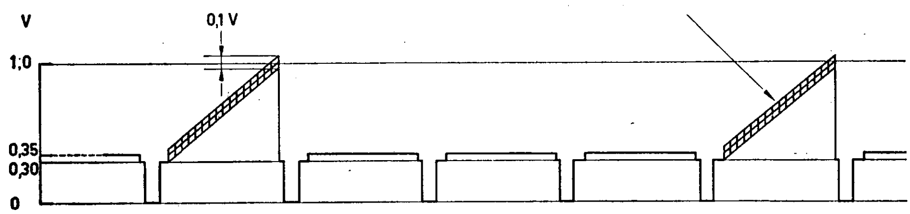
Test signal No. 2

3. Test signal No. 3 *

Test signal No. 3 is used in the measurement of non-linearity distortion. As shown in Fig. 14, it is a signal in which the " picture " portion of every fourth line consists of a sine-



(a) Intermediate lines at black level



(b) Intermediate lines at white level

FIGURE 14

Test signal No. 3

* Considerable errors in measurement occur when using Test signals Nos. 2 and 3, if the signal-to-noise ratio is less than 30 dB (see Doc. CMTT/2, Paris, 1962).

wave of 0·1 V peak-to-peak amplitude superimposed on a sawtooth, the three intermediate lines being set either to black level or to white level by means of a switch at the sending end. If desired, a field-synchronizing signal may be included and the pedestal may be omitted.

For measuring line-time non-linearity distortion, the frequency of the superimposed sine-wave is $0 \cdot 2\, f_c$.

At the receiving end of a circuit, any variation of the sine-wave amplitude over the duration of the sawtooth is taken as indicative of non-linearity distortion.

ANNEX II

LOW-PASS FILTER FOR USE IN MEASUREMENTS OF CONTINUOUS RANDOM NOISE

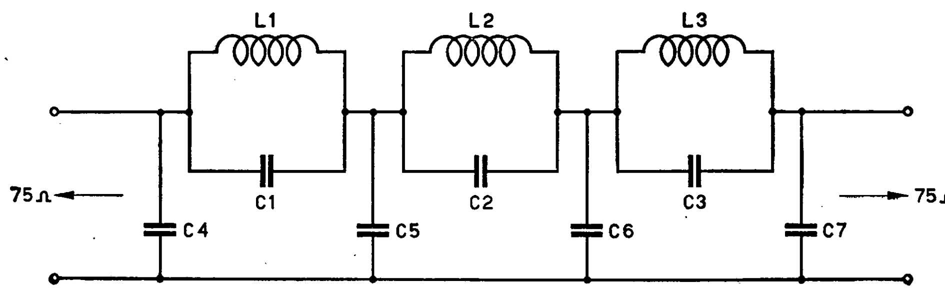
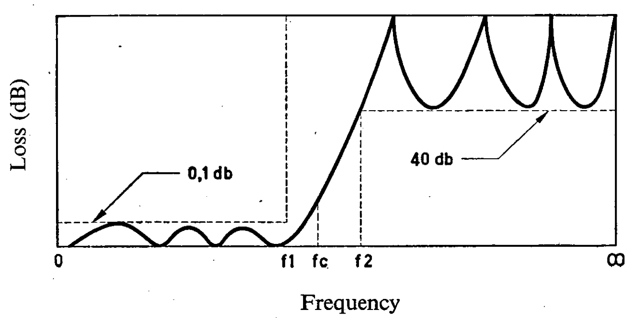


FIGURE 15

	Nominal upper video-frequency limit: f_c (MHz) *		
	L (μH)	C (pF)	f (MHz)
1	$14 \cdot 38/f_c$	$497 \cdot 6/f_c$	$1 \cdot 8816\, f_c$
2	$7 \cdot 673/f_c$	$2723/f_c$	$1 \cdot 1011\, f_c$
3	$8 \cdot 600/f_c$	$1950/f_c$	$1 \cdot 2290\, f_c$
4		$2139/f_c$	
5		$2815/f_c$	
6		$2315/f_c$	
7		$1297/f_c$	

* For system M (Canada and the U.S.A.), a value of $f_c = 4 \cdot 2$ MHz is adopted for the design of the low-pass filter used for noise measurement.

f/f_c	dB	f/f_c	dB
0·98	0·1	1·04	14·8
0·99	0·5	1·05	18·8
1·00	1·8	1·06	23·0
1·01	4·2	1·07	27·7
1·02	7·3	1·08	33·3
1·03	10·9	1·09	41·0



Theoretical insertion loss
$f_1 = 0{\cdot}9 f_2$ by design.
Ringing frequency $= f_c$ by design.
$f_1 = 0{\cdot}9807 f_c$
$f_2 = 1{\cdot}0897 f_c$

FIGURE 16

Note 1. — Each capacitance quoted is the total value, including all relevant stray capacitances, and should be correct to $\pm$ 2%.

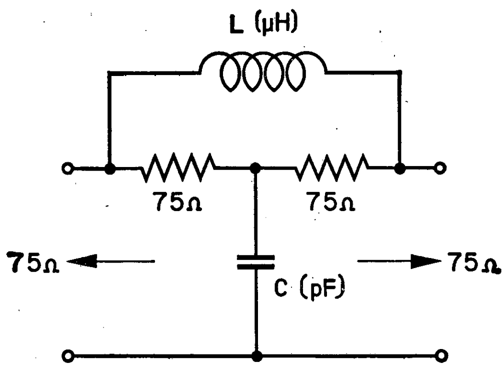
Note 2. — Each inductor should be adjusted to make the insertion loss a maximum at the appropriate indicated frequency, f (MHz).

Note 3. — The theoretical insertion loss curve above corresponds to an infinite Q-factor. In practice, Q should be at least of the order of 100 at frequency f_c.

Note 4. — Limits for the insertion-loss/frequency characteristic are specified indirectly by the indicated tolerances on the component values.

ANNEX III

CONTINUOUS RANDOM-NOISE WEIGHTING NETWORKS



L (μH) = 75 τ (μs); C (pF) = [τ (μs)/75] $\times$ 10^6
Insertion loss (dB) = 10 $\log_{10}$ [1 + $(2\pi\tau f)^2$]

FIGURE 17

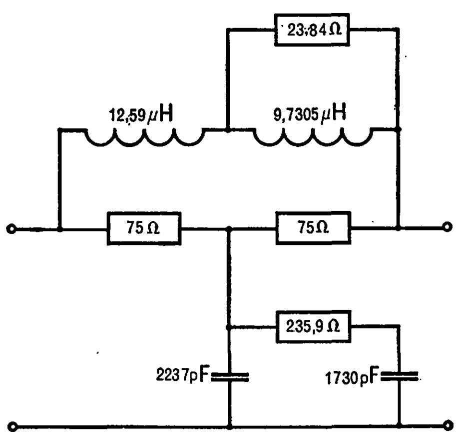
System	f_c[1] (MHz)	τ (μs)	τf_c	Theoretical weighting (dB), for "White" noise	Theoretical weighting (dB), for "Triangular" noise
M (Canada and U.S.A.)	see Note 1			6·1	10·2
M (Japan)	4	0·415	1·66	8·5	16·3
B, C, G, H	5	0·33	1·66	8·5	16·3
D, K, L	6	0·33	2·0	9·3	17·8
F	5	0·33	1·66	8·5	16·3
E	10	0·166	1·66	8·5	16·3

(1) f_c is the nominal upper video-frequency limit of the system (MHz).

Note 1. —For system *M* (Canada and the U.S.A.), the following weighting characteristic is used :

Frequency (MHz)	0·01	0·05	0·10	0·50	1·00	2·00	3·00	4·00
Weighting (insertion loss) (dB)	0	0	0·3	2·8	4·7	8·1	10·8	13·0

A weighting network, such as that shown below, may be used:



Insertion loss (dB) $= 10 \log_{10} ([1 + (f/f_1)^2] [1 + (f/f_2)^2] [1 + f/f_2)^2]/[1 + (f/f_3)^2]$

where: $f_1 = 0{\cdot}270$ MHz, $f_2 = 1{\cdot}37$ MHz and $f_3 = 0{\cdot}390$ MHz

FIGURE 18

Note 2. — For system *M* (Japan), the weighting curve of Fig. 19 is used for colour (see WATANABE, K.: Effects of continuous random noise on colour television pictures. *Electrical Telecomm.* Laboratory. Report No. 1528, *N.T.T. Japan* (1964).

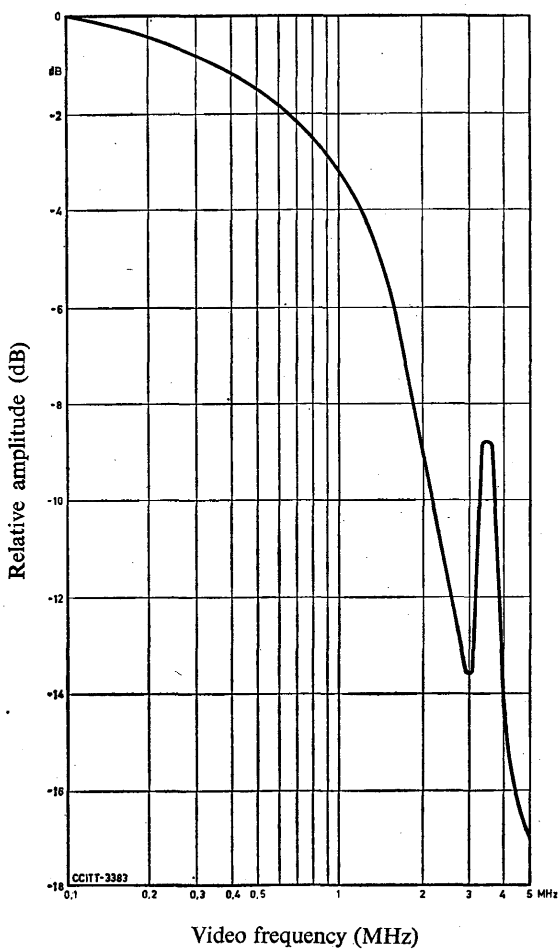


FIGURE 19

Weighting curve for continuous random noise of a 525-line television system

ANNEX IV

CIRCUITS HAVING MORE OR FEWER VIDEO SECTIONS THAN THE HYPOTHETICAL REFERENCE CIRCUIT

1. Introduction

The purpose of this Annex is to give some indication of the design objectives of hypothetical circuits that have more or fewer video-to-video sections than the three sections of the hypothetical reference circuit defined in § 1.2 of this Recommendation. The values calculable from Tables I and II provide only indications of the probable design objectives, which should be used with caution when considering specifications of actual circuits, because the law of addition is not precisely known for every type of impairment.

2. Laws of addition

If D_3 = design objective as expressed in this Recommendation, or the parameter derived therefrom and indicated in Table II, permitted in the hypothetical reference circuit.

and D_n = design objective, or the parameter mentioned above, permitted in n sections,

then $D_n = D_3 \cdot (n/3)^{1/h}$,

where h has the value 1, 3/2 or 2 in accordance with Table II; $h = 1$ gives linear or arithmetic addition, $h = 3/2$ gives the " three-halves power " law of addition, and $h = 2$ gives r.s.s. or quadratic addition.

Calculated values of $(n/3)^{1/h}$ are given in Table I.

TABLE I

n	$(n/3)^{1/h}$		
	$h = 1$	$h = 3/2$	$h = 2$
1	0.33	0.48	0.58
2	0.67	0.76	0.82
3	1.00	1.00	1.00
4	1.33	1.21	1.15
5	1.67	1.41	1.29
6	2.00	1.59	1.41
7	2.33	1.76	1.53
8	2.67	1.92	1.63
9	3.00	2.08	1.73
10	3.33	2.23	1.83
11	3.67	2.38	1.91
12	4.00	2.52	2.00
13	4.33	2.66	2.08
14	4.67	2.79	2.16
15	5.00	2.92	2.24

TABLE II

Relevant section of this Recommendation	Characteristic	D_s expressed in	h	Note
3.1	*Insertion gain* (tolerance)	dB	2	
3.2	*Insertion gain variation*			
	short period	dB	2	
	medium period	dB	2	
3.3.1	*Continuous random noise*			
	signal-to-noise ratio			1
3.3.2	*Periodic noise*			
	signal-to-noise ratio	amplitude of noise		
	power-supply hum		2	2
	1 kHz to 1 MHz		2	3
	1 MHz to f_c		2	3
3.3.3	*Impulsive noise*	amplitude of noise		4
3.4	*Non-linearity distortion*			
3.4.2	Picture signal	$(1-m/M) \times 100\%$	3/2	
3.4.4	Synchronizing signal	%	3/2	
3.5	*Linear waveform distortion*			
3.5.1	Field-time	%	1	
3.5.2	Line-time	%	2	6
3.5.3	Short-time			
	— overshoot and ringing	mask	2	6
	— rise-time	μs	no law	
3.6	*Steady-state characteristics*			
	Attenuation/frequency	dB	3/2	5
	Envelope-delay/frequency	μs	3/2	5

Note 1. — For circuits on coaxial cables, quadratic addition ($h = 2$) applies to random noise expressed in terms of r.m.s. voltage. For circuits on radio-relay links, see Recommendation 289.

Note 2. — Considering the probability of arithmetic addition of power-supply hum in circuits of few sections, it may be advisable to put $h = 1$ when $n \leqslant 3$.

Note 3. — Considering the probability of arithmetic addition when periodic noise consists of a few components that are very close in frequency, it may be advisable to put $h = 1$, when the number of such components is small.

Note 4. — When each of a number of sources of impulsive noise is operative for a small percentage of the time (e.g. $< 0{\cdot}1\%$), arithmetic addition of the percentage will apply.

Note 5. — In Canada and U.S.A., the practice is to use $h = 2$.

Note 6. — For systems *D* and *K*, the method outlined in Doc. CMTT/60, 1963-1966 could be used.

3. Examples of the use of Tables I and II

3.1 In the hypothetical-reference circuit, if the tolerance on gain is $\pm$ 1 dB, the tolerance on gain for a video section will (with $h = 2$) be:

$$D_1 = D_3 \sqrt{1/3} = D_3 \times 0{\cdot}58 = \pm 0{\cdot}58 \text{ dB}$$

3.2 In the hypothetical reference circuit, if the tolerance on the signal-to-noise ratio is 50 dB, the tolerance on the signal-to-noise ratio for a 9-section circuit will be calculated as follows (with $h = 2$):

noise amplitude for the hypothetical reference circuit: D_3;

noise amplitude for the 9-section circuit:

$$D_9 = D_3 \sqrt{9/3} = D_9 \times 1{\cdot}73$$

signal-to-noise ratio for the 9-section circuit:

$$\frac{S}{D_9} = \frac{S}{D_3} \times \frac{1}{1{\cdot}73}$$

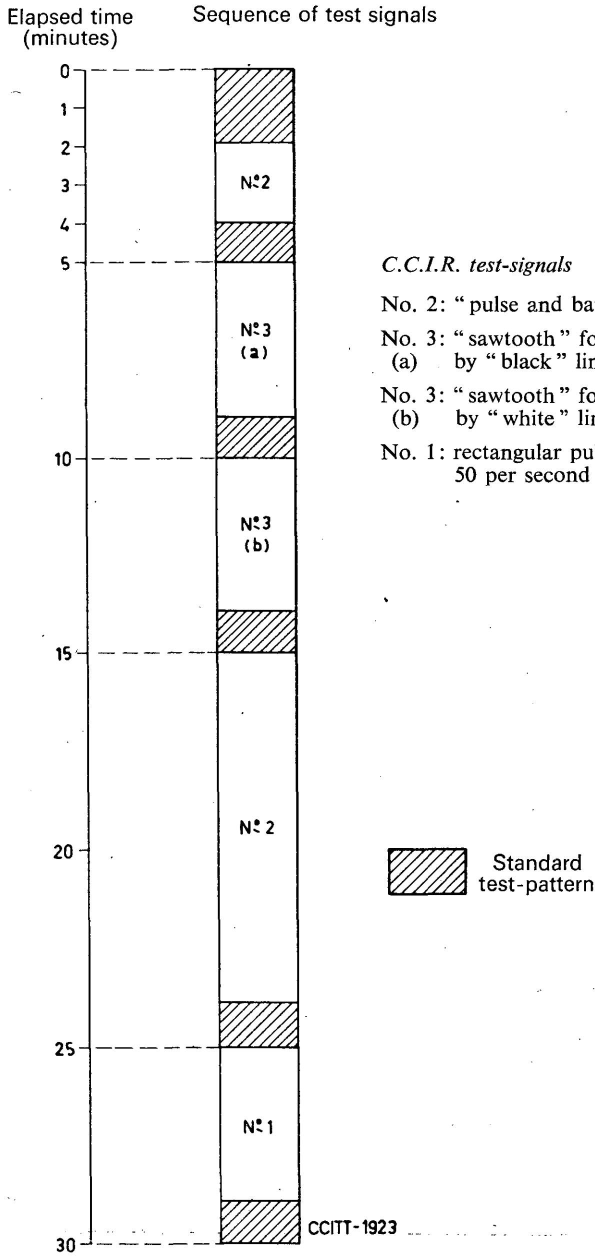
or, in dB: $\left(\frac{S}{D_9}\right)$ dB $= 50 - 4{\cdot}8$, i.e. about 45 dB.

3.3 In the hypothetical reference circuit, if the tolerance on non-linearity is 20%, the tolerance on non-linearity for a video section will be (with $h = 3/2$):

$$D_1 = D_3\,(1/3)^{2/3} = D_3 \times 0{\cdot}48$$
$$D_1 = 20 \times 0{\cdot}48 = 9{\cdot}6\%$$

SUPPLEMENT No. 5.2

TEST SEQUENCE USED BY MEMBERS OF THE E.B.U. DURING THE LINE-UP PERIOD (SOMETIMES, BY AGREEMENT, A SHORTERED VERSION IS USED)



C.C.I.R. test-signals

No. 2: " pulse and bar "

No. 3: " sawtooth " followed
(a) by " black " lines

No. 3: " sawtooth " followed
(b) by " white " lines

No. 1: rectangular pulses at 50 per second

Pre-transmission vision test schedule

SUPPLEMENT No. 5.3

TEST SIGNAL PROPOSED BY THE FEDERAL GERMAN REPUBLIC FOR COLOUR TELEVISION TRANSMISSION

1. As far as colour television signals are concerned no decision as to the recommendations relating to the maintenance of television circuits have so far been reached either by the C.C.I.T.T. or the C.C.I.R. (C.M.T.T.) (exception: system J).

The German Administration has submitted proposals which, in its opinion, set out suitable interim measures in line with come of the documents submitted to the C.C.I.R. (C.M.T.T.) in a consultative capacity. They refer to the extension of test signals Nos. 2 and 3 (See Annex I to Supplement No. 5.1) and the form of a special signal to be inserted in the field-blanking interval of a television signal (Recommendation N.59 and C.C.I.R. Report 314-1, point 5). In view of the increasing numbers of parameters to be taken into account, these proposals have observed the principle of simplifying the measurements required, in order to counteract the ever-increasing shortage of sufficiently qualified staff.

2. *Extension of C.C.I.R. test signals Nos. 2 and 3 for colour television*

2.1 With the aid of the test signals represented in Annex I to Supplement No. 5.1 a measurement is taken of the service values that have to be maintained for a television circuit. For test signal No. 2, a certain time (marked by A = 0.5/0.4 H) is provided for an extension by means of a high-frequency signal, for example a burst.

If, for this purpose, we choose an oscillation of the colour carrier frequency with the same amplitude as the next white bar, usually the picture white level, it is possible to measure, in addition to the insertion gain, the transient response for signals of one line length and the transient response for burst signals, the very considerable insertion gain of the colour carrier oscillation and to compare it with that of the luminance signal. Figure 1 shows the proposed test signal. Since test signal No. 2, apart from the addition of the colour carrier

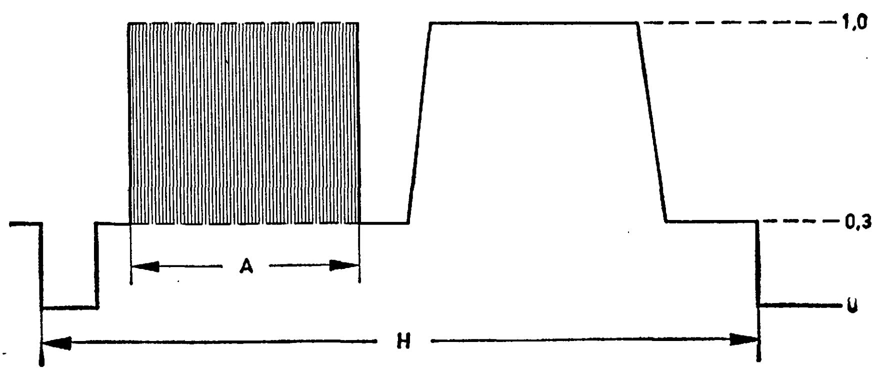


FIGURE 1.—Expanded test signal No. 2

oscillation, keeps the shape it had up to the present, the methods of assessment hitherto applied for monochrome measurements (for example the one in Figure 5 of Supplement No. 5.1) are relatively unaffected.

2.2 To determine non-linearity distortion, especially within the limits of the frequencies near the colour carrier, test signal No. 3 should, as already proposed and applied a number of times, be amended so that, instead of the superimposed oscillation of frequency $0.2 f_c$, an oscillation is used at the colour carrier frequency. This would completely correspond, for all other systems, to the method already established in the *M* system (Canada and United States (see point 3.4.2 of Supplement No. 5.1). It is thus very likely that, as a result of further studies, future C.C.I.R. recommendations will take account of this model in the same way.

3. *The shape of a special test signal in the field-blanking interval of a television signal*

3.1 With reference to C.C.I.R. Study Programme 12 A/XI, the German Administration is also of the opinion that, for international television circuits, it should be possible to transmit over the circuits, in addition to the usual special signals for measuring circuits (see Supplement No. 5.1), a special test signal together with the current programme signals. Such a signal is inserted in the field-blanking interval. Without the help of a test line, only a subjective estimate of a transmission can be made. A test line has also the following advantages:

1) it enables an objective assessment to be made of the transmission quality during the programme and

2) on the basis of that assessment, it enables the various parameters to be readjusted in so far as the shapes of the test lines correspond.

Displacement compensations can then easily be avoided by corresponding observations of the test lines, carried out at several points along the transmission channel.

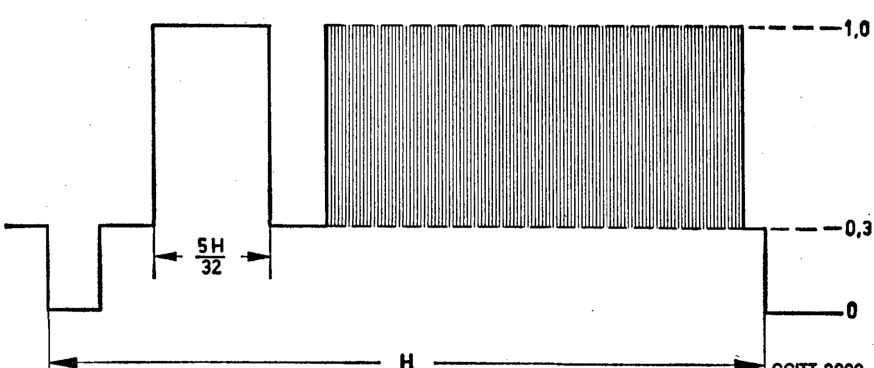


FIGURE 2.—Shape of the special signal to be inserted in the field-blanking interval (test line)

3.2 The structure of the special signal to be inserted in the field-blanking interval must be as simple as possible so that the maximum data can be provided at a reasonable cost. Moreover, the signal must be adapted for automatic assessment and response. The German Administration proposes the signal shown in Figure 2. It consists of a white bar of 10 μs duration, at the picture white level and is thus in conformity with the one reproduced in Recommendation N.59. The colour carrier oscillation, with the same amplitude throughout the rest of the line (at least for a duration of 10 μs) follows. The line required for this signal in the field-blanking interval is still to be determined [1]). With this test line it will be a simple matter (for example with an ordinary oscillograph) to obtain, in addition to control of the amplitude condition for the monochrome picture (luminance signal), important information relating to the attenuation of the colour carrier oscillation in relation to the luminance signal, also while the programme is running. On the basis of past experience, the essential condition for the maintenance of circuits used for transmission of television signals with a colour component is already met by this means of testing.

4. *Future design*

After the method of inserting special signals in the field-blanking interval used by administrations has produced good results, it is probable that in future other parameters will also be measured by this method, the test signals in Annex I to Supplement No. 5.1 being used primarily for adjustment measurements only.

To ensure that, when the test lines are further modified for the measurement of other parameters, the test lines can still be assessed clearly and simply, the German Administration considers that two test lines should be introduced. As hitherto, the first line should be used to determine linear distortion and the second line to determine non-linearity distortion. The first line would continue to have, in essence, the form of the signal proposed in point 3 above; if necessary it could also comprise, in addition to the colour carrier oscillation, some other oscillations with other frequencies and also at full amplitude. The line for measuring non-linearity distortion should comprise a multi-riser staircase signal similar to the one shown in Recommendation N.59 or a saw-tooth signal, superimposed in each case on the colour carrier oscillation. By this separation it would be possible, after the introduction of a first test line (according to point 3 above) for each administration or organization to be free to decide whether and when it adopts the expanded method of inserting special signals in the field-blanking interval.

[1] For example the 18th line (see document CMTT/66 of 26 May 1966, point 7 (see also annex to Recommendation N.67).

SUPPLEMENT No. 5.4

USE OF AN ELECTRONIC TEST PATTERN FOR MAINTAINING THE QUALITY OF TELEVISION CIRCUITS

(Note by the Federal German Administration)

International circuits for television transmissions are very often and frequently at short notice required for the exchange of programmes so that it would be advisable that they remain permanently switched. For a permanent supervision of the transmission performance and a shortening of the test times hitherto required prior to each transmission it is a good idea to occupy permanently the circuits with an electrical signal made up in such a way as to allow conclusions to be drawn in a simple way on the transmission performance and the place of origin of the signal.

It is proposed to use, for instance, an electronic test pattern according to the drawing in Figure 1. The test pattern allows the simultaneous observation in one picture of the insertion gain, the frequency characteristic, the transient response, and the linearity with an accuracy sufficient for maintenance purposes and the feeding-in of an identification signal for the place of origin. The test pattern supplies a complete video signal (including the frame synchronizing signal) so that a correct modulation of all installations to be measured is ensured and the observation of the signals on an ordinary television receiver is rendered possible. Thus, the routine maintenance tests according to No. 1 of the table in Recommendation N.73 (Measurement of insertion gain using test signal No. 2) are no longer required.

If, furthermore, assuming that the actual transmission systems (coaxial cable and radio-relay systems) are regularly measured according to methods and at intervals required by the respective transmission systems, it will suffice to perform the measurements listed in the table in Recommendation N.73, under 2, 3 and 4, at longer intervals.

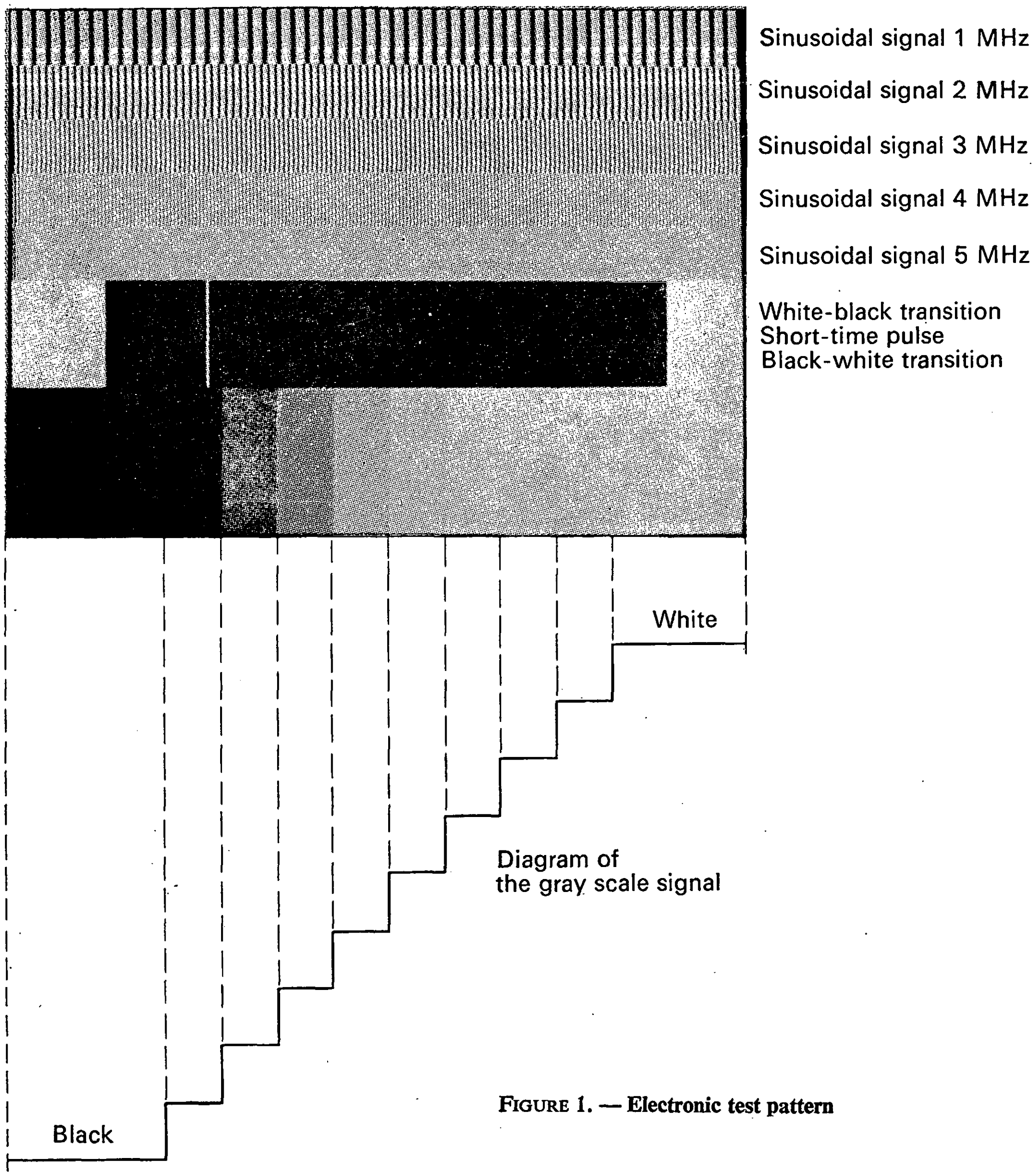


FIGURE 1. — Electronic test pattern

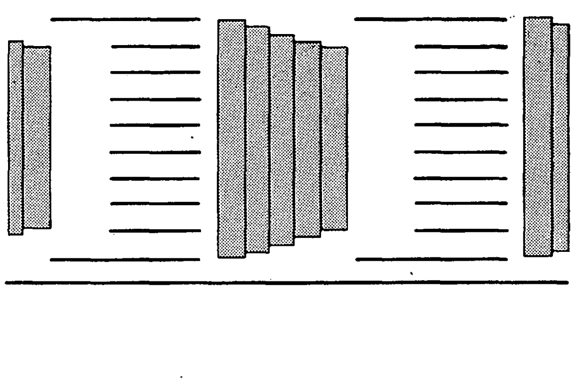


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FIGURE 2. — Signal in the V oscillogram

SUPPLEMENT No. 5.5

SUMMARY OF PROVISIONAL OBJECTIVES FOR NATIONAL TELEVISION CIRCUITS ANALOGOUS TO INTERNATIONAL TELEVISION CIRCUITS BEING STUDIED BY THE UNITED KINGDOM FOR BOTH MONOCHROME AND COLOUR 625-LINE TELEVISION TRANSMISSION

1. Signal amplitude at video interconnection points	0.7 V p-p luminance	0.3 V p-p synchronizing pulse
2. Waveform return loss at video interconnection points (75-ohm unbalanced resistive)		30 dB
3. Non-useful d.c. component unrelated to video signals		0.1 W (2.74 V) in 75-ohm load. 5 V maximum on open circuit
4. Insertion gain after line-up		0±0.25 dB
5. Gain variation		
Short period (1 s)		±0.1 dB
Medium period (1 h)		±0.25 dB
Between routine tests		±0.5 dB
6. Noise		
6.1 Random noise (p-p picture/r.m.s. noise)		
Monochrome and luminance weighted		60 dB
Chrominance weighted		54 dB
6.2 Periodic noise (p-p picture/p-p noise)		
Very low frequency noise below 10 Hz		26 dB
Power supply and lower harmonics		35 dB
Periodic noise 1 kHz to 5.5 MHz		55 dB
Inverter noise		59 dB
7. Crosstalk (p-p picture/p-p noise)		
Undistorted crosstalk and crosstalk at colour subcarrier frequency		58 dB
8. Step-signal response		
Overshoot from 0.7-V step waveform on synchronizing pulses		35%
9. Non-linearity of synchronizing pulses		
9.1 Synchronizing signal-distortion using staircase signal and taking worst result from three lines black and three lines white		3%

	9.2 As 9.1 with signal raised in level by 3 dB	6%
	9.3 Synchronizing signal distortion using black-to-white and white-to-black step with 30% overshoot as test signal	6%
	9.4 As 9.3 with test signal raised in level by 3 dB	12%
10.	Non-linearity of line time	
	10.1 Normal level test signal	4%
	10.2 Signal level raised by 3 dB	8%
11.	Differential phase and gain	
	11.1 Differential phase test signal at normal level	±1°
	11.2 Differential phase test signal level raised by 3 dB	±2°
	11.3 Differential gain test signal at normal level	±2%
	11.4 Differential gain test signal level raised by 3 dB	±4%
12.	Chrominance/luminance crosstalk	3%
13.	Luminance k-rating	1%
14.	Chrominance k-rating (this test may not be necessary)	2%
15.	Luminance/chrominance inequalities	
	15.1 Gain	4%
	15.2 Delay	20 ns
16.	Blanking-level discontinuity	1%

SUPPLEMENT No. 5.6

NETWORK SWITCHING EQUIPMENT PERFORMANCE

(Note by the United Kingdom Administration)

The waveform distortion introduced by a number of network switching equipments in a tandem connection of video links is insignificant and it is not necessary for it to be taken into account in apportioning the distortion between the elements of the networks.

Typical target performance limits for a network switching équipment capable of switching 40 405-line vision channels and 40 associated sound channels to 40 vision and associated sound destinations and having full flexibility between sources and destinations include:

a) For the video matrix:

i) the waveform performance from any input to any output should have a " K-rating " less than 0.25%;

ii) the insertion gain (measured by observation of the amplitude of a 40-microsecond bar) should be 0 ± 0.1 dB;

iii) the hum level should give a p-p picture signal to p-p hum ratio greater than 45 dB;

iv) over a 1-kHz to 3-MHz bandwidth the unweighted noise expressed as a p-p picture to the r.m.s. noise should be greater than 76 dB, and the signal/crosstalk at any output under the most severe conditions should give a p-p picture signal to p-p crosstalk ratio greater than 65 dB.

b) For the sound matrix:

i) the insertion gain at 800 Hz should be 0 ± 0.26 dB;

ii) the gain at any frequency between 50 Hz and 12 kHz should not differ from that of any other frequency in the range by more than 1 dB;

iii) the gain between 30 Hz and 50 Hz should not differ from that at 100 Hz by more than 1 dB;

iv) the harmonic distortion should be negligibly low and the unweighted noise should not exceed 65 dB below 1 mW in 600 ohms;

v) the signal/crosstalk ratio at any output in any operating condition should be greater than 85 dB.

SUPPLEMENT No. 6.1

EFFECT OF TRANSISTORS ON MAINTENANCE

(Summary of studies by C.C.I.T.T. Study Group IV in 1964-1968)

General

To avoid any misunderstanding, the Study Group has defined *component* as the smallest part of an assembly, such as a resistor, capacitor, transistor, etc. By *sub-assembly* is to be understood a certain number of components mounted together (sub-assembled) in rigid mechanical fashion. Sub-assemblies must be easily replaceable.

Primary maintenance consists in replacing a sub-assembly by another identical spare for the purpose of rapidly clearing a fault.

Secondary maintenance consists in locating and replacing the defective component(s) of a sub-assembly.

1. *Maintenance of transmission lines provided with transistor equipment*

1.1 *Amplifications or amendments considered necessary to the Recommendations in Volume IV of the C.C.I.T.T.* Blue Book

The consensus of the answers to this item of the questionnaire is that the introduction of transistor equipment made it necessary to amplify existing recommendations.

One reply, for example, drew attention to the daily reading of line pilot levels and the regular readjustment to nominal level mentioned in point 1 of Recommendation M.51. It was proposed that this check be made less frequently and that the periodicity of measurements be decided by mutual agreement among the administrations concerned according to the experience acquired.

1.2 *Additional tests of transmission performance in view of possible ageing of transistors*

The impression that the electrical characteristics of individual transistors are no longer regularly checked in transistor systems was confirmed.

Improved transistor reliability, a large amount of feedback and easily replaceable sub-assemblies now make this sort of preventive maintenance unnecessary.

Practical experience of transistor systems has not so far indicated that it is either necessary or advantageous to make additional transmission tests such as non-linearity distortion measurements.

In this connection, however, it was emphasized that the noise level might be a more sensitive indication of the condition of the line link than the line pilot level (see M.51, 1 c), *Blue Book*, Volume IV, page 93).

2. *Maintenance and repair methods applicable to equipment sub-assemblies. Special precautions to be taken during maintenance and repair*

2.1 *Reduction of preventive maintenance*
Reduction of corrective maintenance

The introduction of transistors has had considerable influence on maintenance, as replies and contributions clearly show.

The elimination of routine testing of valves and their associated alarm circuits, for instance, in itself represents a great saving in preventive maintenance; in one case a 30% reduction in the working time required for the maintenance of repeater station equipment was reported.

But the major factors in reducing preventive maintenance to this extent are the improved stability and reliability of transistor equipment.

Generally speaking, longer intervals between regular measurements could be allowed.

More detailed information on the type of measurements or the length of time between them is not yet available, but it has been shown quite clearly that a reduction in preventive maintenance has been obtained above all in transistor line-equipments. The introduction of transistors has made it possible to cut down considerably the number of maintenance tests on line amplifiers and to continue the maintenance of a steadily extending symmetric or coaxial cable network without any significant increase in staff.

A reduction in the number of measurements is not the only advantage. Maintenance methods have been simplified by incorporating ancillary circuits in the equipment which could not have been feasible without transistors: for example, local oscillators can be inserted in the line-equipment at unattended repeater stations, both buried and above-ground. By the injection of additional measuring frequencies, the condition of individual line repeaters and line sections can then be checked from a manned station some distance away.

One contribution mentioned the tendency to concentrate preventive maintenance on the complete circuit rather than to apply it to separate equipment parts.

With regard to the preventive maintenance of transistor systems, special attention was drawn to experience acquired in the maintenance of valve type systems, and it was observed that frequent testing was of doubtful value. Thus a planned reduction in preventive maintenance was accompanied by a reduction in corrective maintenance.

It is therefore necessary to draw up an appropriate maintenance programme based on an analysis of available data.

The introduction of transistors had led to a definite improvement in equipment reliability.

Far less faults occur in modern equipment than in old valve-type equipment. The best results have been obtained when printed circuit systems are also incorporated in equipment of new design and when care is taken to select components offering maximum reliability.

It has been shown that the number of faults in terminal equipment built on these principles has diminished by four to nine times.

A reduction of up to 25% in the number of faults occurring with a certain type of transistor line repeater, fitted to coaxial pairs, has likewise been noted in comparison with similar repeaters using valves.

Modern transistor equipment thus seems to have brought about a marked improvement which also applies to corrective maintenance.

2.2 *Effect of a reduction in the size of equipment and of new manufacturing techniques*

In transistor, as in other systems, the equipment consists of a number of replaceable sub-assemblies. With small-size electronic components and printed circuits several electrical circuits can be included in one and the same sub-assembly and, with suitable manufacturing methods, a larger number of such sub-assemblies can be housed on a single rack.

As the size of measuring and access points can be reduced only to a very limited extent, the tendency is to reduce their number. This can be done since it will no longer be necessary, or even desirable, in case of a fault to locate the defective component immediately for in many cases it will not be possible to carry out repairs right away.

To prevent transmission impairment due to mistakes made by staff at the measuring points, these points should be disconnected from the transmission path to ensure, for example, that the general attenuation will not exceed 1 dB or 1 dNp if there is a short-circuit.

Consequently, it will be sufficient simply to locate the defective sub-assembly. Once this is replaced by a spare, the fault will be cleared (see 2.3 below). Thus the minimum number of measuring points is determined by the need in case of a fault to be able to identify the sub-assembly responsible and to do this it must be possible to check the input and output levels of the various sub-assemblies.

The rule now applied in valve type systems, namely, that in principle corrective maintenance should be confined to replacing the faulty sub-assembly, has been followed in planning transistor systems and equipment is so designed that sub-assemblies are easily replaceable.

The alarm circuits in the rack are so arranged that, so far as possible, they indicate clearly which sub-assemblies are the cause of the fault.

It is hoped that in future automatic measuring equipment will be a valuable aid to maintenance. There is every reason to believe that basic corrective maintenance will be limited to replacement of the defective sub-assemblies which will have been located to a large extent by the equipment itself by means of appropriate logic circuits.

It is probable that such basic maintenance will finally be undertaken by lower grade staff.

Secondary maintenance, that is to say, the tracing of defective sub-assembly components or the cause of deterioration of electric characteristics and repair or readjustment, will become increasingly complicated. Staff will have to be more highly qualified and, with the increasing miniaturization of equipment, manual skill will be of great importance (see also 2.3).

2.3 *Repair methods*

For the repair of transistor equipments with printed circuits, the staff, besides being highly specialized and fairly skilful with their hands, must have considerable experience in locating faults in electronic equipment.

However, it seems no longer practicable to have transistor equipment repaired on the spot by repeater station personnel.

Because of the improved reliability of equipment, faults caused by defective components occur so rarely that it would not be worth while to provide every repeater station with trained staff or special tools and materials for repairs. It is not certain, moreover, that such staff would be capable of acquiring the required expertise.

Contributions show that there is a tendency to cut down the number of repair centres, for example by establishing regional workshops, by designating a few large repeater stations as repair centres for a number of smaller stations or by having repairs of all sub-assemblies done in a central workshop.

With regard to the actual execution of repairs, attention is drawn to the following:

The use of semi-conductors and printed circuits, combined with small-size components, entails a greater risk of damage to electrical or mechanical parts when a breakdown is being checked or during the repair of modern compact equipment.

In particular, the soldering of components and of printed boards is an extremely delicate operation demanding the greatest care. To avoid stray currents, the soldering iron must be fed through a transformer. It must be possible, by means of transformer tappings, to prevent the temperature of the bit from rising above 290°C. To avoid overheating of components and printed boards, soldering should not take more than a few seconds; the mechanical pressure exerted during this operation should be slight.

3. *Need for special apparatus for testing and measuring transistor equipment or lines provided with such equipment*

Conventional measuring and testing apparatus if expertly used can also be applied to transistor equipment in many cases. The qualifications of the staff who have to operate measuring instruments are often a more important consideration than the characteristics of the instruments.

It will seldom be necessary to purchase new testing or measuring apparatus for transistorized equipment for technical reasons. The need will arise mainly when existing apparatus such as tone buzzers, megohmmeters and voltmeter-ohmmeters overload the components used in transmission equipment.

One contribution made a number of suggestions on the performance to be required of testing and measuring apparatus in order to reduce the risk of damage to transistors to a minimum. For example:

a) voltmeters with an internal resistance below 20 000 ohm/volt should not be used;

b) the maximum current of an ohmmeter should not exceed 1 mA;

c) in alternating current measuring equipment, a transformer should be inserted in the power circuit to stop mains interference;

d) a common earth should be provided for transmission and measuring equipment.

The introduction of an apparatus similar to that used for testing valves is not contemplated, in general, for testing transistors. The working of a transistor can be adequately checked by making tests or measurements directly on the faulty sub-assembly.

For the maintenance of transistor line amplifiers, mobile battery-operated measuring apparatus often has to be used.

4. *Miscellaneous*

4.1 *Power supplies for transistor equipment*

At small stations, power for transmitter equipment may be provided by batteries. This is a simple and reliable solution and may be equally suitable for large stations. However, since large stations have a heavy power demand, a.c. supply at a higher voltage may be prepared.

Some administrations which use alternating current at 220 volts for transistor equipment have had to alter their power plant to satisfy points 2.5 d) of Recommendation M.16 (*Blue Book*, Volume IV) since in conventional installations, in case of emergency, interruptions of the order of a second were permitted in the tube heater current, the cathode thermal persistence being sufficient to ensure that transmission was not interrupted.

As the operating voltage of a transistor is lower than that of a valve, feeding at lower voltage is possible. This ensures greater safety to staff so that special safety precautions against contact with live components can be simpler or even dispensed with.

4.2 *Staff training*

The introduction of transistor equipments at repeater stations has not presented much difficulty with regard to the training of staff, who were prepared for the new techniques by special courses and individual study.

So far as new staff are concerned, the study of transistors is now included in the training given by the administrations and private operating agencies.

With regard to the training of maintenance staff, it has been found that intensive specialization is essential for good results. Coaching in the rapid identification of faults is very important and helps to shorten the outage: once the defective sub-assembly is located, it has only to be replaced in order to clear the faults.

Statistical performance control depends to a great extent on the total information supplied by staff in repeater stations about faults that have occurred or been repaired.

To encourage the staff to supply the requisite information and make it as accurate as possible, the personnel concerned should be made aware of the importance of the various statistical observation and data-processing methods and should have some idea of what these methods are.

4.3 *Formation of fungus growth*

As less heat is dissipated by the new equipment, it is easier to provide certain units or assemblies with a protective layer.

It can therefore be said that the prevention of fungus growth and the problems it poses in maintenance need no longer create difficulties for the manufacturer.