THE INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE

(C.C.I.T.T.)

IInd PLENARY ASSEMBLY

NEW DELHI, 8-16 DECEMBER 1960

RED BOOK

VOLUME IV

Maintenance

Part 1 — RECOMMENDATIONS
(Series M and N)

Maintenance Instructions

Section 1 — General
Section 2 — Setting-up and maintenance of international carrier systems
Section 3 — Setting-up and maintenance of international telephone circuits
Section 4 — Maintenance of international telephone circuits used for telegraphy or phototelegraphy
Section 5 — Lining-up and maintenance of international programme transmissions
Section 6 — Lining-up and maintenance of long-distance television transmissions

Part 2 — QUESTIONS

Study Group IV Questions

Part 3 — DOCUMENTARY PART

Supplements to Maintenance Instructions

Published by the
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Symbols and measuring units

Volume IV of the C.C.I.T.T. Red Book (New Delhi, 1960),

replaces

the last part of Volume III of the C.C.I.F. Green Book (Geneva, 1954)

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PART I

MAINTENANCE INSTRUCTIONS

PART 1

MAINTENANCE INSTRUCTIONS

INTRODUCTION

RECOMMENDATION M.1

GENERAL RECOMMENDATION CONCERNING THE MAINTENANCE OF INTERNATIONAL CIRCUITS

So that there shall exist among Administrations and recognized private operating Agencies the co-operation necessary for the maintenance of good transmission in the international telephone service, the C.C.I.T.T. recommends the application of the following Maintenance Instructions, which are based on long experience.

For their dealing with their colleagues in other countries, repeater station personnel will find it helpful to refer to the " Vocabulary of basic line transmission terms ", published by the C.C.I.T.T. for their benefit.

Section 1

GENERAL

CHAPTER 1

Division of responsibility for the maintenance of transmission * — Control and sub-control stations

RECOMMENDATION M.10

1. CONTROL STATION

A control station is nominated for :

- every international *circuit*;
- every group *link* **, supergroup link, mastergroup link or supermastergroup link (group control station, supergroup control station, mastergroup control station, supermastergroup control station);
- any regulated line section ** used for transmission in a carrier system (regulated line section control station **), particularly a symmetric pair line, a coaxial line or a radio relay link.

The control station is responsible for ensuring that the circuit line or link 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 so that interruptions to the commercial service are limited to the shortest possible duration;

c) ensuring that the stations concerned take action when a fault occurs, and for controlling the various tests or investigations necessary in clearing the fault;

d) recording, on forms provided for the purpose, all incidents which arise, giving the time of occurrence of the fault, the exact location, the action taken and the time of restoration to service.

A control station is designated by agreement between the technical services of the Administrations and private operating Agencies concerned. It is normally one of the two

* See also, in Section 3, the rules for the division of responsibility for tests and fault clearance on semi-automatic circuits.

** See definitions in Recommendation M.30.

terminal stations. In choosing between the terminal stations, special consideration is given to :

— whether the station is permanently attended,

— the amount of work at each terminal station,

— the length of the circuit, link or line within the territory of each terminal country.

For automatic or semi-automatic circuits, the choice of control station is governed by the direction in which the circuit is operated; it is the station at the outgoing end of the circuit that is designated as the control station.

In the case of programme or television circuits (uni-directional circuits), the control station is the terminal receiving station.

RECOMMENDATION M.11

2. SUB-CONTROL STATIONS

For setting up and maintaining circuits, links or lines, "sub-control" stations are designated to work in co-operation with the control station.

In general, a sub-control station is designated for each country other than the control station country. The sub-control station functions as a control station for the national section for which it is responsible.

Whenever action is required in one of these 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 the control of the location and clearance of the fault, and for advising the control station of the appropriate details. The sub-control station is responsible for seeing that the transmission on the national section with which it is concerned is within the prescribed limits.

In a transit country, a group, supergroup, mastergroup or supermastergroup sub-control station is one of the group, supergroup, mastergroup or supermastergroup through-connection stations, and in a terminal country, it is the distant terminal station (remote from the control station) where the group, etc. is broken down.

Each group, supergroup, mastergroup or supermastergroup sub-control station is responsible for the setting-up and the maintenance of that part of the link between the through-connection stations nearest to the two frontiers.

In a transit country, a regulated line section sub-control station is one of the intermediate repeater stations and in a terminal country it is the regulated line section terminal station remote from the control station.

RECOMMENDATION M.12

3. SERVICE CIRCUITS

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

Where radio relay links are involved, the following provisions are normally applied, in accordance with C.C.I.R. Recommendation 295 (Los Angeles 1959):

1. All attended stations are connected direct to the public telephone network.
2. When a radio relay link is extended by short cable sections, and when these cable sections plus the radio relay link constitute a regulated line section, the terminal stations of the radio relay link proper are connected to the stations at the end of the regulated line section by a service circuit.
3. A service telephone line (main or direct speech circuit) is set up to carry telephone calls between attended stations receiving supervisory signals.
4. A second service telephone channel (omnibus speech circuit) is set up to connect together all the stations of the system, whether attended or not.

RECOMMENDATION M.13

4. RESPONSIBILITIES OF CONTROL AND SUB-CONTROL STATIONS IN LOCATING AND CLEARING FAULTS

1) Sources of fault reports

Faults on international circuits will in general be reported to the control station as a result of:

a) group pilot or line pilot alarms at repeater stations;

b) local alarms at repeater stations, observed and reported by maintenance staff;

c) reports by the traffic staff at the international terminal exchanges (in the case of automatic circuits, through the I.M.C.);

d) routine maintenance measurements.

2) Principles of the procedure for locating and clearing faults

When a fault has been reported to a terminal station, the control station and the terminal sub-control station should determine whether the fault is in the equipment at one of the terminal stations or in one of the exchanges or on the line.

* Sometimes called " speaker circuits ", although the term " service circuits " should be used in C.C.I.T.T. texts.

The following principles apply to circuits routed on one group link. They can be extended to apply to circuits routed otherwise.

a) Circuit routed on a group link with a group pilot

i) Control or sub-control station which notices, as a result of pilot indications, that there is a fault condition on the group link, should immediately advise the distant terminal station and should proceed to locate the fault to a national section, or to a section crossing a frontier, by measuring the level of the pilot at appropriate through-connection stations nearest to a frontier. They should do this in co-operation with the sub-control stations in the various countries concerned.

ii) Where " busying " facilities are available, the control and terminal sub control stations should arrange to " busy " the faulty circuits immediately a fault has been notified to them. Where "busying" facilities are not provided, the operating staff should be advised immediately.

iii) When the fault has been cleared, the sub-control station in whose territory the fault was located should immediately advise both terminal stations of the clearance and of the nature of the fault on the link. These two stations in co-operation with other sub-control stations should arrange to check the levels at through-connection stations where necessary and also to ensure that the pilot levels at these stations and at the terminal stations on the link are correct; if they are not correct, the stations should make appropriate adjustments where necessary in order to restore the group link to its normal condition.

If there is any reason to suspect, from the nature of the fault, that the level of the group link may be affected to a greater extent at frequencies other than the pilot frequency, checks should be made of the level of the channels and, if necessary, these should be adjusted to their correct relative level value.

When the group control is satisfied that the group link and the channels on the link are satisfactory, the " busy " condition on the circuits should be removed, or the traffic staff advised, whichever is appropriate.

If it appears that the fault will cause a serious interruption to traffic, wherever possible, the faulty section should be made good with a reserve section.

b) Circuit routed on a group link without a group pilot

When a fault has been localized on the group link, the faulty circuits should be blocked or the traffic staff advised.

An 800 c/s test signal should be sent on the channel previously used for the line-up of the group and the fault should be located to a national section or a section crossing a frontier by making appropriate measurements at transfer stations.

After clearance of the fault, the procedure given in *a)* for circuits routed on a group link with a group pilot should be followed.

3) Faults observed at repeater stations as a result of local or extended alarms

All fault conditions observed at repeater stations as a result of local or extended alarms should be reported to the control or sub-control station of the country concerned, so that arrangements can be made to make good the circuits or so that the traffic staff can be advised.

4) In the case of unusual faults, or those which are difficult to locate with the available testing equipment or where the same kind of fault occurs very frequently on a particular section, the control or sub-control station should advise its respective technical services without delay. These services in co-operation will take appropriate action to locate such faults or prevent such faults in the future.

CHAPTER II

RECOMMENDATION M.14

DESIGNATION OF INTERNATIONAL CIRCUITS AND GROUPS

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.

1. Telephone circuits

Telephone circuits used in *manual operation;* the circuit number follows immediately after the names of the two international terminal exchanges arranged in alphabetical order :

Example : London-Paris 1.

Circuits used for *international 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 number for 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-Paris direction (alphabetical order) : London-Paris Z 21.

For a circuit operated in the Paris-London direction (inverse alphabetical order) : Paris-London Z 18.

Special telephone circuits for private services or particular purposes (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.

Example : London-Paris P 1.

2. Circuits used for voice-frequency telegraphy

Circuits for voice-frequency telegraphy for *general public service* are distinguished by the letter T.

Example : London-Paris T 1.

Circuits for voice-frequency telegraphy for *private or special* services are distinguished by the letters TP.

Example : London-Paris TP 1.

In the case of telephone circuits used as *reserve circuits* for voice-frequency telegraphy, 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-Paris 65 (ST 1)

describes the circuit designated as a reserve for the London-Paris T 1 voice-frequency telegraph circuit.

For telephone circuits that are reserve circuits for voice-frequency telegraph circuits used for private or special purposes, the normal telephone designation of the circuit is followed by brackets enclosing the letters STP and the number of the voice-frequency telegraph circuit for which the circuit under consideration is normally used as a reserve.

3. Data-transmission circuits

For data-transmission circuits, the letter D and a special numbering system is used.

Example : London-Paris D 1.

The letter and the number in the data-transmission numbering system are put in brackets after the normal designation of the telephone circuit, when a normal public circuit is used for data transmission.

Example : London-Paris 62 (D 3).

The letters DP with special numbering system designate data-transmission circuits specially provided for private service.

Example : London-Paris DP 3.

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.

Example : London-Paris 23 (F 1).

For specialized circuits for private services (press agency, etc.) phototelegraphy or facsimile, the letters FP are used.

Example : London-Paris FP 2.

5. Circuits for programme or television transmissions

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).

Examples :

— circuit transmitting only in the direction London-Paris, London-Paris R 1 or London-Paris V 1
— circuit transmitting only in the direction Paris-London, Paris-London R 1 or Paris-London V 1
— reversible circuit London-Paris RR 1 or London-Paris VV 1.

6. International groups : 12-channel group, 8-channel group, supergroup *

12-channel groups are designated by the numbers 901, 902 ... 998, 999, 9100, 9101, 9102 ... (for example, London-Lugano 901), this series being reserved exclusively for numbering 12-channel groups.

8-channel groups are designated by the numbers 801, 802, 803 ... 898, 899, 8100, 8101, 8102 ..., this series being reserved exclusively for numbering these 8-channel groups.

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

The above numbers are used for the 12-channel group, 8-channel group or supergroup from the point where it is assembled to the point where it is broken down, independently of the position it occupies in the band of frequencies transmitted on the line.

* See the definitions in Recommendation M.30.

CHAPTER III

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.

This routine maintenance programme 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 links.

The dates 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 Sections 2 and 3 of the Maintenance Instructions.

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. This document is also sent to the operating services and is used in place of the " List of international circuits " that was formerly published.

2. Presentation

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

2.1 Abbreviated title of transit countries :

When indicating the name of the country (or countries) of transit, the full name is not given. A code indication is used (the code used for motorcars).

2.2 Order of circuits in the list :

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) automatic circuits (including semi-automatic) . . . . (Z)

b) manual circuits (no special indication)

c) voice-frequency telegraph circuits . . . . (T)

d) special circuits (service, etc.) . . . . (P)

Example: Düsseldorf-Rotterdam Z_1, Z_3 . . . . . . Z_{73}

Rotterdam-Düsseldorf Z_2, Z_4 . . . . . . Z_{82}

Düsseldorf-Rotterdam 1, 2	9
Düsseldorf-Rotterdam T_1, T_2	
Düsseldorf-Rotterdam P_1	

Automatic or semi-automatic circuits operated in reverse alphabetical order (Z_2, Z_4, 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.

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 is responsible, in agreement with other interested technical services. If the technical service responsible for a sub-control station considers it necessary to alter the testing days for an international link or circuit, it should ask the control station technical service to make the necessary arrangements.

CHAPTER IV

RECOMMENDATION M.16

IMPROVEMENT OF THE TRANSMISSION STABILITY OF INTERNATIONAL CIRCUITS

1. Basic factors for transmission stability

The basic factors for achieving a stable network are as follows :

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 circuit or a phototelegraph circuit.

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) *Careful organization of work in repeater stations*

The large number of sudden phase or attenuation variations caused by work done in the stations makes it desirable that work liable to cause considerable interference should be carried out, when possible, during times of light traffic and where necessary at night.

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.

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).

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 engine 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.

2. Action specially recommended by the C.C.I.T.T.

The C.C.I.T.T. strongly recommends that the following action should be taken to improve transmission stability :

RECOMMENDATION M.17

2.1 VIBRATION TESTING

Vibration tests, using the principles described in Supplement No. 7 (See Part III of this Book) should be made :

a) when new 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

2.2 AUTOMATIC REGULATION BY PILOTS

In carrier systems, the presence of *pilots* (line pilots, group pilots, supergroup pilots) 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 have 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 :

2.2.1 Regulation of supergroups

Supergroup links should normally have an automatic regulator at the receiving end. Automatic regulation of supergroups can be dispensed with only when the supergroups use only one regulated line section.

Complex supergroups may need to have regulators at one or more through-connection points in order to maintain the nominal level at those points. In particular, when the supergroup uses at least two regulated line sections within the territory of one country, an outgoing automatic regulator should be inserted on the supergroup at the through-connection point nearest to the frontier.

2.2.2 Group regulation

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

— when, after it has been ensured that no fault exists, the magnitude of the variations is such that the required stability cannot be obtained;

— when a group link comprises more than two group sections (connected in tandem by means of through group equipment).

When an international group 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 to regulation in this sense, 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

3. 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.53 for the regulated line section;

— in Recommendation M.56 for supergroup and group links;

— in Recommendation M.65 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

CHAPTER I

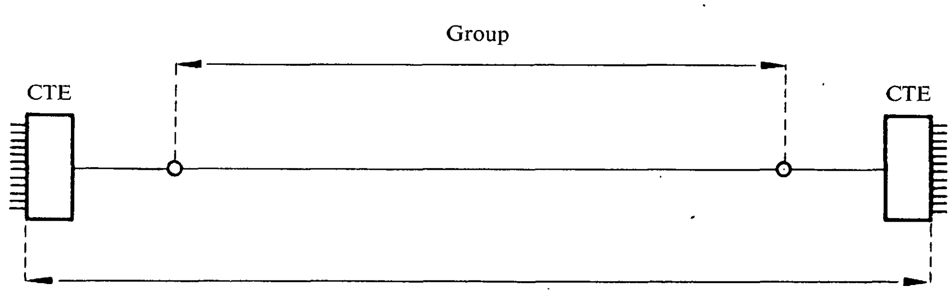
General

RECOMMENDATION M.30

1. DEFINITIONS CONCERNING INTERNATIONAL CARRIER SYSTEMS

In the maintenance of international carrier systems, the following definitions should be used :

1. *Group.* — In carrier systems, a set of a given number of telephone channels (normally 12), occupying adjacent frequency bands in a band of 48 kc/s. When there is no risk of ambiguity, the term " group " may apply equally to the corresponding number of channels in both directions of transmission. In practice, a 12-channel group consists of a group link terminating at each end in channel translating equipment.



CTE = Channel translating equipment

FIGURE 1

2. *Supergroup.* — In carrier systems, a set of 5 groups, occupying adjacent frequency bands in a 240 kc/s band. In practice, a supergroup consists of a supergroup link terminating at each end in group translating equipment.

3. *Mastergroup.* — In carrier systems, a set of 5 supergroups, occupying frequency bands separated by 8 kc/s in a 1232 kc/s band.

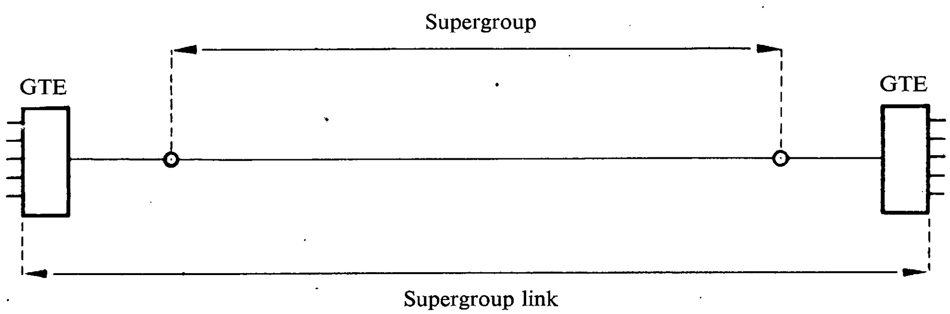
4. *Supermastergroup.* — In carrier systems, a set of three mastergroups separated by two free spaces of 88 kc/s and occupying a band whose total width is 3872 kc/s.

5. *Group link.* — The whole of the means of transmission, using a frequency band of specified width (48 kc/s) connecting two group distribution frames (or their equivalent). It extends from the point where the group is formed to the point where it is broken down. This expression is usually applied to the combination of GO and RETURN channels.

6. *Group section.* — Part of a " group link " between two adjacent group distribution frames (or the equivalent).

7. *Through group point.* — A " group link " is generally made up of several " group sections ", connected in tandem by means of " through group filters " at points called " through group points ".

8. *Supergroup link.* — The whole of the means of transmission using a frequency band of specified width (240 kc/s) connecting two supergroup distribution frames (or their equivalent). This extends from the point where the supergroup is assembled to the point where it is broken down. This expression is usually applied to the combination of GO and RETURN channels.



GTE = Group translating equipment

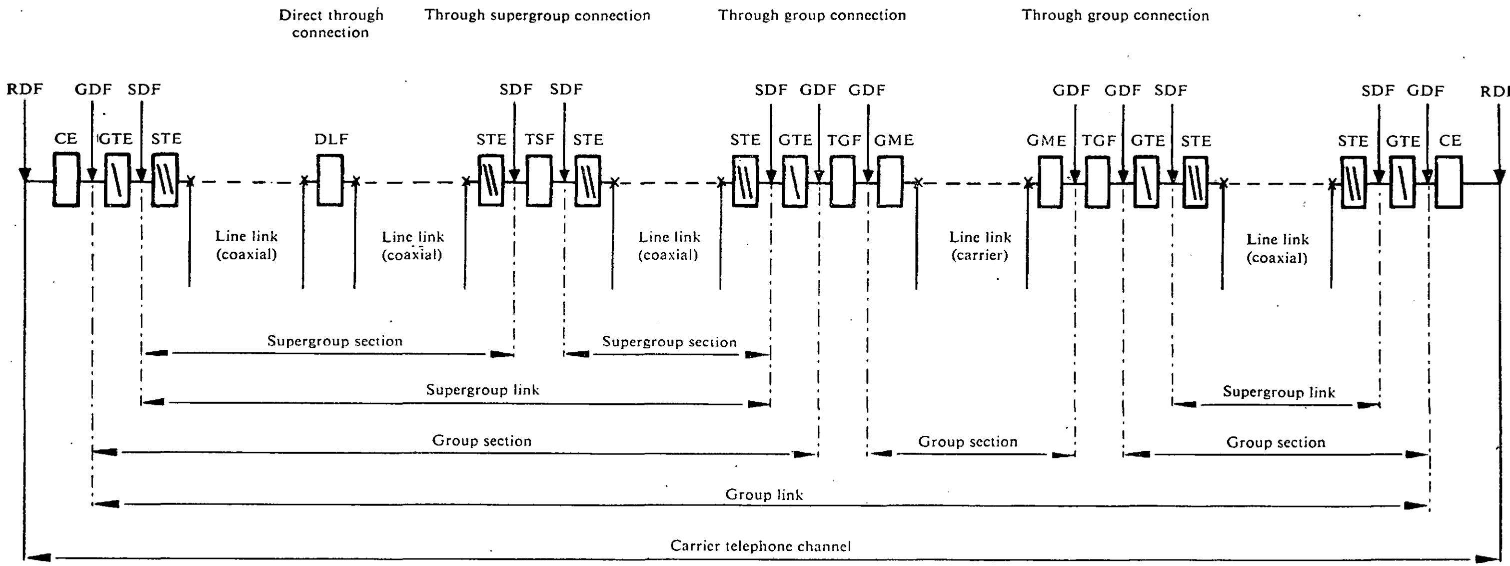
FIGURE 2

9. *Supergroup section.* — Part of a "supergroup link " between two adjacent supergroup distribution frames (or the equivalent).

10. *Through supergroup point.* — A " supergroup link " is generally made up of several " supergroup sections ", connected in tandem by means of " through supergroup filters " at points called " through supergroup points ".

11. *Mastergroup link.* — The whole of the means of transmission using a frequency band of specified width (1232 kc/s) connecting two mastergroup distribution frames (or their equivalent). It extends from the point where the mastergroup is assembled to the point where it is broken down. This term usually applies to the combination of GO and RETURN channels.

12 and 13. The concepts of *mastergroup section* and *through mastergroup point* are to be defined in a similar way to that for groups and supergroups.



CE — Channel translating equipment (translation of the audio band into the basic group and 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, and vice versa)
GME — Group modulating equipment
DLF — Direct through-connection filter
TSF — Through supergroup filter
TGF — Through group filter
RDF — Repeater distribution frame
GDF — Group distribution frame
SDF — Supergroup distribution frame

(This diagram shows only one direction of transmission)

FIGURE 3

14. *Line link.* — 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.

15. *Regulated line section.* — 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. This definition applies also to the case of a radio relay link.

Figure 3 represents a long carrier telephone channel set up on several tandem-connected carrier systems on symmetric pairs or coaxial cable. It gives an example of the use of the terms defined above for the component parts of a circuit of the group.

RECOMMENDATION M.31

2. REFERENCE MEASUREMENTS. MAINTENANCE MEASUREMENTS

The definitions given in Recommendation M.30 are taken into account in Chapters III and IV in describing measurements to be made on carrier and coaxial systems before putting them into service and for their routine maintenance, considering successively the following parts of the systems:

- radio relay regulated line sections,
- coaxial regulated line sections,
- symmetric pair regulated line sections,
- mastergroup links,
- supergroup links,
- group links,
- channels of the group.

For each of these parts, Chapter III describes the setting-up and reference measurements to be made before putting the system into service and Chapter IV describes the routine maintenance measurements.

Reference measurements chosen from among the " setting-up measurements " are detailed measurements (at a fairly large number of test frequencies) made at appropriate points at the time the line or link is set up. These reference measurements are intended to be used later for localizing a fault or for checking the line-up conditions of the line or link.

Maintenance measurements required for preventive routine maintenance proper can be made at fewer points and with fewer test frequencies.

The present part does not contain a chapter covering the localization of faults on carrier systems; for such localization it is sufficient to apply the general principles given in Recommendation M.12 and to use the reference measurements.

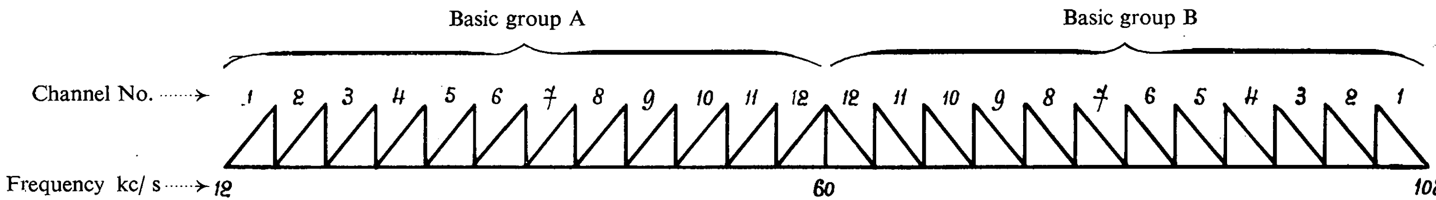


FIGURE 4

Numbering of channels in 12-circuit groups

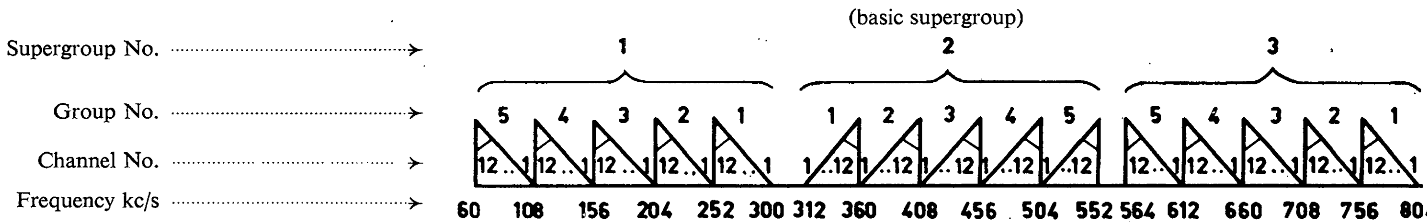


FIGURE 5

Numbering of 12-circuit groups and channels in supergroups

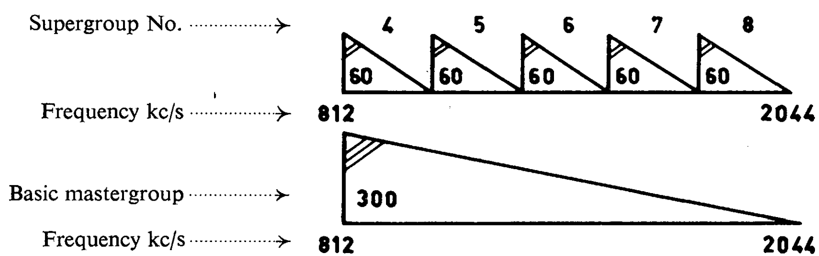


FIGURE 6

Numbering of supergroups within a mastergroup

CHAPTER II

Numbering of circuit groups and channels in a carrier system

RECOMMENDATION M.35

1. NUMBERING OF CHANNELS WITHIN A 12-CIRCUIT GROUP

The position occupied by a channel within a 12-circuit group is identified by a number from 1 to 12. The numbers of the different channels are taken in order of frequency:

— in ascending order when the group is " erect ", that is, having the audio-frequencies in *ascending* order in the different channels (as in basic group A),

— in descending order when the group is " inverted ", that is, having the audio-frequencies in *descending* order in the different channels (as in basic group B, and in groups C, D and E considered later).

The numbering is shown in Figure 4 on the opposite page.

RECOMMENDATION M.36

2. NUMBERING OF GROUPS WITHIN A SUPERGROUP

The position of a group within a supergroup is identified by a number from 1 to 5. These numbers are taken in frequency order:

— in ascending order when the groups are " erect " groups (as in the groups of the basic supergroup 312-552 kc/s),

— in descending order when the groups are " inverted " groups (as for groups within the other supergroups).

The numbering is shown in Figure 5 on the opposite page.

RECOMMENDATION M.37

3. NUMBERING OF SUPERGROUPS WITHIN A MASTERGROUP

The position of a supergroup within a mastergroup is identified by a number 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 Mc/s coaxial system.

The numbering is shown in Figure 6 on the opposite page.

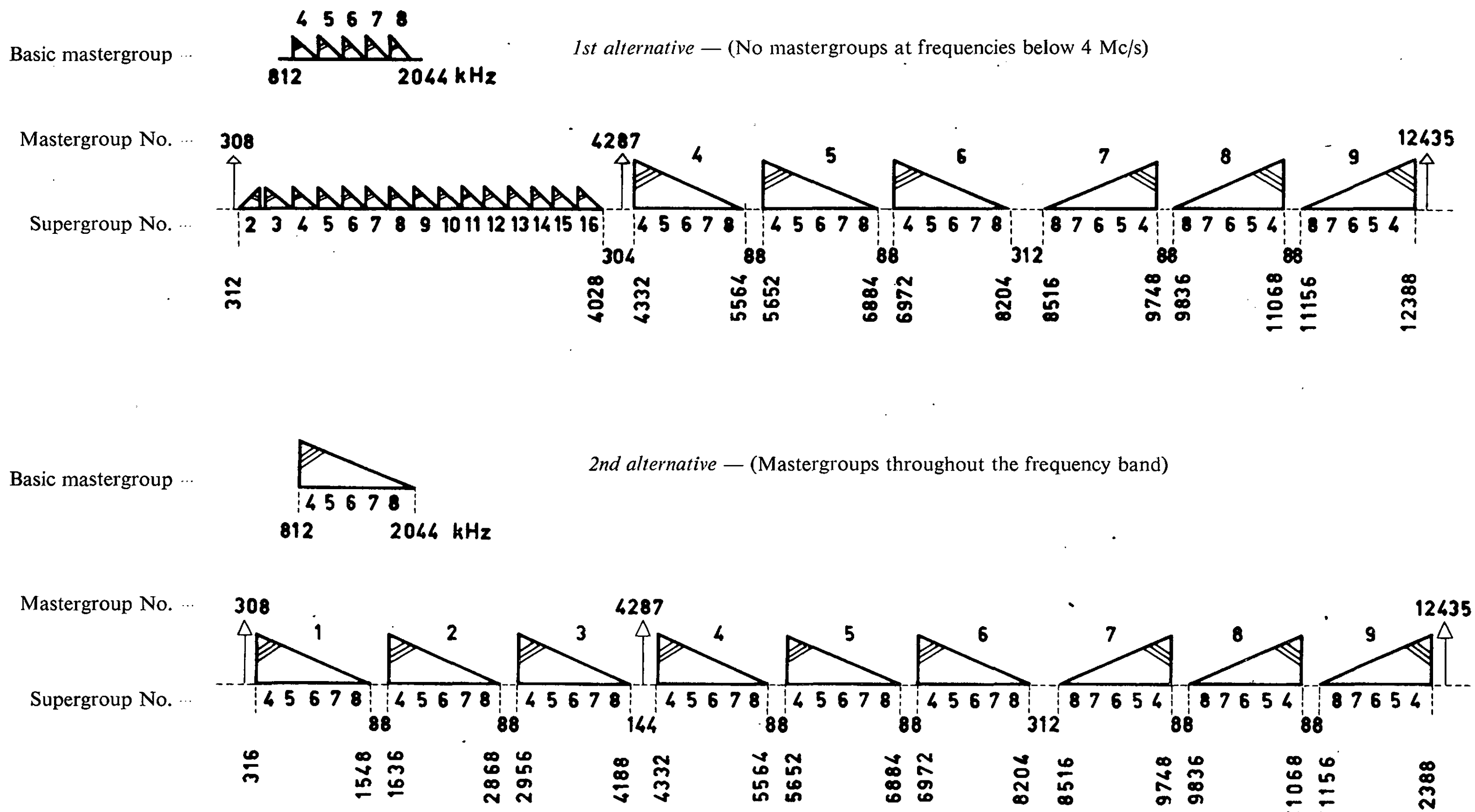


FIGURE 7

Numbering of supergroups and mastergroups in 12 Mc/s coaxial systems

RECOMMENDATION M.38

4. COAXIAL SYSTEMS

a) *Numbering of a mastergroup.* — The different 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 Figure 7.

b) *Numbering of a supergroup.* — The different supergroups of the standard 4 Mc/s coaxial system are identified by numbers giving their respective position in the frequency spectrum transmitted on the line. The numbering is shown in Figure 8.

The position of a supergroup which is part of a mastergroup in a 12 Mc/s system is designated by the number of that mastergroup, followed by the number of the supergroup within that mastergroup.

c) *Numbering of a 12-circuit group.* — The position of a circuit group is designated by the number of the supergroup in which it is placed, followed by the number of the 12-circuit group within that supergroup.

d) *Numbering of a channel.* — The position occupied by a channel in a coaxial system is designated by three figures (e.g. 3-4-11) : the first indicates the number of the supergroup, the second the number of the 12-circuit group and the third the number of the channel.

If the carrier system includes mastergroups, the place occupied by the telephone channel is designated by four numbers (e.g. 4-5-4-11), the first number indicating the mastergroup number, the second the supergroup number, etc.

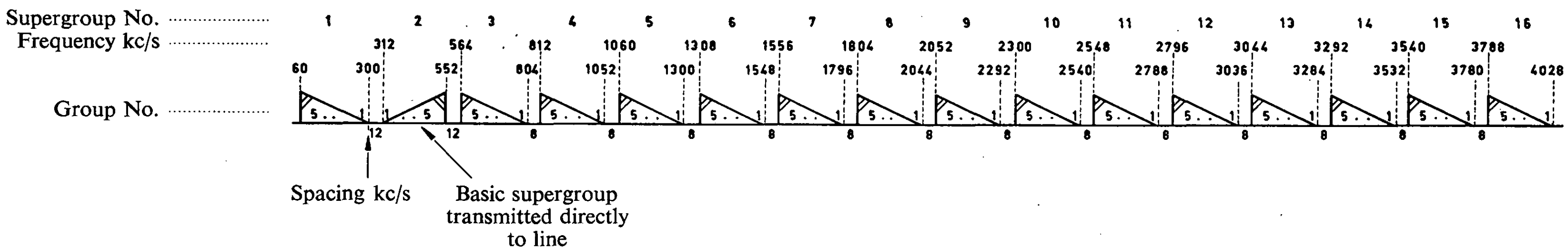


FIGURE 8

Numbering of supergroups and 12-circuit groups in the standard 4 Mc/s coaxial system

RECOMMENDATION M.39

5. SYSTEMS ON SYMMETRIC PAIR CABLE

(This text applies only to systems using a pair for each direction of transmission. In systems of the n + n type, 12 go and 12 return channels constitute one 12-circuit group).

There are two cases to distinguish :

1) where one of the groups is a basic group A as defined by the C.C.I.T.T.;
2) where the groups transmitted on the line are all in the same sense (there is no basic group A).

The first case is normal for systems providing less than 5 groups.

The second case is the normal one for 5 group systems.

The rules outlined below apply to systems with 5 groups or less. They apply also to 2 supergroup systems on symmetric pair cables.

5.1 Systems where there is a basic group A

Where there is more than one group, the basic group A is inverted in relation to all the others.

a) Designation of groups

The following indications are used to define the position of the group on the line, as shown in Figure 9 :

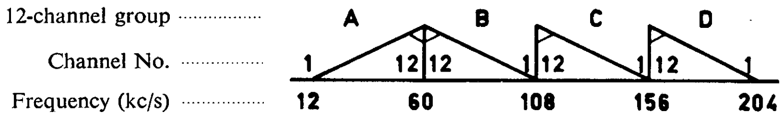
A : 12-60 kc/s group
B : 60-108 kc/s group
C : 108-156 kc/s group
D : 156-204 kc/s group
E : 204-252 kc/s group

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

b) Designation of channels

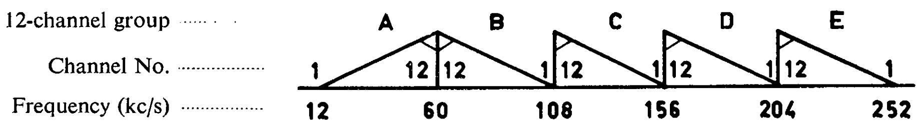
The position occupied by a telephone channel of a carrier system is designated by means of a letter giving the position of the group (transmitted on the line) containing the channel and by means of the number of the channel within this group.

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.)



Scheme No. 1

(recommended by the C.C.I.T.T. for systems with 1,2 , 3 or 4 groups)

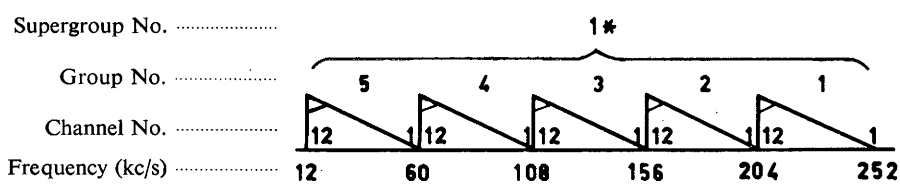


Scheme No. 2 *bis*

(may be used by agreement between Administrations for systems with 5 groups as an alternative to scheme No. 2 of Figure 10)

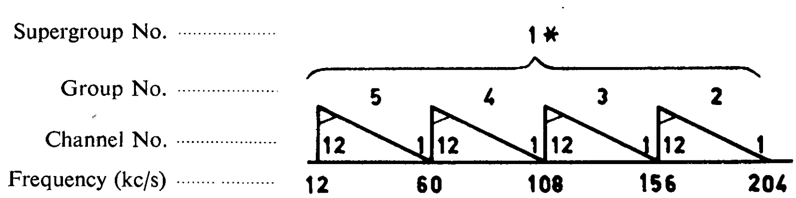
FIGURE 9

Numbering of 12-channel groups and channels of carrier systems on symmetric pair cable where there is a basic group A.



Scheme No. 2

(recommended by the C.C.I.T.T. for systems with 5 groups)



Scheme No. 1 *bis*

(may be used by agreement between Administrations for systems with four 12-channel groups, as an alternative to scheme No. 1 of Figure 9)

FIGURE 10

Numbering of 12-channel groups and channels of carrier systems on symmetric cable pair (without a basic group A), where all groups are assembled in the same sense.

5.2 Systems without basic group A

In this case, all the groups are in the same sense. For systems with 5 groups on symmetric pair cable, this is the normal arrangement which is as shown in Scheme 2 of Figure 10.

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 kc/s towards the lower frequencies of supergroup 1 of a 4 Mc/s 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).

c) The case of systems with 4 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 No. 1 *bis* of Figure 10).

RECOMMENDATION M.40

6. RADIO RELAY OR OPEN-WIRE LINE SYSTEMS

When a radio link using frequency division multiplex has to be connected to the international carrier and coaxial cable network, the system of designation and numbering to be used should be the same as that for the corresponding cable.

The same arrangements should be used for carrier systems on open-wire lines providing at least 12 telephone channels.

CHAPTER III

Carrier and coaxial systems. Bringing into service. Reference measurements

RECOMMENDATION M.45

1. BRINGING A NEW INTERNATIONAL CARRIER OR COAXIAL 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 or coaxial 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.

The technical services of each Administration are responsible for arranging for setting up the line sections on their own territory and must make the adjustments and tests required (for example non-linearity distortion measurements, etc.).

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 or, 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 should be settled by bilateral agreement between Administrations :

— arrangement of radio channels (middle frequency, upper or lower channel frequencies, polarization);

— line regulating pilots;

— continuity pilots;

— channels outside the radio channel, for noise measurement;

— service channel; etc.

b) Coaxial line section

Details of the following points should be settled by bilateral agreement between Administrations :

— for 12 Mc/s lines, 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 *;

— service, supervisory and remote control circuits;

— 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 setting-up tests, the relative power level measured at the output of the frontier repeater should not differ, for any frequency, by more than $\pm$ 0.2 nepers or $\pm$ 2 decibels 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 setting 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 should be fixed by bilateral agreement between the Administrations :

— frequency allocation,

— pilots,

— service, supervisory or remote control lines, etc.

* See at the beginning of Volume III of the *Red Book*, the Table indicating the pilot frequencies for coaxial systems.

When a symmetric-pair line section crossing a frontier 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 :

4 kc/s between 12 and 60 kc/s
8 kc/s between 60 and 108 kc/s
12 kc/s between 108 and 252 kc/s

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

Level measurements at the frequencies selected will be made at the output of each line amplifier by the frontier stations. The value obtained at each frequency should normally be + 0.5 neper or + 4.5 decibels for systems with 1, 2 or 3 groups, and + 0.2 neper or + 1.75 decibel for systems having 4 or 5 groups (except in cases where special cables, such as submarine cables, are involved or where a special equalization method is employed, e.g. systematic equalization). The relative power level in these tests should never differ by more than ± 0.2 neper or ± 2 decibels from the nominal value mentioned above.

3) Overall reference measurements for the entire 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 or coaxial system, excluding the terminal equipment. These measurements are made at the following frequencies :

a) Coaxial line

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

For a 2.6 Mc/s system

60, 308, 556, 808, 1056, 1304, 1552, 1800, 2048, 2296, 2604 kc/s

For a 4 Mc/s system

60, 308, 556, 808, 1056, 1304, 1552, 1800, 2048, 2296, 2544, 2792, 3040, 3288, 3536, 3784, 4092 kc/s

* See at the beginning of Volume III of the *Red Book*, the Table of line pilot levels and frequencies for the various symmetric-pair carrier systems.

For a 12 Mc/s system

1. At frequencies below 4 Mc/s

   a) If frequency allocation without mastergroups is used :

   308, *560*, *808*, 1056, *1304*, 1552, *1800*, 2048, *2296*, 2544, *2792*, 3040, 3288, *3536* and 3784 kc/s (the frequencies in italics are those at which the measurements must *always* be made);

   b) If frequency allocation with mastergroups is used :

   308, 560, 808, 1304, 1592 and 2912 kc/s;

2. At frequencies above 4 Mc/s

   4287, 5608, 6928, 8248 *, 8472, 9792, 11 112 and 12 435 kc/s.

b) *Symmetric-pair line*

Frequency of the line pilot or pilots and frequencies showing the insertion loss/frequency characteristic of the line (e.g. frequencies spaced at

4 kc/s between 12 and 60 kc/s
8 kc/s between 60 and 108 kc/s
12 kc/s between 108 and 252 kc/s).

Level measurements at the frequencies selected will be made at the output of each line amplifier at all frontier stations, whether attended or not. 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.

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 line-up record) and II (symmetric-pair line-up record) below.

* The frequency 8248 kc/s will perhaps be used for other purposes, such as radio-relay systems. This problem is being studied.

APPENDIX I

LINE-UP RECORD FOR A COAXIAL LINE

Technical Service of :	France
Designation of link :	Bern-Besançon
Date of measurements :	15 April 1953
Control station :	Besançon
Sub-control station :	Bern
Resistance of conductors used for temperature reference :	(Neuchâtel-Morteau : 1632 ohms)
Issue :	5 May 1953

Distance between stations (km)	Station	Relative level * at frequencies (kc/s)																		Equalizers		Remarks *
		60	*308*	556	808	1056	1304	1552	1800	2048	2296	2544	2792	3040	3288	3536	3784	4032	*4092*	CT	dN	
		Direction of transmission : Bern — Besançon																				
44.9	Bern [1]	—5.75	—5.45	—5.20	—5.03	—4.86	—4.71	—4.57	—4.45	—4.33	-4.22	—4.15	—4.04	—3.97	—3.87	—3.82	—3.75	—3.70	—3.68	—	—	Nt
16.0	Neuchâtel [2]	—4.70	—4.70	—4.62	—4.58	—4.61	—4.68	—4.66	—4.61	—4.60	-4.60	—4.64	—4.64	—4.66	—4.67	—4.64	—4.62	—4.66	—4.65	2	1	Np
7.25	La Baume [1]	—5.90	—5.52	—5.28	—4.98	—4.85	—4.78	—4.62	—4.44	—4.30	-4.20	—4.12	—4.05	—4.00	—3.91	—3.83	—3.73	—3.73	—3.72	1	2	Nt
8.6	Villers-le-Lac [3]	—3.95	—3.87	—3.70	—3.63	—3.52	—3.56	—3.50	—3.38	—3.34	-3.36	—3.34	—3.32	—3.30	—3.28	—3.26	—3.25	—3.26	—3.28	1	2	Nt
60.5	Morteau [2]	—4.54	—4.57	—4.55	—4.55	—4.56	—4.58	—4.57	—4.58	—4.60	-4.58	—4.61	—4.62	—4.62	—4.57	—4.55	—4.60	—4.64	—4.62	1	1	Np
	Besançon [2]	—4.61	—4.64	—4.50	—4.53	—4.52	—4.60	—4.55	—4.50	—4.52	-4.53	—4.57	—4.56	—4.54	—4.50	—4.46	—4.53	—4.58	—4.63	4	1	Np
		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	-3.61	—3.56	—3.52	—3.49	—3.48	—3.47	—3.47	—3.46	—3.45	—	—	Nt
60.5	Morteau [2]	—4.60	—4.59	—4.58	—4.59	—4.58	—4.59	—4.56	—4.55	—4.56	-4.57	—4.57	—4.57	—4.56	—4.56	—4.56	—4.55	—4.57	—4.59	4	2	Np
8.6	Villers-le-Lac [3]	—3.80	—3.67	—3.65	—3.64	—3.63	—3.61	—3.55	—3.55	—3.54	-3.54	—3.53	—3.49	—3.44	—3.39	—3.36	—3.35	—3.33	—3.35	1	2	Nt
7.25	La Baume [1]	—5.85	—5.50	—5.28	—5.00	—4.82	—4.73	—4.62	—4.45	—4.33	-4.21	—4.12	—4.04	—3.97	—3.88	—3.81	—3.73	—3.73	—3.70	1	1	Nt
16.0	Neuchâtel [2]	—4.62	—4.59	—4.61	—4.57	—4.56	—4.63	—4.60	—4.58	—4.56	-4.59	—4.57	—4.56	—4.54	—4.53	—4.53	—4.51	—4.55	—4.56	1	2	Np
44.9	Bern [2]	—4.63	—4.60	—4.64	—4.64	—4.59	—4.70	—4.66	—4.68	—4.62	-4.66	—4.70	—4.68	—4.63	—4.60	—4.58	—4.57	—4.59	—4.63	2	0	Np

* 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)

[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 Np, giving −4.60 N for additional measuring frequencies.

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

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APPENDIX II

LINE-UP RECORD FOR CARRIER LINE (SYMMETRIC PAIR)

Technical Service of : Netherlands
Designation of link : Antwerp-Rotterdam
Date of measurements : 10-10-1959
Control station : Rotterdam
Sub-control station : Antwerp
Issue : 22-3-1960

	Direction B — NL				Direction NL — B			
Distance (in km)	15.8	17.7	72.4		72.4	17.7	15.8	
Test frequencies kc/s	Antwerp	Bras-schaat	Zundert	Rotter-dam	Rotter-dam	Zundert	Bras-schaat	Antwerp
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	sending station	1.75	1.75	1.75	sending station	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		1.75	1.80	1.85		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 kc/s line pilot . . .	-13.2	-13.1	-13.1	-13.2	-13.2	-13.2	-13.3	-13.1
Addit. measuring frequencies *	—	—	—	—	—	—	—	—
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 **	db	db	db	db	db	db	db	db

* Indicate frequencies of these pilots.

** The appropriate indication to be given in the " Remarks " column for each station using the following abbreviations :

N = nepers

db = decibels

t = " niveau relatif de tension " or 600-ohm through level, when 0.775 volt is applied to the (two-wire) sending end.

p = relative power level (dbr)

RECOMMENDATION M.46

2. BRINGING INTERNATIONAL 12-CIRCUIT GROUP, SUPERGROUP AND MASTERGROUP 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. As a rule, there will be only one sub-control station for each country concerned.

The technical services indicate the routing to be used and, in the case of group or supergroup links, 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 12-circuit group link on two supergroup links. (Where this is impossible, the *supergroup* pilot should be blocked at the through group point.)

The information will be entered on a " routing form " * 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).

The overall routing form for the entire circuit is drawn up by the control station on the basis of information furnished by each sub-control station for the national section 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 the sub-control stations (one copy for the technical services and one for the sub-control station).

* See specimens in Appendix III (supergroup link routing form) and Appendix IV (group link routing form).

APPENDIX III

ROUTING FORM FOR A SUPERGROUP LINK

Technical Service of : United Kingdom
Supergroup links : Bruxelles-London 6001
Supergroup length : 385 km
Control station for supergroup : London
Sub-control stations for supergroup : Canterbury, Bruxelles
Date of issue : 1/12/59

Stations *	Distance (in km)	Sections in cable					Sections on radio links		Nominal levels at through supergroup points ***		Remarks ** ***
		Designation of cable	Carrier sections (symmetrical pairs)		Coaxial sections		Designation of radio link	Position of supergroup			
			Pair number	Position of supergroup	Number of coaxial system	Position of supergroup			A-B (db)	B-A (db)	
London (A)											
	123	L-XM No. 4			A	4					
Canterbury									–30	–35	Submarine cable
	140	CU - OS			A	1					CU - OS 60-300 kc/s
Ostende									–30	–35	OS - CU 924-1164 kc
	24	No. 1									
Bruges											
	45	No. 3	11						—	—	60 ch. carrier
Gent											
	53	No. 3	11						—	—	60 ch. carrier
Bruxelles											

* Underline through supergroup points.

** 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.

*** The appropriate indication to be given in the " Remarks " column for each station using the following abbreviations :

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

APPENDIX IV

ROUTING FORM FOR A GROUP LINK

Technical Service of : United Kingdom
Group link : London-Rotterdam 903
Group length : 475 km
Control station for group : London
Sub-control stations for group : Bourne Hill, Aldeburgh, Domburg, Rotterdam
Issue dated : 1/12/59

Stations *	Distance (in km)	Designation of cables	Group section ** Pair numbers	Group section ** Position of group (A, B, C, D, E)	Supergroup sections *** Supergroup number	Supergroup sections *** Position of the supergroup, followed by the position of the group in the supergroup	Nominal levels at through group points * A-B (db)	Nominal levels at through group points * B-A (db)	Remarks **** +)
London (A)									24 circuits
	115	1 and 2	15	B					
Bourne Hill									12 circuits
	45	3 and 4	3	A					
Aldeburgh							–37	–8	Submarine cable ADB-DBG
	153				1	3			120-168 kc/s DBG-ADB
Domburg							–37	–8	408-456 kc/s
	38	5	7	B					48 circuits
Goes									
	53	1	9	B					48 circuits
Roosendaal									
	25	1	9	B					48 circuits
Breda									
	46	4	9	B					48 circuits
Rotterdam									48 circuits

* Underline the through group points.

** Sections in cable, open wire or radio link not providing a supergroup.

*** Sections in cable or radio links with at least one supergroup.

**** 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.

+) The appropriate indication to be given in the " Remarks " column for each station using the following abbreviations :

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

2) Setting up the link

2.1) Once the route has been agreed, the 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 group, supergroup and mastergroup section making up the link, should make setting-up tests and check the equipment to be used, such as the through group and supergroup filters, etc. The check should include a general inspection by means of vibration tests if the equipment has remained unused for some time since acceptance tests were carried out after installation.

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

mastergroup link: 814, 1056, 1304, 1550, 1800 and 2042 kc/s;

supergroup link: 313, 317, 333, 381, 411, 429, 477, 525, 545 and 549 kc/s;

group link: frequencies spaced at 4 kc/s in the group frequency band, to be determined by agreement between Administrations.*

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 ascertains that the measured values are satisfactory.

When each country has set up the national part within its territory, each international group section is set up by the stations at the ends of this section in the two countries concerned (which are the group, supergroup, or mastergroup transfer stations closest to the frontier). These national and international sections are interconnected and the sub-control stations inform the control station.

2.3) Before beginning the initial line-up of the circuit 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 transmission.

2.4) The group, supergroup, or mastergroup sections are inter-connected by through group, through supergroup, or through mastergroup filters, as may be appropriate, and the pilot is applied at the beginning of the link under ordinary working conditions, with especial care being taken to see that it is at its nominal level ** (see Table 1).

* If the channel-modulating equipment at the sending end of the group connection is used to generate the group measuring frequencies by applying a frequency of 800 c/s to the input of such 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.

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

For a group or supergroup:
Supergroup: 411 kc/s
Group: 84 kc/s (or 36 kc/s).

The level of this test signal will be 0 dbm0 (test level used for a telephone channel).

TABLE 1

Frequencies and levels of group, supergroup, and mastergroup pilots

Group, supergroup, and mastergroup pilots for	Frequency (in kc/s)	Absolute power at a zero relative level point
Basic group A	35.860 35.920	— 25 dbm or — 2.9 N — 20 dbm or — 2.3 N
Basic group B	84.080 84.140	— 20 dbm or — 2.3 N — 25 dbm or — 2.9 N
Basic supergroup	411.860 411.920	— 25 dbm or — 2.9 N — 20 dbm or — 2.3 N
Basic mastergroup	1552	— 20 dbm or — 2.3 N

Note: To avoid errors in interpreting test results, the results will be stated in terms of the departure from the nominal pilot level in dbm at that particular point.

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 need be transmitted.

Tolerances for transmitted pilots

At the point where a pilot is injected, its level should be adjusted as closely as possible to its nominal value. Its level should never differ by more than ± 0.5 decibel or 5 centinepers from its nominal value.* This tolerance which is the sum of:

— the initial line-up tolerance, and
— permissible variations with time

applies to group pilots (84.080 and 84.140 kc/s), supergroup pilots (411.860 and 411.920 kc/s) and the mastergroup pilot (1552 kc/s). The pilot source should be monitored and an alarm given when the level deviates by more than ± 0.5 db or 5 cN from nominal.

The permissible frequency tolerances for transmitted pilots are as follows:

84.080 kc/s and 411.920 kc/s pilots = ± 1 c/s
84.140 kc/s and 411.860 kc/s pilots = ± 3 c/s
1552 kc/s pilot = ±2 c/s.

* This value is now being studied by the C.C.I.T.T. (Question 19/XV).

The level of this 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 planned 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 the exact location of a fault within the national territory.

The measuring points must be those at which routine maintenance measurements or reference measurements will be made later (for rapid checks in tracing 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.

2.5) The frequencies shown in paragraph 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 attenuation frequency characteristic of the link (maximum spread between the two horizontals at the limits of the attenuation-frequency characteristic) should not exceed :

— for a mastergroup : * —
— for a supergroup : 4 decibels or 0.4 neper
— for a group : 3 decibels or 0.35 neper.

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

3) **Reference measurements for a link**

The measurements described above 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 ** summarizing all these data and sends it to the technical

* Experience of mastergroup working does not as yet make it possible to fix a limit for the mastergroup.

** For example, see Appendix VI (supergroup link line-up record) and Appendix V (group link line-up record).

services in the other countries. These latter compare the data shown in the reference sheet with those obtained in their own stations. Should they find a discrepancy, they inform the technical service responsible for the control station.

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.

5) Setting up group sections after line-up of the supergroup link

Once the link has been lined up, each end of it is connected to the group translating equipment, and the group sections are then set up.

a) Preliminary test : before connecting the group translating equipment to the ends of the supergroup link, the equipment must be checked and adjusted to ensure that it meets C.C.I.T.T. Recommendations.

b) Setting up group sections : to adjust the 5 group sections of the supergroup, an 84 kc/s test signal is sent successively over each group with a power of 1 mW at a point of zero relative level. The group translating equipment is adjusted at the sending end in such a way that the level of each group at the output of the equipment is as close as possible to its nominal value. At the receiving end, the group translating equipment is adjusted in such a way that the output level in each group is as close as possible to its nominal value.

APPENDIX V

LINE-UP RECORD FOR A GROUP LINK

Technical Service of :	United Kingdom
Group link :	London-Rotterdam 903
Group link length :	475 km
Direction :	London-Rotterdam
Date of measurements :	14 January 1960
Control station :	London
Sub-control stations :	Bourne Hill, Aldeburgh, Domburg, Rotterdam
Issue dated :	1 February 1960

Distance (in km)	Stations	Relative levels ****											
		Test frequencies in kc/s (4 kc/s 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
115	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

Frequency of group reference pilot in kc/s: 84.080 kc/s.
Absolute power level dbm (referred to 1 mW) of group reference pilot at a point of zero relative level —20 db.

* Show in these columns the differences relative to the nominal values.
** State if the equipment is selective or not.
*** Indicate the presence of group automatic gain control.
**** The appropriate indication to be given in the " Remarks " column for each station, using the following abbreviations:

N = nepers
db = decibels
t = " niveau absolu de puissance " or 600-ohm through level when 0.775 volt is applied to the (two-wire) sending end.
p = relative power level (dbr)

LINE-UP RECORD FOR A GROUP LINK

(Continued)

Pilot A *	Measuring point	Measuring equipment **	Nominal relative level at measuring point ****	Impedance at measuring point	Remarks *** ****
+0.6	G.D.F.	Non-select.	— 37 db	75 ohms	db
— 0.2	G.D.F.	Non-select.	— 37 db	75 ohms	db
— 0.4	G.D.F.	Non-select.	— 37 db	75 ohms	db
+ 0.6	G.D.F.	Non-select.	— 8 db	75 ohms	db

APPENDIX VI

LINE-UP RECORD FOR A SUPERGROUP LINK

Technical Service of :	United Kingdom
Supergroup link :	Bruxelles-London 6001
Supergroup link length :	385 km
Direction :	London-Bruxelles
Date of measurements :	15 June 1958
Control station :	London
Sub-control stations :	Canterbury, Ostende, Bruxelles
Issue dated :	24 June 1958

Distance (in km)	Stations	Relative levels **** Test frequencies kc/s 313	317	333	381	429	477	525	545	549	Pilot A *	Pilot B *	Measuring point	Measuring equipment **	Nominal relative level at measuring point ****	Impedance at measuring point	Remarks *** ****
	London	0	0	0	0	0	0	0	0	0	0		S.D.F.				
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 ohms	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 ohms	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	75 ohms	db

Frequency (kc/s) of supergroup reference pilot : 411.920 kc/s.
Absolute power level dbm (referred to 1 mW) of supergroup reference pilot at a zero relative level point : –20 db.

* Show in these columns the differences relative to the nominal values.

** State if the equipment is selective or not.

*** Indicate the presence of supergroup automatic gain control.

**** The appropriate indication to be given in the " Remarks " column for each station, using the following abbreviations:

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

RECOMMENDATION M.47

3. SETTING UP CHANNELS

1) Preliminary checks

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.

A) *Carrier leak transmitted to line*

The absolute power level (decibels referred to 1 mW) at the output of the terminal equipment should be less than the following values :

Channel carrier leak per channel:

−2.0 nepers or −17 decibels (values referred to zero relative level point).

Total of channel carrier leaks per group :

−1.7 nepers or −14.5 decibels (values referred to zero relative level point).

B) *Variations with frequency of the transmitting terminal equipment output power level:*

In this graph, which applies to each channel of the system at the output of the terminal equipment :

— *N* is the relative power level measured at a frequency produced by an audio frequency of 800 c/s 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.

C) *Crosstalk*

The crosstalk ratio (intelligible crosstalk only) measured between two carrier channels in the same group, must not be less than 7.5 nepers or 65 decibels.

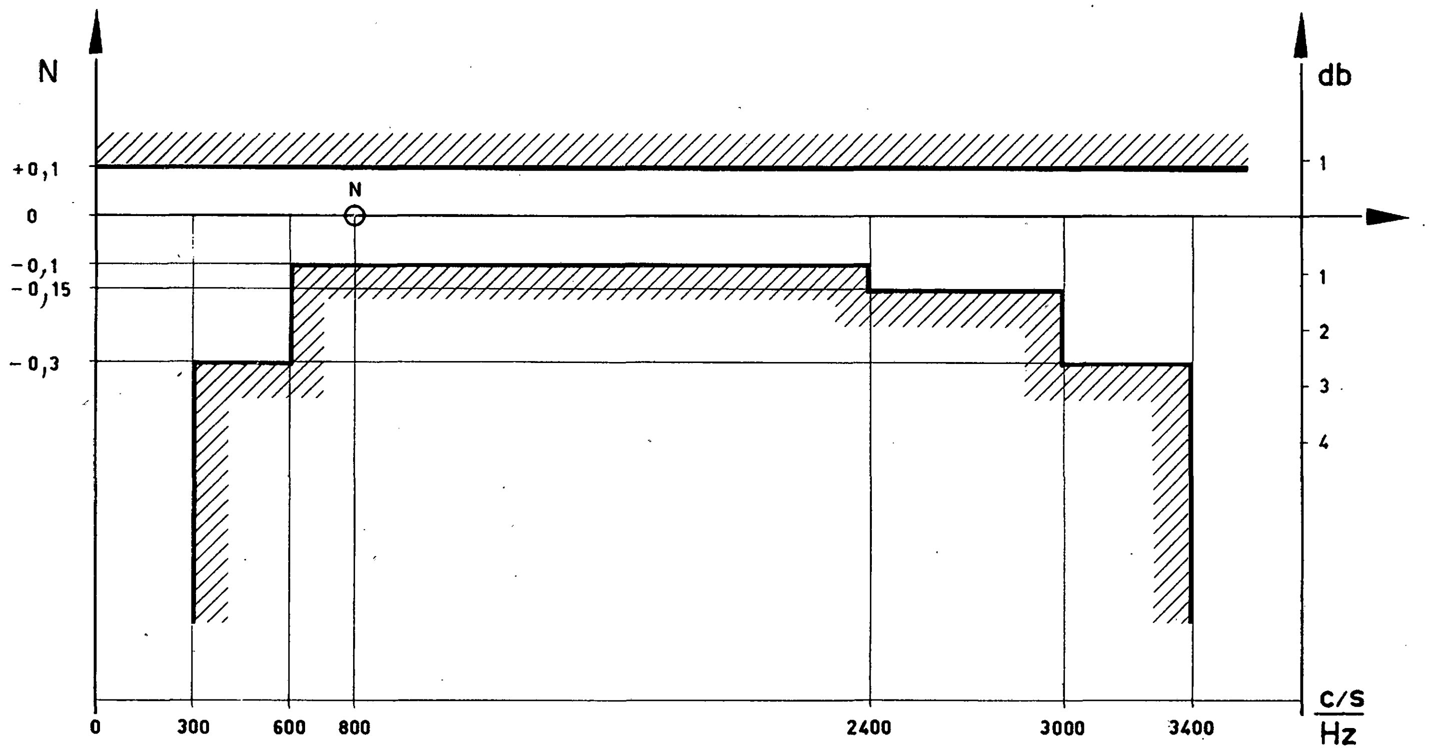
To ensure that there is no interference between pilot signals on different links, a check should be made during these tests to see that on each channel the attenuation through the demodulator and modulator at frequencies corresponding to 3860 c/s and 3920 c/s is at least 4.6 nepers or 40 decibels.

2) Setting up channels. Measurement of levels

The procedure is as follows :

Once the group link has been set up, the channel translating equipment at each end of the group link is connected and the channels are then adjusted.

For this, an 800 c/s test signal is sent over each channel in turn, at a power of one milliwatt at a zero relative point. At the transmitting end, the channel translating equip-



Corresponding audio frequency in c/s

FIGURE 11

Variation of the relative power level in nepers at the output of the terminal equipment of a carrier channel ment is adjusted so that the side-band 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 the following frequencies :

300, 400, 600, 800, 1400, 2000, 2400, 3000, 3400 c/s.

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. on page 262). In the absence of a psophometer, an unweighted noise measuring set will be used. A listening test should also be made.

It is recommended that, so far as possible, Administrations should use Channels 1 and 12 of a group only to set up telephone circuits terminating at the same points as the group concerned.

CHAPTER IV

Routine maintenance of an international carrier system
Routine measurements to be made on regulated line sections

RECOMMENDATION M.50

1. RADIO RELAY REGULATED LINE SECTION

In the regulated line section terminal stations, there should be :

1) daily reading of the line pilot level, preferably always at the same time of day;

2) regular readjustment to the nominal value as described in Recommendation M.53.

RECOMMENDATION M.51

2. COAXIAL REGULATED LINE SECTION

a) In the regulated line section terminal stations there should be :

1) *daily* reading of the line pilot level, preferably always at the same time of day;
2) regular readjustment to the nominal value as described in Recommendation M.53;
3) *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.

b) In attended frontier stations :

1) as in 1) above;
2) as in 2) above;

c) In attended stations (including the terminal stations of the regulated line section), there should be :

1) *daily* reading of the line pilot level (in manually regulated sections);
2) *monthly* measurement at the additional measuring frequencies and of the two line pilots (manually or automatically regulated sections).

The Administrations concerned are left to decide for themselves about the measurement at these additional measuring frequencies in unattended stations and about checking the operation of the regulators.

Note

Precautions to be taken with additional measuring 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.

RECOMMENDATION M.52

3. SYMMETRIC PAIR REGULATED LINE SECTION

a) In the regulated line section terminal stations, there should be :

1) daily reading of the line pilot levels, preferably always at the same time of day;

2) regular readjustment to the nominal value as described in Recommendation M.53;
3) in certain circumstances, measurement at the additional measuring frequencies by agreement between the Administrations concerned.

b) In attended frontier stations :

1) as in *a)* 1 above;
2) as in *a)* 2 above.

c) In attended stations (including terminal stations), *there should be :*

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.

d) In unattended stations :

Administrations are left to decide on such measurements as they think fit.

RECOMMENDATION M.53

4. READJUSTMENT TO THE NOMINAL VALUE OF A REGULATED LINE SECTION

(on coaxial cable or symmetric pair cables)

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 variations. 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 0.03 N or 0.3 db can be obtained;

b) in the case of a system with step by step gain control, the permissible tolerance might be ± (one half the gain control step + 0.03 N or 0.3 db).

Number of Group, Supergroup or Cable	CN	DAILY MEASUREMENT OF GROUP AND SUPERGROUP PILOTS Name of station:
308 kc/s receive Cable	+ 20 + 10 0 — 10 — 20	
4092 kc/s or Supergroup receive	+ 20 + 10 0 — 10 — 20	
Group or Supergroup send	+ 20 + 10 0 — 10 — 20	
Group or Supergroup send	+ 20 + 10 0 — 10 — 20	
Group or Supergroup send	+ 20 + 10 0 — 10 — 20	
Group or Supergroup send	+ 20 + 10 0 — 10 — 20	
Group or Supergroup send	+ 20 + 10 0 — 10 — 20	
Group or Supergroup receive	+ 20 + 10 0 — 10 — 20	
Group or Supergroup receive	+ 20 + 10 0 — 10 — 20	
Group or Supergroup receive	+ 20 + 10 0 — 10 — 20	
Group or Supergroup receive	+ 20 + 10 0 — 10 — 20	
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

FIGURE 12

Routine measurements

RECOMMENDATION M.55

5. GROUP, SUPERGROUP OR MASTERGROUP LINKS

a) Links with a pilot

At incoming terminal stations, sub-control stations and through-connection stations, a daily reading should be made of the pilot level, preferably at the same time each day.

Note : Where an automatic regulator is fitted, both the input level to the regulator and the setting of the regulator should be recorded.

Records of the daily measurements of the reference pilot levels should be maintained at each control, sub-control and through-connection station, preferably on a suitable form designed for the purpose. Figure 12* is an example of a form suitable for these records. The records will be used to study the performance of the supergroup and group links and in determining the readjustments to be made. The conditions for regular readjustment to the nominal value are described in Recommendation M.56.

b) Group links without a line pilot

A monthly measurement should be made using an 800 c/s signal at 0 dbm0 on 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.

A weekly measurement might be made, by agreement between the Administrations or private operating Agencies concerned, because of the length and complexity of certain group links.

Note : For the maintenance of groups not yet equipped with a pilot, it would be as well if Administrations did not use Channel 6 of the group except for a circuit ending at the same points as the group in question.

c) Supergroup links without a pilot

The maintenance of these circuits is left to the Administrations or private operating Agencies concerned.

d) Checking through-connection equipment on group, supergroup, or mastergroup links

Through group, supergroup and mastergroup filters are checked by local tests, so that the circuit can remain in service if the through-group equipment is replaced by reserve equipment.

* See previous page.

RECOMMENDATION M.56

6. REGULAR READJUSTMENT TO THE NOMINAL VALUE OF A SUPERGROUP OR GROUP LINK

6.1 Supergroup links

a) Before any adjustment is made to the supergroup link it must first be ensured that each regulated line section 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 adjustments will be made on the supergroup link except under the direction of the control station, after consideration of the results of the daily measurements.

b) For supergroups 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 $\pm$ 0.2 neper or $\pm$ 2 db from the original line-up at the time the supergroup link was first established must be investigated to ensure that there is no fault.

c) For supergroups of more complex constitution, there should be frequent examination of the results of the daily measurements of reference pilot levels. If these measurements reveal a slow drift, adjustments should be made when the drift between the nominal and measured level exceeds about 0.1 neper or 1 db. The correction should be made at the ends or at a through-connection point, according to the circumstances. Adjustment may be made at the terminal station, in cases where the adjustment required does not exceed $\pm$ 0.2 neper or $\pm$ 2 db relative to the original line-up at the time the supergroup link was first established. In all other cases, 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.

If the level variations noted in the course of consecutive measurements at close intervals are of random nature around the nominal value, no readjustments should be made. If they are of appreciable amplitude (more than 0.15 neper for example) the use of an automatic regulator should be considered.

6.2 Group links

a) 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.

b) For groups 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 systematically after each measurement or location of a fault. Any departure in excess of ± 0.2 neper or ± 2 db from the original setting of the gain control at the time the link was first established must be investigated.

c) For groups of more complex constitution, there should be frequent examination of the results of the daily measurements of reference pilot levels. If these measurements reveal a slow drift, adjustments should be made when the drift between the nominal and measured level exceeds about 0.1 neper or 1 db. The correction should be made at the end or at a through-connection point, according to the circumstances. Adjustment may be made at the terminal station, in cases where the adjustment required does not exceed ± 0.2 neper or ± 2 db relative to the original setting of the gain control at the time the link was first established. In all other cases 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.

RECOMMENDATION M.57

7. CHECK OF MASTER OSCILLATORS

7.1 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. This frequency standard is guaranteed to about 10^{-8} by means of the three-way frequency comparisons organized by the C.C.I.R.

7.2 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;

b) to receive from a neighbouring country, over a metallic circuit, a frequency stabilized by comparison with the national standard of that country.

It does not seem necessary in any case to make a direct comparison of the frequencies of the master oscillators of the carrier systems of different countries.

7.3 The changeover of master oscillators may cause a short interruption of a few milliseconds and a sudden phase-change. Since the effect of these interruptions and phase-changes is felt throughout the carrier system, changeovers of master oscillators should be made as rarely as possible. Any such change should be made at times of light traffic.

Section 3

SETTING-UP AND MAINTENANCE OF INTERNATIONAL TELEPHONE CIRCUITS

CHAPTER I

Bringing an international telephone circuit into service

RECOMMENDATION M.60

1. PRELIMINARY EXCHANGE OF INFORMATION CONSTITUTION OF THE CIRCUIT

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 station, and the technical service of each transit country should advise the other technical services concerned of the name of the sub-control station chosen for its territory. If the circuit is routed in a direct group crossing a transit country without demodulation, no sub-control station need be provided for the transit country.

At the same time, the technical services of all the countries concerned should send the following necessary details about the constitution of the circuit to the technical service responsible for the control station. In addition they should give the signalling frequency(ies) and the overall loss of the circuit. These details are :

— for a circuit without audio sections, the numbers of the groups used and the number of the channel in each group, e.g. :

  routing for a circuit London-Roma 12
  (data supplied by the French technical services)

    London-Paris : 912/3
    Paris-Nice : 902/4
    Nice-Roma : 905/11
    Sub-control : Paris

— for a circuit with an audio section, besides the data on group sections, the terminal stations of the voice-frequency section or sections, showing the frequency band, e.g. :

routing for a circuit London-Paris Plage 4
(data supplied by the French technical services)

St. Margaret's Bay-Calais : 902/4
Calais-Paris Plage : 300-2200 c/s
Sub-control : Calais

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 Section *b)* of Recommendation M.55.

Using the above-mentioned information and the data supplied by sub-control stations, the control station makes out a " circuit routing form " * which is used as a level diagram for voice-frequency sections. This routing form shows the relative levels measured at :

— control and sub-control stations;
— frontier stations, if the circuit includes a 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 responsible for the control station must send the routing form as promptly as possible to the technical services of all the sub-control stations on the international circuit. There should be two copies : one for the technical service and one for the sub-control station.

* See Appendix VII below, which can serve as routing form or level diagram as required.

APPENDIX VII

CIRCUIT ROUTING FORM

Technical service of :	United Kingdom
Designation of circuit :	Bucuresti-London 1
Date of measurements (or of putting into service) :	9 September 1947
Control station :	London
Sub-control stations :	Frankfurt-am-Main, Wien, Szeged, Bucuresti
Signalling frequency :	500/20 c/s
Circuit length :	2510 km
Issue dated :	7 March 1961

Stations	Make-up	Length of section (in km)	Relative level at repeater output direction * ***		Group delay time at 800 c/s (milliseconds) **	Remarks ***
			Direction A — B	Direction B — A		
London			– 0.46	+ 0.46		Nt
	901 channel 9	840				
Frankfurt			+ 1.00	+ 1.00		Nt
	901 channel 11	740				
Wien			+ 1.00	+ 1.00		Nt
	1+1 channel 2	400				
Szeged			+ 1.40	+ 0.57		Nt
	Cn3 channel 3	530				
Bucuresti			– 0.80	+ 2.16		Nt

* An asterisk placed after the relative level indicates that the nominal value of the impedance at the measuring point differs from 600 ohms.

** This column will be completed only if there are long audio sections on loaded cables.

*** The appropriate indication to be given in the " Remarks " column for each station, using the following abbreviations :

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

RECOMMENDATION M.61

2. SETTING UP AND LINING UP THE CIRCUIT

1. Setting up the circuit

a) The sub-control stations responsible for the various national sections and sections crossing a frontier should arrange to set up and connect these sections together and advise the control station. In addition, the terminal stations 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 station has been advised by all the sub-control stations that the sections constituting the circuit have been connected together, the control station should agree with the sub-control stations a time when the whole circuit may be lined up.

2. Lining up the circuit

a) At the appropriate time of line-up, the control station, in co-operation with the various sub-control stations, proceeds with the overall line-up of the circuit, first at a frequency of 800 c/s.

For this, the control station arranges to send an 800 c/s test signal at a power of one milliwatt at zero level at the two-wire test point of the circuit or at the appropriate relative test level at a convenient point at this station.

b) The intermediate sub-control stations will then arrange to measure the level of the 800 c/s test signal and adjust it to the nominal value at all the audio points along the circuit 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 station the received level of the test signal should be adjusted until the overall loss required is obtained.

The procedure is then repeated for the other direction of transmission of the circuit.

3. Measurement of the loss-frequency response

When the circuit has been lined up at 800 c/s, similar measurements should then be made at frequencies from 300 c/s to 3400 c/s between the terminal stations, and also at frontier stations when an audio section crosses a frontier, using automatic level recorders where these are available. If such recorders are not available, measurements should be made at least at the following frequencies for circuits effectively transmitting the band 300 c/s to 3400 c/s :

300, 400, 600, 800, 1400, 2000, 2400, 3000 and 3400 *

Technical Services can agree to make measurements at other frequencies if it is considered useful to do so.

* In the case of old-type circuits in cable, which do not transmit frequencies above 2400 c/s, measurements should be made at 300, 400, 600, 800, 1400, 2000 and 2400 c/s.

During these measurements the signalling connections to the automatic equipment should be disconnected if the signalling units are incorporated in the carrier terminal equipment.

If the limits in Table 2 on p. 73 are exceeded, the Technical Services should co-operate in an endeavour to achieve the recommended limits.

4. Measurement of circuit noise

The measurement of circuit noise should be made for both directions of transmission.

For the measurement of noise in one direction of transmission, the far end of the circuit should be terminated at the 2-wire or 4-wire test point, as convenient, with an appropriate non-reactive resistance.

At the measuring end, using a psophometer having the characteristics recommended by the C.C.I.T.T., the measured noise should not exceed a mean value corresponding to a psophometric voltage of 1 millivolt at a −0.8 N or −7 db point.

If the overall loss of the circuit is not 0.8 N or 7 db, the appropriate correction should be made.

The procedure should be repeated for the opposite direction of transmission.

5. Measurement of crosstalk between go and return channels

Measurement of the GO to RETURN crosstalk should be made after disconnecting the circuit at suitable 4-wire test points at each end, and terminating both directions of transmission at the far end with appropriate non-reactive resistances. The measurements should be made at each end of the circuit. The measured signal to crosstalk ratio should not be worse than 5 N or 43 db for V.F. telegraph circuits and this value should be the objective for telephone circuits.

6. Check of level of signalling current

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 2 on page 73.

7. Record of results

All measurements made during the lining-up of the circuit are reference measurements and should be carefully recorded and sent to the control station for completion of the routing form referred to in Recommendation M.60.

EXTRACT FROM VOLUME III OF THE RED BOOK

C.C.I.T.T. LIMITS FOR AN INTERNATIONAL TELEPHONE CIRCUIT

1. **Permissible limits for the variation with frequency of the overall loss in terminal service with respect to its value measured at 800 c/s**

(International circuit effectively transmitting the band of frequencies from 300 to 3400 c/s)

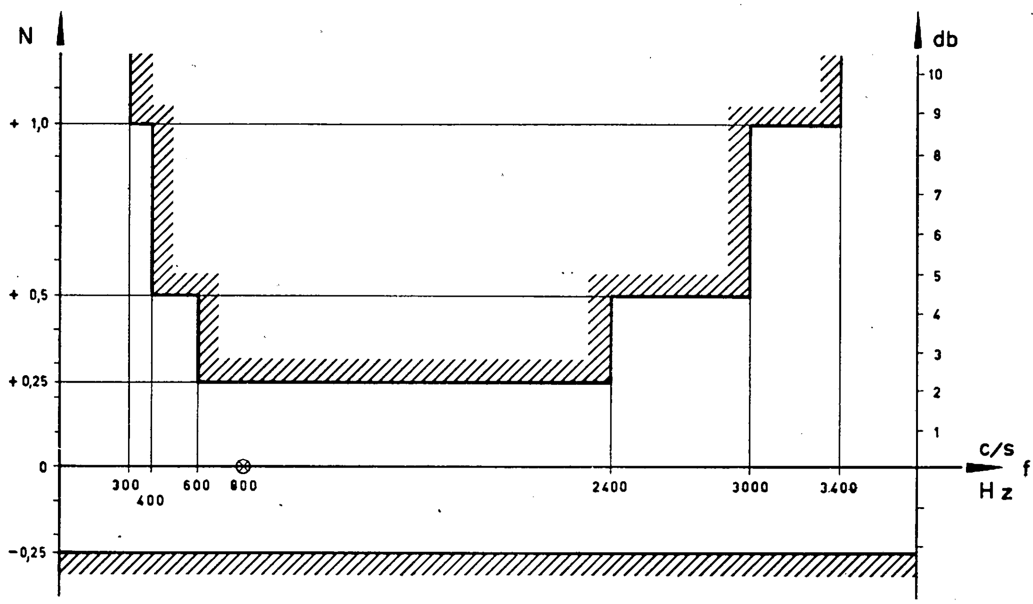


DIAGRAM No. 1

f = frequency (c/s)

N = variation of overall loss (nepers)

Note: The curve of the variations of overall loss with frequency should be within the hatched lines.

2. **Permissible noise limit**

The total circuit noise (including non-linear crosstalk) measured with the C.C.I.T.T. psophometer [1]) should not exceed a mean value corresponding to a psophometric e.m.f. of 2 millivolts, i.e. a psophometric voltage of 1 mV [2], at the end of the circuit, at a −0.8 N or −7 db relative level point. If the overall loss of the circuit is not 0.8 N or 7 db, the necessary correction is to be made.

3. **Absolute power level of signalling currents**

TABLE 2

	Signalling frequency		Absolute power (decibel referred to 1 mW) at a zero relative level point			
	Nominal value	Tolerance	Nominal value N	Tolerance N	Nominal value db	Tolerance db
Manual signalling	500 c/s interrupted at 20 c/s	± 2%	uninterrupted (500 c/s) 0	± 0.1	uninterrupted (500 c/s) 0	± 1
		± 2%	interrupted (500/20 c/s) − 0.35	± 0.1	interrupted (500/20 c/s) − 3	± 1
1-frequency signalling	2280 c/s	± 6 c/s	− 0.7	± 0.1	− 6	± 1
2-frequency signalling	2040 c/s 2400 c/s	± 6 c/s ± 6 c/s	− 1 − 1	± 0.1 ± 0.1	− 9 − 9	± 1 ± 1

4. **Go to return crosstalk on a telephone circuit**

The near-end signal/crosstalk ratio between the two directions of transmission of a telephone circuit must be at least 5 nepers or 43 decibels, as the circuit may be used for a duplex voice-frequency telegraph system.

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[1] See the weighting curve for this psophometer in Supplement No. 19, p. 262.

[2] The limit for the psophometric e.m.f. is raised from 2 to 3 millivolts in the case of an open-wire carrier circuit.

RECOMMENDATION M.62

OVERALL CIRCUIT LOSS

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 " equivalent " (insertion loss between non-reactive resistances of 600 ohms) between the switchboard jacks at the end international exchanges, including the line transformers, measured at 800 c/s, should not exceed 0.8 N or 7 db. This limit includes the insertion loss of the connecting circuit between the two international circuits at an international transit exchange.

For semi-automatic international circuits, it is necessary to standardize the nominal " equivalent ", and the value at present recommended by the C.C.I.T.T. is 0.8 N or 7 db 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.

CHAPTER II

Routine maintenance of an international telephone circuit

RECOMMENDATION M.63

1. ORGANIZATION OF ROUTINE MAINTENANCE MEASUREMENTS

The *dates* for routine maintenance are fixed by the " Routine Maintenance Programme ".

The *times* for measurement are fixed by agreement between the control and sub-control stations.

It is essential to choose the times for routine measurements so that they do not interfere with the telephone traffic. Particularly in the case of circuits carrying a large amount of traffic, Administrations or private operating Agencies should study the possibility of carrying out the measurements during times of light traffic.

RECOMMENDATION M.64

2. PERIODICITY OF MAINTENANCE MEASUREMENTS

Routine maintenance measurements made on a complete circuit comprise measurements of:

a) overall loss and levels at one frequency,

b) overall loss and levels at several frequencies,

c) stability (for 2-wire audio circuits or sections of circuit only),

d) signalling current and operation of signalling units,

e) noise.

The periodicity for the measurements is given in Tables 3 and 4 below.

Table 3 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:

— *4-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 a repeater;

TABLE 3

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 4-wire circuits [2]	4-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 "Guiding principles for the maintenance of semi-automatic circuits"
	4-wire circuits with 15 or more repeaters	Weekly	Half-yearly		
	4-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 routed on a single group link and terminating at the same points as the link	Every two months	Yearly		
	Circuits routed over several group links in tandem	Monthly	Half-yearly		
4-wire circuits of mixed constitution	Circuits routed mainly on carrier systems	Monthly	Half-yearly		
	Circuits routed mainly on audio sections	Weekly or monthly as agreed between Administrations	Half-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 4

PERIODICITY OF MEASUREMENTS TO BE MADE ON INTERNATIONAL TELEPHONE CIRCUITS

(Types of circuit not normally used in the international network)

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	
		Measurements of overall loss and levels at one frequency *	Measurements of overall loss and levels at several frequencies	Measurements of stability	Signalling tests	
Category of circuit	Type of circuit				Manual circuits	Automatic circuits
	2-wire circuits with one repeater	Yearly	Yearly	Yearly	at the same time as measurements of overall loss and levels at several frequencies (see column 4)	As agreed between Administrations
	2-wire circuits with 2 or 3 repeaters	Half-yearly	Yearly	Half-yearly		
	2-wire circuits with at least 4 repeaters	Quarterly	Half-yearly	Quarterly		
	2-wire circuits including an open-wire section with at least one repeater	Monthly	Half-yearly	Monthly		
	4-wire circuits with a 2-wire section having at least one repeater	As agreed between administrations				

* 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.

— or *4-wire carrier circuits* on telephone channels of systems providing at least one 12-circuit group;

— or *4-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.

In the case of circuits of mixed constitution, it is desirable that the dates and times of the measurements made on the overall circuit and on the audio-frequency sections should be the same as on the carrier section, in order to cause the least possible interference to the operating services.

Table 4 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.

RECOMMENDATION M.65

3. METHODS FOR MAKING ROUTINE MEASUREMENTS

1) Measurements of overall loss and relative levels

On each circuit, measure the overall loss and, when necessary, the relative levels (the relative levels are 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 frequencies in those cases where the circuit passes via a series of groups). The measurements should be made :

— at a frequency of 800 c/s, when measurements are confined to one frequency,

— at frequencies of 300, 400, 600, 800, 1400, 2000, 3000 and 3400 c/s, when measurements are made at more than one frequency *. 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 c/s at least.

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) When, during a routine measurement, the overall loss at 800 c/s is not equal to its nominal value, the following procedure should be followed :

a) Circuits working entirely at audio frequencies (coil-loaded cables)

These circuits should be *readjusted to their nominal overall loss after each measurement.* Adjustment at the terminal station may be permissible if this does not involve deviations greater than 0.2 N or 2 db between the nominal adjustments and the adjustments to be made in this station. Otherwise, the necessary corrections should be distributed as well as possible among the different repeater stations.

b) Circuits set up throughout on a channel of one group link

For these circuits, readjustment should also be made if there is a variation of overall loss, but subject to the reservation that the group link itself has been correctly adjusted beforehand.

c) Circuits of more complex constitution

Deviations of 0.2 N or 2 db or less may be left. If measurements reveal a variation of overall loss of more than 0.2 N, the variations should be located and readjustment should be made in those repeater stations where it is most necessary.

3) 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 Diagram No. 1, page 72). If they are not, the circuit should be readjusted.

* With old-type circuits, which do not transmit frequencies above 2400 c/s, measurements should be made at 300, 400, 600, 800, 1400, 2000 and 2400 c/s.

4) **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 at the point of measurement, the measured absolute power level of the signalling current transmitted at 500/20 c/s (interrupted signalling current) should fall within the following limits:

$$(n - 0.35)\ {}^{+\,0.1}_{-\,0.2}\ \text{neper or}\ (n - 3)\ {}^{+\,1}_{-\,2}\ \text{decibels}$$

assuming that the signalling units used conform to the new specifications (C.C.I.T.T. *Red 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:

$$-0.95 + n \leqslant N \leqslant +0.25 + n \text{ nepers}$$
or
$$-8.5 + n \leqslant N \leqslant +2.5 + n \text{ decibels}$$

b) Semi-automatic or automatic circuits

(See the " Guiding principles for the maintenance of semi-automatic circuits ".)

RECOMMENDATION M.66

4. MEASUREMENTS AT A 4-WIRE END OF THE CIRCUIT

Because of the increasing rate of automatization of international traffic, and of the increasing use of 4-wire switching, it happens more and more often that the 2-w/4-w terminating unit is remote from the end of the circuit in the repeater station.

Hence, it will often be expedient to make measurements at the 4-wire end of the circuit, i.e. not including the terminating unit.

It would of course have been convenient to make 4-wire measurements in a similar way to the measurements of overall loss made between 2-wire ends. Unfortunately, however, it is impossible to lay down any standard value for the attenuation between the 4-wire ends of a circuit. In fact, the impedance values which exist at the switching points between switchable terminating units and the 4-wire ends of the circuits are different in different countries. Moreover, the attenuation of terminating equipment is also different depending on the country.

Thus, the level at the access points at the outgoing and incoming ends of the channel are very different depending on the level diagrams for the various countries.

The measurements to be made at a 4-wire end will have to be measurements of absolute level instead of measurements of " equivalent " (see Supplement No. 2). To send the test signal at the 4-wire end, a generator will have to be applied which supplies an absolute voltage level equal to the relative voltage level at that point. Obviously, a standard generator (output 1.55 volts; 600 ohms) could not always be used; the e.m.f. and impedance of the generator must be in accordance with the data on the level diagram of the circuit. At the receiving end, the absolute level will have to be measured with the circuit terminated by an impedance equal to that to which the 4-wire end of the circuit is normally connected.

To avoid confusion in the exchange of test results between terminal stations, manual measurements made at a 4-wire end must be expressed in the form of deviations from the nominal value at the point concerned, as shown on the level diagram, and not as absolute level.

The following information should be given on level diagrams :

a) measuring points at the 4-wire ends of the two directions of transmission;

b) the nominal level at these points.

* * *

Another way of measuring is to complete the 4-wire circuit by a network reproducing the terminal equipment.

RECOMMENDATION M.67

5. ROUTINE MEASUREMENTS TO BE MADE ON THE LINE REPEATERS OF AUDIO-FREQUENCY CIRCUITS OR SECTIONS

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 tests for determining singing points (with 2-wire repeaters).

The measurement of stability is obtained from the definition of stability 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 c/s 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 c/s 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.

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CHAPTER III

Guiding principles for the maintenance of automatic telephone circuits *

The following note on the guiding principles for the maintenance of automatic telephone circuits deals 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.).

Recommendations M.70 to M.73 also appear in Volume VI of the *Red Book*, under the title

" Guiding principles for the maintenance of automatic circuits " where they bear the reference numbers Q.41 to Q.43.

* It has been agreed that the expression "automatic circuit", except where otherwise indicated, means circuits which may be used either for semi-automatic or automatic operation.

MAINTENANCE OF AUTOMATIC CIRCUITS

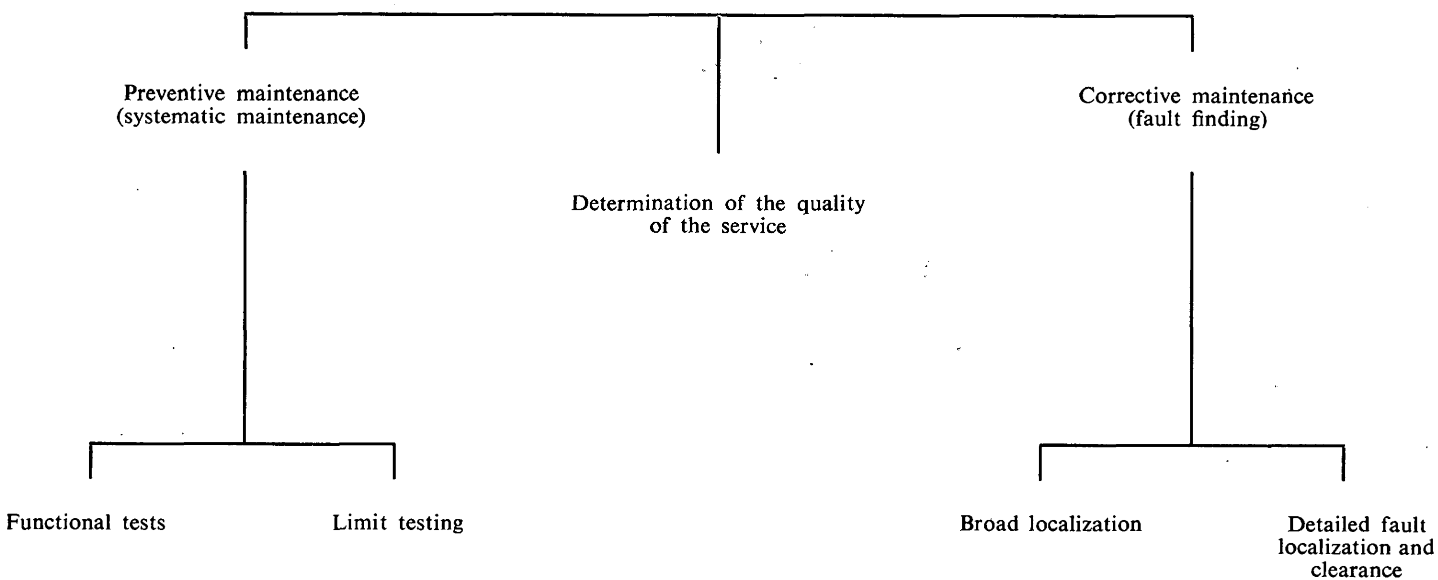


Diagram showing the various operations implied by " maintenance "

RECOMMENDATION M.70 *

1. DEFINITIONS

International line. — Telephone transmission system contained between the test jack panels of the two terminal repeater stations.

International circuit. — The whole of the international line and the outgoing and incoming equipment proper to the line.

Automatic switching equipment. — That part of an international exchange concerned with switching operations for routing the call in the desired direction.

Maintenance. — All the operations concerned with maintaining telephone circuits and automatic switching equipment in a good working condition. (See, for this and the following definitions, the diagram on the opposite page).

Preventive maintenance. — Tests, measurements and adjustment to specific values carried out before the appearance of a fault.

Corrective maintenance. — Tests, measurements and adjustments carried out following a fault.

Determination of the quality of the service. — Tests carried out under normal working conditions to find the percentage incidence of fault failure.

Functional tests. — Tests carried out under normal working conditions to verify that a circuit or a particular part of the equipment functions correctly.

Limit testing. — Tests carried out under conditions more severe than those corresponding to the specific nominal values, to determine the margin of security existing under normal working conditions.

Localization of faults:

The *broad localization* of a fault consists of finding the technical service area in which it exists.

Fault finding consists of determining the faulty part of the equipment.

RECOMMENDATION M.71 **

2. GENERAL MAINTENANCE ORGANIZATION FOR AUTOMATIC CIRCUITS

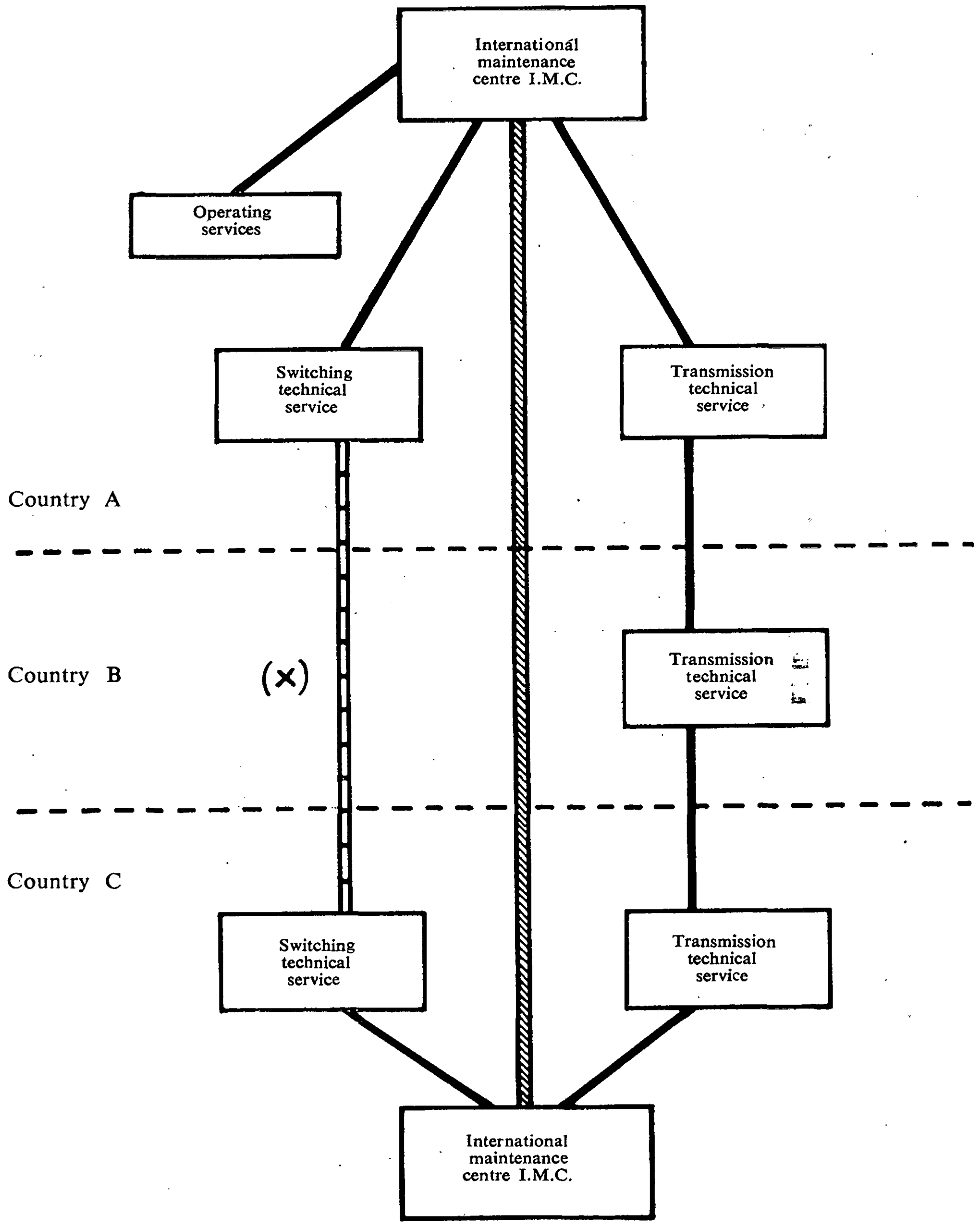
2.1. Principles

With international semi-automatic or automatic operation, each Administration shall assume responsibility for the testing and clearance of faults on its outgoing circuits. The other administrations will co-operate in testing and in clearing faults on these circuits at the request of the responsible Administration.

* This Recommendation also appears in Volume VI of the C.C.I.T.T. *Red Book* as Recommendation Q.41.

** This Recommendation also appears in Volume VI of the C.C.I.T.T. *Red Book* as Recommendation Q.42.

Organization Chart for maintenance of automatic circuits



*The link between switching technical services of different countries is marked by a cross, because such a link is not considered as indispensable. The staff of international automatic exchanges does not normally need to know foreign languages. However, this link may exist and may be of good service when it does.

2.2. International Maintenance Centre (I.M.C.)

2.2.1 The body which will exercise this responsibility for the outgoing circuits of an international centre is the " International maintenance centre " or in short I.M.C. The person in charge of the international maintenance will be referred to hereafter under the name of " Officer-in-charge of I.M.C." or in short by the expression " officer-in-charge ".

2.2.2 To carry out the maintenance of outgoing circuits, the International maintenance centre may give directions to the competent services of:

— the international automatic exchange,

— the repeater station.

2.2.3 The operating services should report all faults affecting the international service to the International maintenance centre and to this centre only.

2.2.4 The responsibilities of the International maintenance centre are as follows:

2.2.4.1 to receive all reports of faults on its outgoing international circuits and to conduct tests with a view to the broad localization of faults limited to ascertaining the technical service responsible for their clearance;

2.2.4.2 to entrust the clearance of faults to the appropriate technical service as determined by the broad localization;

2.2.4.3 to ensure that the out-of-service times of its outgoing international circuits (due to faults or other causes) are kept to a minimum compatible with the needs of the service;

2.2.4.4 to return a circuit to the operating services after having verified its correct functioning;

2.2.4.5 to keep detailed records of the faults, localizations and clearances with which it has been concerned;

2.2.4.6 to co-operate with the I.M.C.s of other countries in respect of the broad localization of faults on its incoming international circuits and to accept responsibility for the clearance of faults found to exist in or beyond the I.M.C. concerned;

2.2.4.7 to be advised of the need to put any of its incoming international circuits out of use and to inform the I.M.C. of the outgoing exchange of the fact;

2.2.4.8 to ensure that the tests prescribed for its outgoing international circuits are carried out at the specified times and that any faults revealed by such tests are dealt with expeditiously;

2.2.4.9 to ensure that new outgoing international circuits are satisfactory in operation before being brought into service and to co-operate with the I.M.C.s of other countries with any tests which may be necessary on new incoming circuits.

2.2.5 So as to ensure that the I.M.C.s are operated efficiently, it is desirable that the following conditions should, as far as possible, be applied:

2.2.5.1 The officers-in-charge (and possibly their direct assistants) should possess a thorough knowledge of the switching equipment with which they will be concerned and have an adequate knowledge of transmission. In addition, these officers should be selected with a view to avoiding language difficulties.

2.2.5.2 The officers-in-charge should possess sufficient authority to direct the clearance of faults.

2.2.5.3 The officers-in-charge should be attached to the I.M.C. and should not be diverted from their normal duties by other occupations which may impede the accomplishment of their principal task. These officers should be appointed as soon as there are any automatic circuits in service and their duties should not be subject to frequent change. They should be authorized to establish personal relations with their opposite numbers in other countries.

2.2.5.4 To facilitate exchange of views on the clearance of faults, the I.M.C. of the outgoing exchange should possess circuit diagrams of the switching equipment installed in the corresponding incoming exchanges together with any other useful information. It is also desirable that the officers-in-charge of the I.M.C. should be able to visit the switching installations of other international exchanges.

2.3. Control (repeater) station

The repeater station attached to each international exchange should be the control station for the automatic circuits outgoing from this exchange. Consequently, in the case of an international route AB comprising automatic circuits operated in the direction A to B and automatic circuits operated in the direction B to A, there will be a control station at each end A and B of the group of circuits:

— at A for the circuits A to B,

— at B for the circuits B to A.

RECOMMENDATION M.72 *

3. PREVENTIVE MAINTENANCE

3.1. Functional tests

3.1.1 *Functional tests* are carried out under conditions similar to normal working conditions and their purpose is to verify that a circuit or a particular part of the equipment functions correctly. The test conditions are such that a circuit or item of equipment will not be withdrawn from service as faulty if, apart from the test, it would be considered as satisfactory in service.

3.1.2 Functional tests are carried out locally, or from one end of an international circuit to the other.

* This Recommendation also appears in Volume VI of the C.C.I.T.T. *Red Book* as Recommendation Q.43.

3.1.3 The tests carried out locally will be left to the discretion of the Administration responsible for the international exchange. The actual tests carried out will depend on the type of equipment concerned and the extent to which alarms and monitoring devices are provided to indicate failures in the setting-up of the calls. Functional tests of common equipment in the international automatic exchange come in this category.

3.1.4 Overall functional tests on an international circuit are such that they can be made from the outgoing end of the circuit without the co-operation of technical personnel at the incoming end of the circuit.

The tests carried out from end-to-end of a circuit are described in paragraphs 3.1.4.1, 3.1.4.2 and 3.1.4.3.

3.1.4.1 Verification of satisfactory signal transmission, i.e. 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.

3.1.4.2 Superficial tests of the transmission conditions, if this is considered useful, by means of a loop test.

The above two tests are simple and so can be carried out quickly and as often as desired, for example, daily.

Signalling tests made by sending seizing and clear-forward signals do not need the provision of any special equipment at the incoming international exchange. On the other hand, the international signalling and switching specifications specify that there must be a loop at the incoming end of an international circuit.

3.1.4.3 Finally, if any Administration wishes to make functional tests which include the exchange of signals over the international circuit other than those mentioned in 3.1.4.1 above, use may be made of any test call answering devices existing in the national service of the incoming country. Information concerning the calling numbers of these devices will be communicated to other international exchanges.

3.2. Limit testing

3.2.1 The object of these tests is to verify whether a particular type of equipment has the specified operating margins. If necessary, these tests may be followed by the readjustment of the equipment to as near the specified nominal values as is practicable.

3.2.2 Limit tests of the signalling will, in general, be carried out locally. The frequency of such tests and the test conditions to be applied will be determined by the Administrations concerned.

These tests will be made using, in particular, the calibrated signal generator and the signal measuring apparatus provided under Recommendation Q.95, Chapter VIII of Volume VI of the *Red Book*.

The verification of the adjustment of signal receivers will be carried out locally but, by special agreement between Administrations, this adjustment can be carried out by overall circuit tests when the signal receiver cannot be dissociated from the terminal equipment of the carrier system of which it is an integral part.

The limit signalling tests will not normally be made from end to end of the circuit but it may nevertheless be desirable to be able to make such tests, for example, where technical disagreement arises between the two I.M.C.s concerned.

3.2.3 This Section 2, on limit testing, does not concern routine maintenance tests made on the line and which are normally followed by a readjustment of the line, for example, to restore it to its planned nominal value of overall loss. Such tests are proper to repeater stations and may be carried out automatically by automatic transmission measuring equipment. A very clear distinction should be made between:

— transmission *measuring* equipment used in the repeater stations;

— automatic transmission *testing* equipment used in the I.M.C.s.

Repeater station tests are carried out in accordance with the Maintenance Instructions in this Volume.

RECOMMENDATION M.73 *

4. CORRECTIVE MAINTENANCE
LOCATION AND CLEARANCE OF FAULTS

4.1. General

The localization and clearance of faults on automatic circuits will be carried out in accordance with the general rules described in Chapter II above, for the organization of maintenance.

Within the framework of this organization four categories of technical personnel may be called upon for the clearance of faults.

a) The I.M.C. personnel comprising one or more officers-in-charge of maintenance.

b) At the control repeater station, the transmission testing service.

c) At the international automatic exchange, the personnel concerned with the maintenance of the international signalling and switching equipment.

d) In the national automatic exchanges of the incoming country, the personnel concerned with the maintenance of the national switching equipment.

The functions of the maintenance personnel at the international and national automatic exchanges do not call for any particular comment except to say that this staff will not need to know foreign languages.

* This Recommendation also appears in Volume VI of the C.C.I.T.T. *Red Book* as Recommendation Q.44.

4.2. Reporting faults to the I.M.C.

All faults affecting the international service are reported to the "International maintenance centre".

These faults are reported:

— by operators,
— by the maintenance personnel of the international automatic exchange,
— by the repeater station staff,
— by the officers-in-charge of the I.M.C. of an incoming country.

The conditions under which operators will report circuits as faulty will be defined by Administrations.

Fault reports can result from functional tests of the equipment and can also arise from faults revealed during tests of the quality of service if this is the practice followed by an Administration for such tests.

If, at an incoming exchange, there is a fault which affects a major part of the equipment at that exchange and which is liable to impede the flow of traffic, the I.M.C. of the incoming exchange should immediately inform the I.M.C.s of the outgoing exchanges that work into the exchange concerned.

4.3. Blocking the circuit

Every circuit reported as faulty to the I.M.C. should be blocked on the initiative of the officer-in-charge if this has not already been done. (For example, in the case where automatic blocking is carried out under the conditions described in Recommendation Q.88, Volume VI of the *Red Book*, Chapter VII.)

Every intervention of the maintenance personnel which incurs the blocking of a circuit should be brought to the notice of the outgoing I.M.C. possibly through the incoming I.M.C. or the control station.

The blocking of a circuit by the incoming exchange by means of the blocking signal (one-frequency system) or by the continuous sending of one frequency (in the two-frequency system) should not exceed a duration of 5 minutes. If the work on the circuit must exceed this duration, the circuit should be withdrawn from service at the outgoing end and the I.M.C. of the incoming exchange should make a request to the outgoing exchange to this effect.

4.4. Broad localization of faults

The maintenance officer-in-charge of the I.M.C. will first verify whether a fault exists and, if so, will then proceed with the broad localization of the fault. He will determine whether the fault is:

(a) on the international switching equipment at the outgoing exchange,
(b) on the line,
(c) in the incoming country.

In carrying out this localization he will, as far as possible, avoid calling-in the I.M.C. of the incoming country and he will use the means put at his disposal which are described in Chapter VIII of the "Specifications" (Volume VI of the *Red Book*).

International experience already acquired confirms the excellent results obtained by the use of loop tests in carrying out this broad localization.

4.5. Priority of fault location tests

As a general rule, fault location tests should have priority over maintenance routine tests of individual circuits.

4.6. Fault clearance

Faults will be passed:

(a) to the maintenance personnel of the international automatic exchange if the fault is located in the international switching equipment of the outgoing country;

(b) to the control station of the international line if the fault is located in the line. (The control station is situated in the same country as the I.M.C.);

(c) to the I.M.C. of the incoming country if the fault is located in the incoming country. This I.M.C. will in turn pass the fault:

- — either to the maintenance personnel of the international automatic exchange,
- — or to any other national transmission or switching service concerned.

The I.M.C. personnel may be able to determine that a fault exists in the national network of a foreign country but discretion should be used as to whether or not it will be useful to inform the I.M.C. of this country of such a fault. Normally, no attempt will be made to report faults found to exist in the national network of the incoming country except faults of a persistent nature or those affecting localized areas that are particularly subject to faults.

4.7. Records of fault clearance

The I.M.C. responsible for an outgoing circuit should, after a fault has been cleared, receive particulars of the cause of the fault, when this has been determined without ambiguity. These particulars should be limited to a few words, for example, in the case of an international automatic exchange (incoming, transit or outgoing):

- — automatic switching equipment,
- — register,
- — incoming or outgoing circuit equipment,
- — signal receiver,

or such a report as:

- — line fault,
- — national network.

This may provide statistics for finding any weak points that may exist in the equipment of an international exchange.

Section 4

MAINTENANCE OF INTERNATIONAL TELEPHONE CIRCUITS USED FOR TELEGRAPHY OR PHOTOTELEGRAPHY

CHAPTER I

Telephone circuits used for voice-frequency telegraphy

RECOMMENDATION M.80

1. CONSTITUTION OF CIRCUITS USED FOR VOICE-FREQUENCY TELEGRAPHY AND OF RESERVE CIRCUITS

1. For voice-frequency telegraphy, four-wire telephone circuits are used. When so used, the terminal equipment, the signalling equipment, and the echo suppressors must be disconnected.

2. *Reserve circuits* consisting of a reasonable number of working telephone circuits shall be allocated for every circuit or group of circuits ordinarily used for voice-frequency telegraphy. A reserve circuit shall end at the same points but shall as far as possible follow a route different from that of the normal voice-frequency circuit.

Changeover switching from the normal voice-frequency telegraph circuit to its reserve circuit should be as rapid as possible.

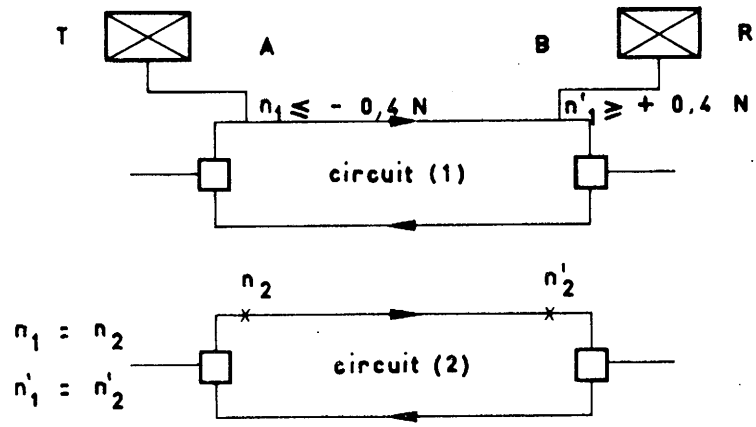
To this end,

— the normal voice-frequency telegraph circuit and the reserve circuit should be routed via the same switching panel at the terminal stations concerned;

— the changeover must take place at two points at the same relative power level of telephone transmission on the normal voice-frequency circuit (point A in Figure 15) and on the reserve circuit (point B in Figure 15).

The relative power level at point A must not exceed − 0.4 nepers or 3.5 decibels. The relative power level at point B must be at least + 0.4 nepers or + 3.5 decibels.

Points A and B are conventionally considered as the beginning and end of the voice-frequency circuit (for that particular direction of transmission).



A and B = points where

1. Voice-frequency telegraph circuit (1) is connected to the telegraph equipment.
2. Changeover takes place from voice-frequency telegraph circuit (1) to the traffic telephone circuit (2) used as a reserve for circuit (1).

T = "Transmit" voice-frequency telegraph equipment.

R = "Receive" voice-frequency telegraph equipment.

FIGURE 15

It is desirable, in view of the distortion which could occur on certain voice-frequency telegraph channels when the changeover from the voice-frequency telegraph circuit to its reserve circuit takes place, that the curves giving the relative power level differences as a function of frequency between the beginning and end of the normal and reserve circuits should be as similar as possible.

3. With a view to co-ordination between staff in different services (telephone operation, telephone transmission, telegraph transmission) the C.C.I.T.T. has issued the following Recommendation R.77 (Volume VII of the *Red Book*) which defines and supplements the basic information given in 2 above.

ANNEX

(to Recommendation M.80)

Reproduction of the text of Recommendation R.77

All necessary action should be taken for the duration of interruption of voice-frequency circuits 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 4-wire circuits in voice-frequency systems;

Although it does not appear necessary for these methods to be the same in details in every country, it would be advisable to reach agreement regarding the general directives to be followed.

The curves showing the differences in relative power levels, in relation to frequency, between the normal voice-frequency telegraph circuit and its reserve circuit at the sending end and receiving end respectively, should not differ at any frequency by more than 0.2 neper, so that when a voice-frequency telegraph system is switched to its reserve circuit, there should be no variation in power level causing excessive distortion in the voice-frequency telegraph system, especially for the upper and lower frequencies in the frequency band transmitted;

The telephone network being what it is, no such limitation can be guaranteed. Generally speaking, the voice-frequency telegraph circuit and its reserve circuit are made up differently, and it often happens that one is an audio-frequency circuit while the other is a telephone channel of a carrier system. Although adjustments can be made to the " equivalent frequency " curve of an audio-frequency circuit, it is difficult to modify the curve in the case of a telephone channel in a carrier system, since it depends essentially on the filter characteristics of the carrier system;

Moreover, the semi-automatic or fully automatic operation of telephone circuits is gradually becoming general.

For the above reasons, the C.C.I.T.T. unanimously declares the view :

1. that for each voice-frequency telegraph circuit or group of circuits between the same terminal stations, a reasonable number of *working* telephone circuits be designated as reserve circuits;

2. that the choice of the reserve circuit should be made by taking, if possible, a circuit which is routed differently from that of the normal circuit;

3. that the changeover should be effected at two points at the same relative power level of telephone transmission on the normal voice-frequency telegraph circuit and on the reserve circuit;

4. that the maintenance measurements taken on the reserve circuits should be the same as those carried out on the normal telephone circuits;

5. that the normal circuits and their reserve circuits should pass through the same changeover panel at each of the terminal stations concerned;

6. that, in view of the above Recommendations, the reserve circuits should be clearly distinguished from other possible circuits;

7. that the procedure to be adopted for the changeover from the normal circuit to be reserve circuit and vice versa should be jointly agreed upon by both Administrations or private operating Agencies concerned;

8. that, should the alarm indicating that the voice-frequency circuit is faulty be received by a station other than the group control station, this other station shall interrupt the return direction of the alarm channel towards the group control station in order to advise the latter to take the necessary action;

9. that the necessary steps must be taken so that the reserve circuits are not faulty or busy for a long period and that if it should happen that all the reserve circuits are faulty or already in use as reserves, the technical departments of the Administrations or private operating Agencies concerned should take immediate joint action to find a temporary remedy;

10. that it would be desirable, in view of the distortion which may occur in certain telegraph channels, that when the changeover from the normal to the reserve circuit takes place, there should be the greatest possible similarity between the overall response characteristics of these two circuits in respect of relative power levels against frequency;

11. that when, on a given route, there are manually operated circuits and automatic or semi-automatic circuits, the use of manually operated circuits as reserve circuits for voice-frequency telegraphy

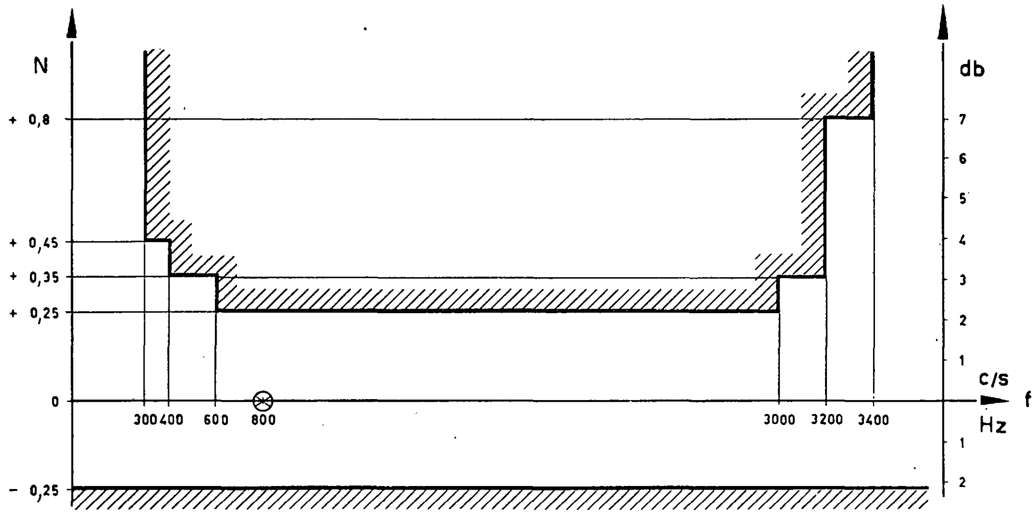


FIGURE 16

GRAPH No. 5. — Limits for the variation with frequency, relative to the value at 800 c/s, of the difference in relative power levels (in nepers) between the origin and extremity of a circuit used for voice-frequency telegraphy (circuit routed on a single group link to provide 24 voice-frequency telegraph channels).

Note: The curve of variations of relative power levels with frequency should lie within the hatched lines. The value at 800 c/s must be brought as near as possible to its nominal value.

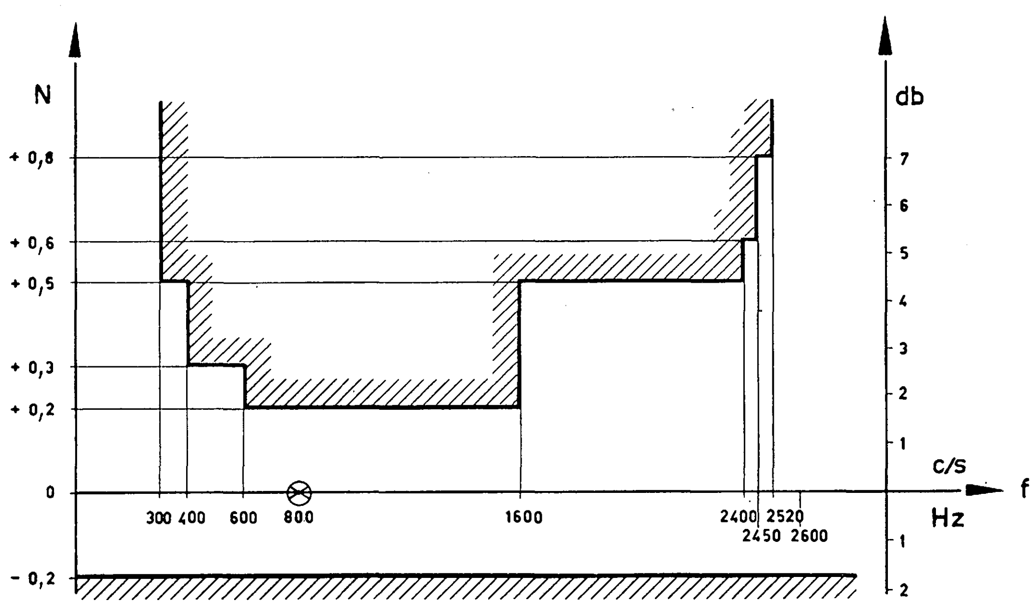


FIGURE 17

GRAPH No. 6. — Limits for the variation with frequency, relative to the value at 800 c/s, of the difference in relative power levels (in nepers) between the origin and extremity of a circuit used for voice-frequency telegraphy (telephone circuit using the band 300-2600 c/s).

is technically and operationally preferable to the use of automatic or semi-automatic circuits for that purpose;

12. that, with manually operated reserve telephone 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 and that the call should be transferred to another circuit, if it lasts longer than six minutes;

13. that, with automatic or semi-automatic reserve telephone circuits, direct indication that the reserve circuits are busy should be given at the changeover point mentioned in paragraph 5;

14. that, if no reserve circuit is available when needed, all the reserve circuits should be blocked against any further call as soon as the calls in progress are finished;

15. that, when a reserve circuit has actually been seized, the preliminary blocking should be removed from the other reserve circuit and the reserve circuit in use should be marked as engaged in the telephone switching equipment.

RECOMMENDATION M.81

2. SETTING UP A CIRCUIT FOR VOICE-FREQUENCY TELEGRAPHY

1) Attenuation distortion

In setting up a telephone circuit for voice-frequency telegraphy (circuits carrying voice-frequency telegraphy and their reserve circuits), special importance must be attached to the attenuation distortion of the circuit. A general graph defining variations with frequency, of the equivalent of an international telephone circuit, is given on page 72 (Graph No. 1).

When a carrier circuit is used for voice-frequency telegraphy it should preferably be one which passes via only one group link. For lining up the circuit, application is then recommended of Graph No. 5, Figure 16, which lays down closer limits than Graph No. 1 and which gives the permissible variation of relative power levels for a circuit set up on a single group link. The use of channels Nos. 1 and 12 of a group should be avoided for voice-frequency telegraphy, since these may present a greater attenuation distortion than the other channels of the group.

Some voice-frequency telegraph circuits are routed on voice-frequency circuits with a frequency band of 300 to 2600 c/s.

For such circuits, Graph No. 6 of Figure 17 shows the permissible variations (relative to the value measured at 800 c/s) of the difference in the relative power levels between the beginning and end of the circuit (points A and B in Figure 15).

2) Crosstalk

When setting up a circuit for voice-frequency telegraphy, it should be checked that the near end signal-to-crosstalk ratio between the two directions of transmission of the circuit is at least 5 nepers or 43 decibels.

3) Marking of circuits used for voice-frequency telegraphy

Any interruption of such a circuit, even of every 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 matter, the channel equipment of circuits used for voice-frequency telegraphy should be specially marked in the terminal exchanges and, where necessary, in repeater stations where the circuits appear in the voice-frequency range.

4) Basic data about voice-frequency telegraphy

The basic data about international voice-frequency telegraphy are given on pages 99 and 100.

RECOMMENDATION M.82

3. MAINTENANCE OF CIRCUITS USED FOR VOICE-FREQUENCY TELEGRAPHY. PERIODICITY OF MEASUREMENTS

1. The recommendations for four-wire telephone circuits concerning the periodicity of measurements are also applicable to circuits used for voice-frequency telegraphy. Measurements on circuits carrying voice-frequency telegraphy may be omitted if the Administrations concerned think fit.

Routine measurements of level at one frequency (800 c/s) should be made at the intervals recommended for international telephone circuits (see Table 3 page 76).

Measurements at different frequencies should be made once every six months.

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 tested.

When several voice-frequency telegraph systems are in use between two repeater stations, 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 telegraph measurements.

3. Maintenance measurements on international voice-frequency telegraph channels concern only the telegraph services. These tests are made once a month in accordance with the " Routine maintenance programme for international voice-frequency telegraph channels " published by the C.C.I.T.T. Secretariat. This programme is so arranged that the channels may be tested soon after the maintenance measurements are made on the telephone circuit used for voice-frequency telegraphy.

BASIC DATA ABOUT VOICE-FREQUENCY TELEGRAPHY

AMPLITUDE-MODULATED VOICE-FREQUENCY TELEGRAPHY

Channel carrier frequencies

For international telegraphy, the frequency series consisting of odd multiples of 60 c/s has been adopted, the lowest frequency being 420 c/s :

TABLE 5

No. of the channel	Frequency c/s	No. of the channel	Frequency c/s	No. of the channel	Frequency c/s
1	420	9	1380	17	2340
2	540	10	1500	18	2460
3	660	11	1620	19	2580
4	780	12	1740	20	2700
5	900	13	1860	21	2820
6	1020	14	1980	22	2940
7	1140	15	2100	23	3060
8	1260	16	2220	24	3180

Power

TABLE 6

Limiting power per telegraph channel, for a continuous marking signal in amplitude-modulated voice-frequency telegraph systems.

Voice-frequency telegraph system	Permissible power per telegraph channel, at a zero relative level point, for sending a continuous marking signal (as absolute power)	
	nepers	decibels (referred to 1 mW)
12 telegraph channels or less	— 1.67	— 14.5
18 telegraph channels	— 2.1	— 18.25
24 telegraph channels	— 2.4	— 20.9

BASIC DATA ABOUT VOICE-FREQUENCY TELEGRAPHY

FREQUENCY-MODULATED VOICE-FREQUENCY TELEGRAPHY

Centre frequencies of telegraph channels

The frequency series consisting of odd multiples of 60 c/s has been adopted for the centre frequencies, the lowest frequency being 420 c/s (standard frequencies for amplitude-modulated voice-frequency telegraphy).

Power

TABLE 7

Normal power limits per telegraph channel in frequency-modulated voice-frequency telegraph systems:

Voice-frequency telegraph system	Mean permissible power per telegraph channel at a zero relative level point (as absolute power)	
	nepers	decibels (referred to 1 mW)
12 telegraph channels or less	— 2.25	— 19.5
18 telegraph channels	— 2.45	— 21.25
24 telegraph channels	— 2.6	— 22.5

Note: Administrations may also agree to apply the limits mentioned in Table 6 above for amplitude-modulated voice-frequency telegraphy.

RECOMMENDATION M.83

4. MAINTENANCE OF CIRCUITS USED FOR VOICE-FREQUENCY TELEGRAPHY. MEASUREMENTS TO BE MADE

1. The routine maintenance measurements to be made on circuits used for voice-frequency telegraphy are measurements of level.

All these measurements should be made by sending, at the beginning of the circuit used for voice-frequency telegraphy, a power corresponding to 1 milliwatt at a zero relative level point on the telephone circuit.

The measuring frequencies are as follows:

Circuits providing an 18-channel telegraph system: 300, 400, 600, 800, 1400, 2000, 2400, 2600 c/s.

Circuits providing a 24-channel telegraph system: 300, 400, 600, 800, 1400, 2000, 2400, 3000, 3200, 3400 c/s.

2. Measurements on telegraph channels and on telegraph circuits used in switched networks (e.g. telex circuits) concern only the telegraph services.

3. For maintenance tests on circuits, the documents normally used for telephone maintenance are employed.

With regard to tests on voice-frequency telegraph channels, it is for the telegraph services to determine what documents should be exchanged.

CHAPTER II

Private telegraph transmission on a rented international telephone circuit

(With alternative private telephone service)

RECOMMENDATION M.86

In private telegraph transmission between subscribers permanently connected via rented international circuits, the maximum permissible power for a continuously transmitted telegraph marking signal is 0.3 milliwatt (equivalent to an absolute power of – 0.6 neper, or about – 5 decibels at a zero relative level point); a frequency of 1500 c/s is recommended for this telegraph transmission.

CHAPTER III

Phototelegraph transmissions

RECOMMENDATION M.88

(1) For phototelegraph transmissions, four-wire type telephone circuits are used. For phototelegraph transmissions they are normally disconnected from the switching equipment by which the telephone calls are put through.

(2) When a telephone circuit is specially allocated for phototelegraph transmission (circuit identified by the letter F), its channel equipment should be specially marked to attract the attention of staff. All interruptions in a phototelegraph transmission, no matter how short, must be avoided.

(3) 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 c/s) should be made at the intervals recommended for international telephone circuits (see Table 3, p. 76).

Measurements at different frequencies should be made once every six months.

(4) There is no need to make special level adjustments for a circuit used for phototelegraph transmissions. However, in the case of amplitude modulation it may be necessary to equalize the lines connecting the phototelegraph offices to the repeater stations. The attenuation distortion between phototelegraph offices must not exceed 1.0 neper (8.7 decibels) over the phototelegraph frequency band, whereas for the telephone circuit itself a distortion of 1.0 neper (8.7 decibels) is permissible.

(5) 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 0 neper (0 decibel referred to 1 mW) for a double sideband amplitude-modulated phototelegraph transmission, and − 1.15 nepers (− 10 decibels referred to 1 mW) for a frequency-modulated transmission. With amplitude modulation, the black level is usually 30 decibels below the white level.

(6) The following paragraphs taken from Recommendation H.32 of Volume III of the *Red Book* give information about the characteristics to be taken into account when choosing the circuit used for telegraph transmissions.

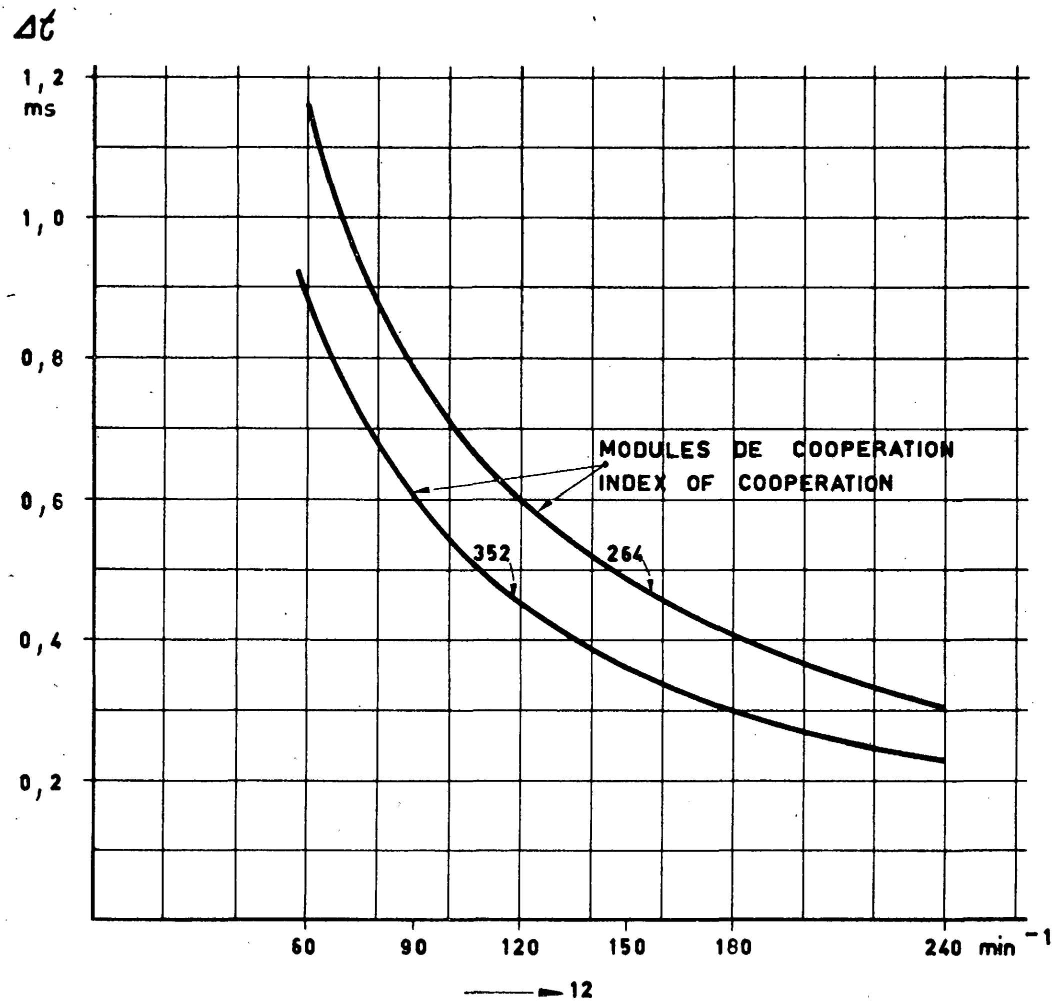


FIGURE 18

Permissible delay distortion in the transmitted frequency band as a function of the phototelegraph transmission speed

Note: The spot is assumed to have the same dimensions in both directions (square or circular).

ANNEX

(to Recommendation M.88)

Taken from Recommendation H.32

Range of phototelegraph transmissions on circuits normally used for telephone calls

1. The differences between the group delays of the various frequencies and the limitation of the transmission band actually usable on a circuit for telephony give rise, when phototelegraph signals are started or stopped, to transient phenomena which limit the phototelegraph transmission speed.

2. The range of phototelegraph calls of satisfactory quality, for a given transmission speed, depends especially on the constitution of the circuit, i.e. on:

— the loading and length, in the case of audio-frequency circuits;

— the number of 12-channel group links used in the case of carrier circuits, and on the choice of the carrier frequency for amplitude-modulated phototelegraph transmission, or on the mean frequency in the case of frequency modulation.

3. Phototelegraph transmission of satisfactory quality requires that the limits of difference between the group delays in the transmitted frequency band, as shown in Figure 18, are not to be exceeded.

4. The C.C.I.T.T. recommends (Recommendation G.131 F) that, for all international circuits, the differences in group delay in the frequency band to be transmitted should not exceed the values defined as follows:

If:

— t_m is the group delay for nominal lower limit of the frequency band to be transmitted,

— t_M is the group delay for the nominal upper limit of the frequency band to be transmitted,

— $t_{\min}$ is the minimum group delay in the whole of the frequency band to be transmitted,

the following conditions must be met:

$$t_m - t_{\min} \leqq 20 \text{ ms},$$
$$t_M - t_{\min} \leqq 10 \text{ ms}.$$

5. In choosing circuits for telegraph transmissions, reference should be made to the following:

A. *Circuits permanently used for phototelegraphy*

A.1. It will generally be possible, by agreement between Administrations, to choose a circuit satisfying stricter limits than those specified above from the point of view of phase distortion.

A.2. Moreover, it will be possible to compensate phase distortion by inserting phase equalizers and to effect phototelegraph transmissions occupying the whole nominal band of the circuit.

B. *Circuits normally (or preferentially) used for phototelegraphy*

B.1. The greater the differences between the delays in the transmission intervals, the narrower should be the bandwidth chosen (leading to a lower phototelegraph definition or transmission speed).

B.2. Hence, audio-frequency circuits should in any case have only small loads.

B.3. Phase distortion is well within the limits indicated above, in the case of carrier circuits, if a single modern-type carrier system (providing at least 12 telephone channels) is considered (and considering especially the telephone channels in the middle of a 12-channel group of such a system).

B.4. Nevertheless, it would be unjustifiable from the financial point of view to make the aforementioned recommendation concerning phase distortion stricter, simply with a view to the occasional use of only a few circuits for high-speed phototelegraph transmissions.

. . . .

C. *Telephone circuits rarely used for phototelegraphy*

If phototelegraph connections are set up on circuits taken at random from modern-type groups of telephone circuits (for example, by automatic switching), a circuit may be taken which has too high a degree of phase distortion, particularly if it has been set up on channels 1 and 12 of a 12-channel group, use of which is inadvisable. It is impossible, in this case, to establish general information on the range of phototelegraph transmissions; however, it will be possible to meet the conditions for a transmission of adequate quality if the phototelegraph connection comprises only one 12-channel group link and if transmission is effected in normal conditions as outlined in Recommendation T.1.

SECTION 5

LINING-UP AND MAINTENANCE FOR INTERNATIONAL PROGRAMME TRANSMISSIONS

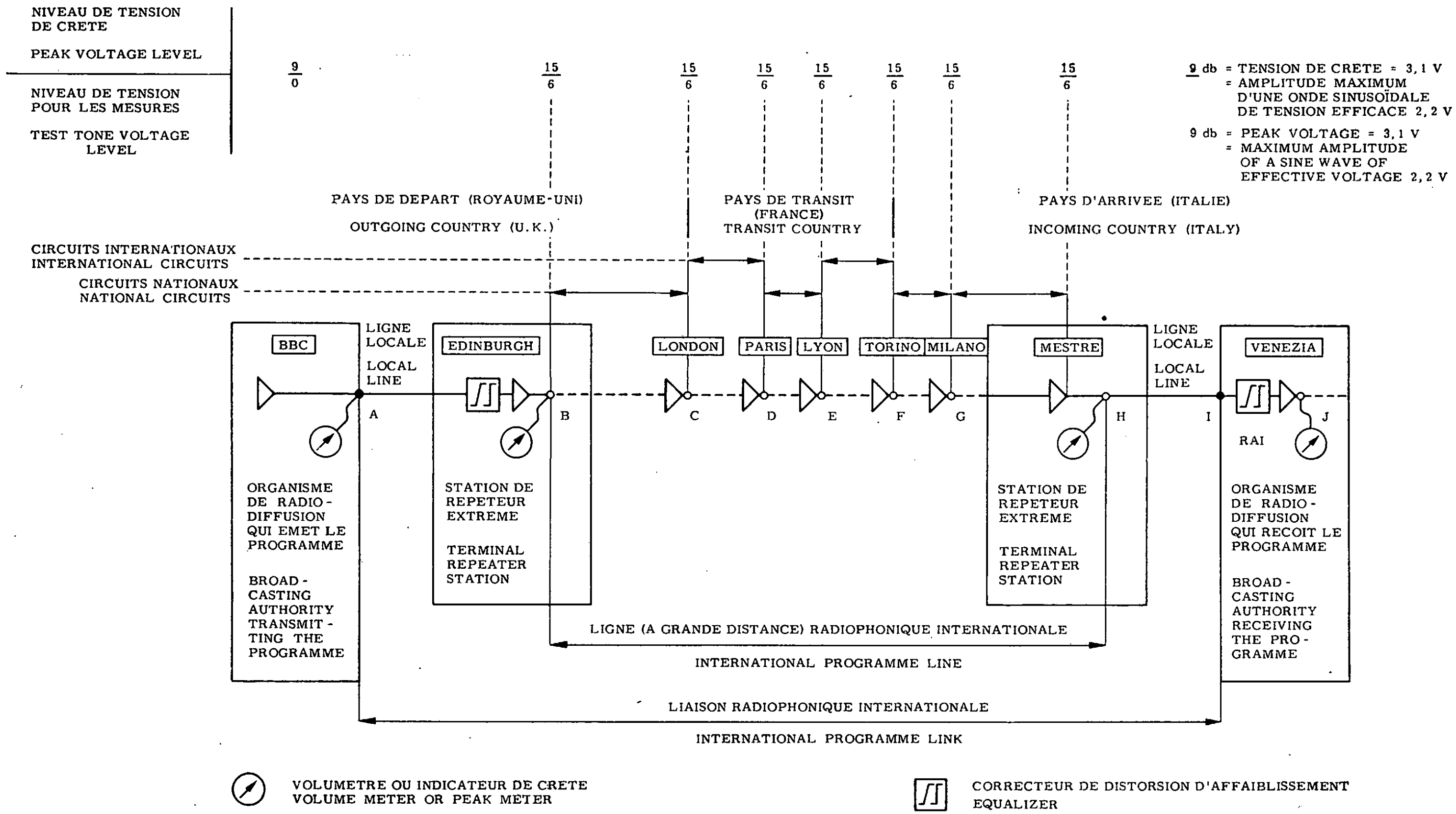


FIGURE 19

Diagram of an international programme link

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CHAPTER I

International programme transmissions
Definitions

RECOMMENDATION N.1

1. DEFINITION OF THE CONSTITUENT PARTS OF AN INTERNATIONAL PROGRAMME LINK

In order to apportion responsibility during the transmission of a broadcast programme there is occasion to distinguish between (see Figure 19 opposite):

a) the broadcast authority that is the source of the programme (studio or outside broadcast point or programme switching centre) and which in the figure is at some distance from the repeater station at *Edinburgh;*

b) the outgoing local line, which connects the broadcast authority to the first repeater station;

c) the " (long-distance) *international programme line* " consisting in principle of a chain of national and international *programme circuits*, the national circuits being of the same type as if they were international circuits. In the figure this " long-distance international programme line " is " *Edinburgh-Mestre* ", and consists of the national circuit *Edinburgh-London*, the international circuit *London-Paris*, the national circuit *Paris-Lyon*, the international circuit *Lyon-Torino* and the national circuits *Torino-Milano* and *Milano-Mestre*;

d) the incoming local line, which connects the last repeater station to the receiving broadcast authority;

e) the receiving broadcast authority for which the programme is intended and which, in the figure, is at *Venezia*, some distance from *Mestre*.

The assembly of the " long-distance international programme line " and the local lines constitutes the " *international programme link* ".

The " international programme line " is, in all cases, the sole responsibility of the telephone administrations.

The local lines may be the responsibility of either the telephone administration, the broadcast authority or the two together, depending on local arrangements in each particular country.

The country at the *incoming* end designates a single *control* station for the " long-distance international programme line " and for the " international programme link " (in principle, the last repeater station at the receiving end).

The country at the *outgoing* end designates a *sub-control* station to serve both the " long-distance international programme line " and the " international programme link ".

Each transit country designates a sub-control station for the " long-distance international programme line ".

Each circuit forming a part of the " international long-distance programme line " retains its normal control station.

RECOMMENDATION N.2

2. DIFFERENT TYPES OF CIRCUIT USED FOR PROGRAMME TRANSMISSIONS

Circuits used for broadcast programme transmissions are :

a) normal programme circuits *, type A;

b) normal programme circuits *, type B;

c) old-type programme circuits.

Exceptionally if none of these three types of circuit is available, ordinary telephone circuits can be used (see point 2.3 of the present Recommendation).

These circuits for broadcast programme transmissions differ mainly in the band of frequencies they effectively transmit.

2.1 Normal programme circuits, type A

When a normal programme circuit type A is used, the band of frequencies effectively transmitted by the complete link should extend from 50 to 10 000 c/s.

For a frequency to be effectively transmitted, the loss at that frequency must not exceed the loss at 800 c/s by more than 0.5 neper (4.3 decibels).

Variations of 600-ohm through relative level with frequency, at the origin and at the far end of a normal programme circuit type A are given in Graph No. 10 of Vol. III of the *Red Book*, and are reproduced below on page 120.

2.2 Normal programme circuits, type B, and old-type programme circuits

When a programme circuit of these types is used, the band of frequencies effectively transmitted by the complete link should extend from 50 to at least 6400 c/s (the upper limit, of course, being less than 10 000 c/s).

* The short expression " Normal programme circuit Type A " is used to designate a normal programme circuit (carrier or audio) having a bandwidth of 50-10 000 c/s, and " Normal programme circuit Type B " to designate a modern programme circuit set up on a carrier system and having a bandwidth of 50-6400 c/s.

An " effectively transmitted frequency " is defined in the same way as for a normal programme circuit, type A.

Variations of 600-ohm through relative level with frequency between the origin and the far end of a normal programme circuit, type B, are given below in the graph of Figure 21, and for an old-type circuit as shown in the graph of Figure 22.

2.3 Telephone circuits

As far as possible, these circuits should effectively transmit a band of frequencies extending from 300 to 3400 c/s.

In telephony a frequency is said to be effectively transmitted if the " equivalent " at this frequency does not differ by more than 1.0 neper (8.7 decibels) from the " equivalent " at 800 c/s.

Although the use of ordinary telephone circuits for a programme transmission should be avoided as far as possible, such circuits may be used for the transmission of spoken commentaries if there are insufficient programme circuits.

When a telephone circuit is used for a programme transmission, the terminating and signalling sets must be disconnected so as to avoid echo effects and false operation of the signalling receivers.

When a telephone circuit is used for a programme transmission, the point of zero relative level of the circuit in question must coincide with the point of zero relative level of the level diagram of the programme circuit.

RECOMMENDATION N.3

3. CONTROL CIRCUITS

a) Definition of a control circuit

A control circuit, which is a telephone circuit distinct from the special circuit for the 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).

In the case of television transmissions, the control circuits can be associated with 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 programme circuit transmitting a commentary in a given language),
— the " complete programme " control circuit (for supervising the programme circuit transmitting the whole of the sound part of a programme).

b) Different types of 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 programme transmissions or multiple programme transmissions.

RECOMMENDATION N.4

4. DEFINITION AND DURATION OF LINE-UP PERIOD AND PREPARATORY PERIOD

For each international programme transmission a distinction is made between :

— the *line-up period* during which the Administrations and private telephone operating Agencies line up the " international 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 programme transmission itself commences.

a) Line-up period

Duration — In principle, the duration of the line-up period should be 15 minutes. However, in the case of 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 programme transmissions on the same route and the second involves extending the " link " already lined up for the first.

Note — In the case of programme transmissions 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 programme link " and the control circuits are handed over at the same time to the broadcasting authorities.

b) Preparatory period

Beginning and duration — When the tests during the line-up period are completed, the " international 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 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 programme link " to the broadcast 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 programme transmission.

However :

the duration of the preparatory period may be extended at the request of the broadcasting authority using the " 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 programme transmissions accompanying a multiple television programme, broadcast by several radio transmitters.

CHAPTER II

Constitution, line-up, supervision and clearing down the international programme link

It is assumed that the " international programme link " is as shown in Figure 19 above. It is also assumed that the various circuits to be interconnected to constitute the " international link " are permanent circuits which are subjected to routine maintenance (see Chapter III below).

RECOMMENDATION N.10

1. THROUGH LEVEL DIAGRAM OF THE INTERNATIONAL PROGRAMME LINK

The through level diagram referred to is that of the " *international programme link* " and not that of the circuits. The levels quoted are in all cases measured as 600-ohm through levels.

On this through level diagram :

a) the reference point for relative levels is normally the " origin " of the " international programme link ", namely, point A in Figure 19. (A different convention may be adopted by agreement between the telephone administration and the broadcasting authorities in one and the same country, provided that the through levels on the " international programme line " are not modified thereby);

b) the nominal value of 600-ohm through level measured at the far end of each of the programme circuits making-up the " (long-distance) international programme line " (points B, C, D and H of Fig. 19) is 0.7 neper or 6 decibels above the nominal value at the " origin "; in other words, if at the " origin " of the " link ", this being a zero relative level point, there is a sinusoidal signal producing 0.775 volt r.m.s. across the circuit at that origin, the 600-ohm through level at B, C, D and H must be + 0.7 neper or + 6 decibels, that is, it must be 1.55 volts r.m.s.;

c) the nominal value of the 600-ohm through level at the near end of an international circuit (point C of circuit CD, point E of circuit EF) is also + 0.7 neper or + 6 decibels.

The setting-up and maintenance measurements made by telephone administrations are thus always carried out by sending a signal such that the nominal 600-ohm through level at the origin of an " international programme line " is + 0.7 neper or + 6 decibels.

In order not to exceed the maximum power which can be transmitted without distortion by the " international programme line " the peak voltage which may be applied at a zero *relative* level point of the " international programme link " must not exceed a 600-ohm through level of + 9 decibels or + 1.0 neper (peak voltage of 3.1 volts, i.e. the maximum amplitude of a sinusoidal signal having an r.m.s. value of 2.2 volts).

RECOMMENDATION N.11

2. MEASUREMENTS TO BE MADE BEFORE THE LINE-UP PERIOD THAT PRECEDES A PROGRAMME TRANSMISSION

The local lines should be so adjusted that when they are connected to the " long-distance international programme line ", the voltage level diagram of the " international programme link " shall be met.*

For example, in Figure 19, the station *Edinburgh* carries out the equalization and line-up of the local line from the British Broadcasting Corporation (B.B.C.).

RECOMMENDATION N.12

3. MEASUREMENTS TO BE MADE DURING THE LINE-UP PERIOD THAT PRECEDES A PROGRAMME TRANSMISSION

The C.C.I.T.T. recommends the use of the line-up method known as " constant voltage ".**

After the connection of the various circuits to form the " international programme line " (conforming to the voltage level diagram of these circuits) it is sufficient to verify, by means of an automatic level recorder or by measurements at individual frequencies, that the relative voltage level at the distant incoming repeater station has the correct value at the following frequencies:

for an international line composed entirely of normal circuits, type A	50, 800 and 10 000 c/s
for an international line comprising at least one normal circuit type B or old-type circuit	50, 800 and 6 400 c/s
for an international line comprising at least one telephone circuit	300, 800 and 3 400 c/s

Also, and only if requested by the control station, a measurement of the psophometric noise is made at the distant incoming repeater station.

* From the definition of the voltage level diagram of an " international programme link " it follows that, at a given point, a sine wave having a maximum amplitude equal to the peak voltage transmitted by the studio, has a nominal 600-ohm through level of + 9 decibels or + 1.0 neper at a zero relative level point on the " long-distance international programme circuit."

** If certain Administrations have programme-circuit amplifiers which are not suitable for use for line-up by the constant-voltage method, there is no objection to using the constant electromotive force method of equalization—even though it may cause inconvenience from the point of view of maintenance—provided that Administrations or private operating Agencies make the necessary arrangements at frontier stations to changeover from the constant electromotive force method to the constant-voltage method recommended by the C.C.I.T.T. However, new amplifiers installed for programme transmissions should be designed to provide for lining-up by the constant-voltage method.

These preliminary adjustments having been made, the local lines are connected to the " long-distance international programme line " at the terminal repeater stations. This is the end of the " line-up period " and the beginning of the " preparatory period " and is the instant when the complete " link " is *placed at the disposal* of the broadcast authorities.

The latter then proceed to measure and adjust as necessary.

RECOMMENDATION N.13

4. MEASUREMENTS TO BE MADE BY THE BROADCAST AUTHORITIES DURING THE " PREPARATORY PERIOD "

After the broadcasting authorities have taken possession of the " international programme link ", they make measurements on the complete " link " in the band of frequencies effectively transmitted, from the point where the programme is picked up to the point where the programme is received.

It is desirable to recommend to the broadcasting authorities that they should, for their measurements, send to the origin of the " international programme link " (point A of Figure 19) a sinusoidal signal, having a maximum amplitude 9 decibels or 1 neper below that of the peak voltage (i.e. of the maximum instantaneous voltage that should never be exceeded at this point in the course of a programme transmission). If necessary, the repeater stations should verify that the nominal 600-ohm through level at each repeater is + 6 decibels or + 0.7 neper, which means that there is a voltage of 0.775 volt (600-ohm through level of zero) at the zero relative level point A of the " international programme link ".

It is not necessary to readjust the output levels of intermediate repeaters since these have already been set during the line-up period.

Note. — The numerical values given above ensure that during the 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 during this final line-up, a voltage 9 decibels or 1 neper below the peak voltage at point A are :

a) it is not desirable to subject the terminal equipments of carrier system to overloading by transmitting continuously 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 with a nominal 600-ohm through level of + 6 decibels or + 0.7 neper at the repeater output, it is convenient, when it is necessary to make a check during the preparatory period, for the level measured to be of the same value.

RECOMMENDATION N.15

5. MAXIMUM POWER TRANSMITTED DURING A PROGRAMME TRANSMISSION

To check that the maximum power transmitted during a programme transmission does not exceed the limits allowed by Administrations, it is recommended that broadcasting authorities and the terminal repeater stations of the international programme link should use volume-meters or peak 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 programme circuit has been accurately adjusted before it was made available to the broadcasting organizations, there will be no danger of overloading the amplifiers during the programme transmission if care is taken not to exceed the permissible limit at the origin of the international programme circuit. Hence this check can be done only by the broadcasting organization and telephone authorities of the transmitting country and a check made further down the line would not seem very effective.

If so desired, monitoring equipment (electrical speech level meters, peak indicators) can be connected at the receiving end of the international programme line (last repeater station) and of the international programme circuit (broadcasting organization) to obtain information about the general nature of the modulation. In which case, the monitoring equipment 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.

It has been seen in Recommendation N.10 above that the peak voltage which may be applied at a zero through relative level point of the international programme link should not exceed a 600-ohm through level of + 9 decibels (+ 1.04 neper) which means that the peak voltage must be less than 3.1 volts, which is the maximum amplitude of a sinusoidal signal having an r.m.s. value of 2.2 volts.

RECOMMENDATION N.16

6. 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 transmit " identification signals " over the international programme links 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 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 programme link from the studio to the broadcasting station.

RECOMMENDATION N.17

7. MONITORING THE TRANSMISSION

The transmission may be monitored in the terminal repeater stations, either by means of loudspeakers, or apparatus with a visual display (peak programme meters, vu-meters, oscilloscopes, etc.).

CHAPTER III

Setting-up and maintenance of permanent circuits for programme transmissions

RECOMMENDATION N.20

1. CONTROL AND SUB-CONTROL STATIONS

For the establishment of a unidirectional international programme circuit, the receiving end terminal station is the control station. The other terminal station is a sub-control station. If the international circuit passes through one or more transit countries, a 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 telephony.

Note. — In the case of a reversible programme circuit, setting-up reference measurements and maintenance measurements are carried out for each direction of transmission. The control station is the same for either direction of use of the circuit.

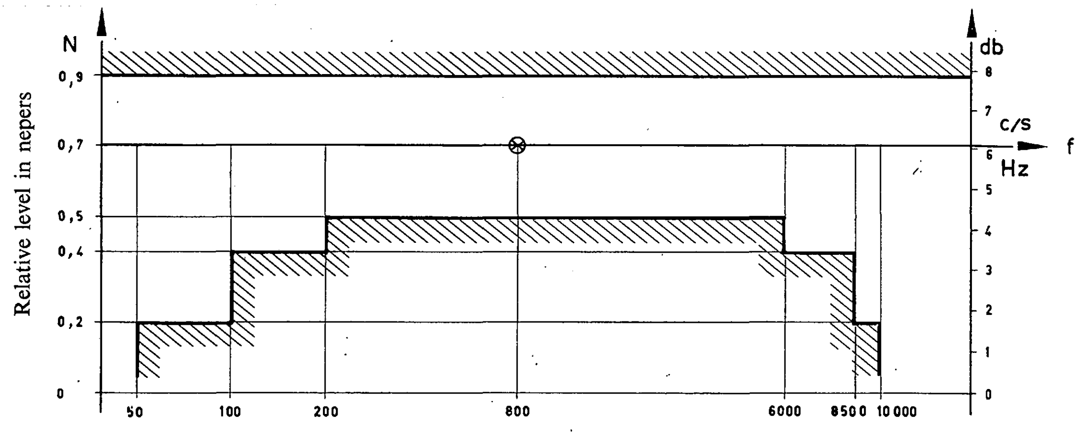
RECOMMENDATION N.21

2. SETTING UP THE CIRCUIT

When each national section of the circuit and each section crossing a frontier has been equalized for attenuation distortion and, where necessary, for phase distortion, so as to meet C.C.I.T.T. recommendations, these various sections are interconnected to form a complete circuit, and the following measurements are made :

a) Measurement of " 600-ohm through relative level "

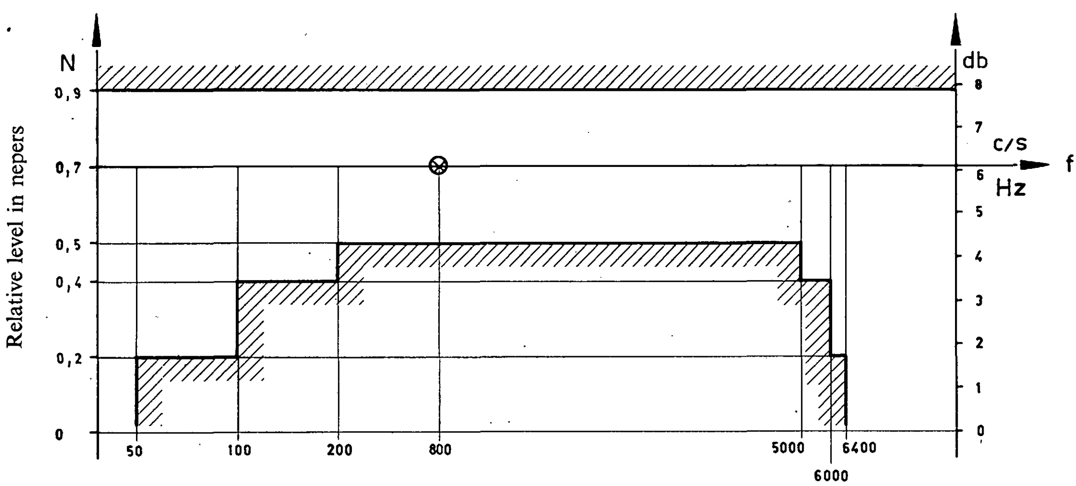
A test signal of 800 c/s is applied to the origin of the circuit with a 600-ohm through level of + 0.7 neper or + 6 decibels. The 600-ohm through level is measured at the end of the circuit (output of last amplifier) and is adjusted to its nominal value of + 0.7 neper or + 6 decibels relative to the value at the " origin ". This ensures that, in the through level diagram of the international programme link, the 600-ohm through relative levels are satisfactory.



Frequency in c/s

FIGURE 20

Graph No. 10 — Permissible limits for variations with frequency of 600-ohm through relative level at the far end (output of last amplifier) of a normal programme circuit, type A



Frequency in c/s

FIGURE 21

Permissible limits for variations with frequency of 600-ohm through relative level at the far end (output of last amplifier) of a normal programme circuit, type B

An automatic level recorder is then used to trace the curve for the circuit of 600-ohm through relative level with frequency. If no such recorder is available, individual measurements must be made at enough frequencies for the curve to be properly drawn. The equalizers are adjusted to bring the curve within C.C.I.T.T. limits, which are summarized hereafter :

(N.21)

Measurement of " 600-ohm through relative level "

The 600-ohm through relative level refers to the through level diagram of the international programme circuit of which the circuit in question is a part (see section above " Through level diagrams for international programme circuits ").

When the circuit is measured independently of any international programme link that may be set up, 600-ohm through relative levels are measured:

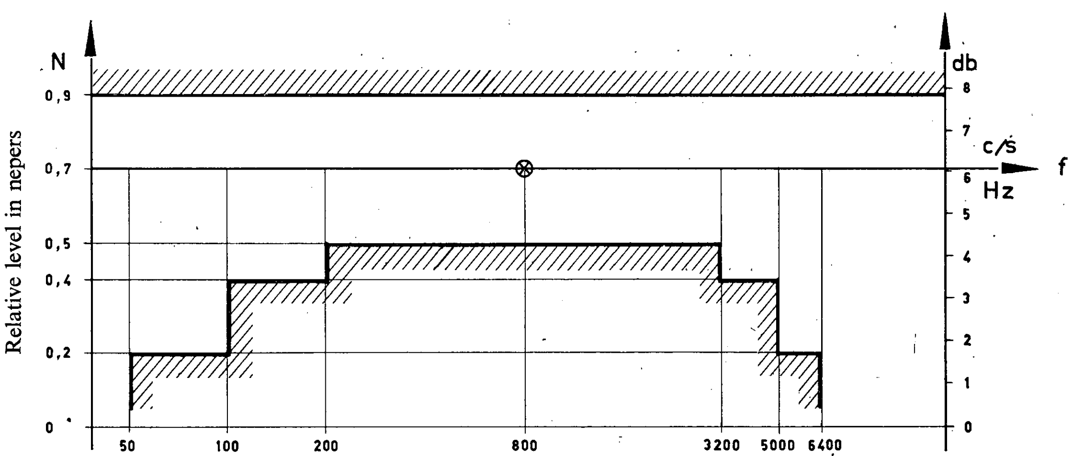
— by sending a signal to the input of the circuit (in Figure 19, point C of circuit CD or point D of circuit DE, at which points on the through level diagram of an international programme link the 600-ohm through relative level is + 0.7 neper or + 6 decibels), such that the 600-ohm through level at the input to that circuit is maintained constant with frequency * at + 0.7 neper or + 6 decibels,

— by measuring actual 600-ohm through levels.

The permissible limits for variations in the " 600-ohm through relative level " with frequency at the output of the last amplifier in the circuit are shown:

— in Figure 20 for a normal programme circuit, type A,
— in Figure 21 for a normal programme circuit, type B, and
— in Figure 22 for an old-type programme circuit.

Non-frontier station



Frequency in c/s

FIGURE 22

Graph No. 8. — Permissible limits for variations with frequency of 600-ohm through relative level at the far end (output of last amplifier) of an old-type programme circuit.

* See the note in Recommendation N.12 regarding the constant e.m.f. method of line-up.

b) Measurement of phase distortion

If necessary, the propagation time/frequency characteristic is plotted for the whole circuit.

c) Measurement of non-linearity distortion

The harmonic margin is measured at the end of the international circuit by sending for a few seconds at the origin (where the nominal 600-ohm through relative level is + 0.7 neper or + 6 decibels) a sine wave at any frequency in the band to be transmitted, with an r.m.s. voltage of 4.4 volts (600-ohm through level + 1.74 nepers or + 15 decibels). A provisional C.C.I.T.T. limit requires that the harmonic margin shall be at least 2.3 nepers (20 decibels), but broadcasting authorities have pointed out that the effects of non-linearity distortion are already apparent in a programme transmission with a harmonic margin of 3.2 nepers or 28 decibels.

d) Measurement of circuit noise

Measure :

— the unweighted noise at the end of the circuit using a measuring set covering a frequency range of at least 50 to 20 000 c/s, and

— the weighted noise, using a programme circuit psophometer (see the weighting curve of this psophometer annexed below).

When, after any necessary adjustments, the circuit meets the C.C.I.T.T. recommendations given below, reference measurements are made.

Permissible limits	Cable circuit	Open-wire line
— unweighted voltage	62 mV	156 mV
— psophometric voltage	6.2 mV	15.6 mV
at the end of the circuit (point where the nominal " relative level " is + 0.7 neper or + 6 decibels)		

RECOMMENDATION N.22

3. REFERENCE MEASUREMENTS

The " 600-ohm through relative level " at the terminal station and at the frontier station is measured at the following frequencies :

— for a normal circuit, type A : 50, 80, 100, 200, 500, 800, 1000, 2000, 3200, 5000, 6000, 8500, 10 000 c/s;
and if considered useful, 30, 40, 11 000, 12 000 and 15 000 c/s;

— for a normal circuit type B and for an old-type circuit : 50, 80, 100, 200, 500, 800, 1000, 2000, 3200, 5000 and 6400 c/s.

The results of these measurements are carefully recorded on a " line-up record " * and also the values of unweighted noise and psophometric voltage measured at the end of the circuit.

RECOMMENDATION N.23

4. ROUTINE MAINTENANCE MEASUREMENTS

The following routine maintenance measurements are made *every two months:*

a) Measurement of " 600-ohm through relative level "

The " 600-ohm through relative level " at the end of the programme circuit is measured at the following frequencies :

— for a normal circuit, type A : 50, 100, 200, 800, 3200, 5000, 6000, 8500 and 10000 c/s;
— for a normal circuit type B and for an old-type circuit : 50, 100, 200, 800, 3200, 5000 and 6400 c/s.

After this measurement, the " 600-ohm through relative level " at 800 c/s is adjusted, if necessary, to its nominal value.

If it is found that the 600-ohm through relative level for a particular frequency at the end of the circuit is not within the specified limits, the reference measurements should be repeated, calling in the frontier stations to determine the faulty sections, and the circuit is then restored, further overall measurements being made to ensure that the normal values are obtained.

b) Measurement of circuit noise

At the time of the two-monthly maintenance measurements, the noise at the end of the circuit should be measured using the C.C.I.T.T. programme circuit psophometer (see the weighting curve of this psophometer in Supplement No. 19).

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* See, as example, the model in Appendix VIII.

APPENDIX VIII

LINE-UP RECORD FOR A PROGRAMME CIRCUIT

Technical Service of :	Zürich
Circuit designation :	Stuttgart-Zürich R 3
Control station :	Zürich
Sub-control station :	Stuttgart
Type of circuit :	Normal
Date of measurements :	2 September 1960
Issue dated :	1 October 1960

" *Loss-frequency* " characteristic

Frequency (c/s)	Niveau relatif de tension (in nepers or decibels) or 600-ohm through level when 0.775 volt is applied at the (two wire) sending end		
	Horb	Donau-eschingen	Zürich
30 ***	0.71	0.74	0.68
40 ***	0.72	0.74	0.69
50	0.72	0.75	0.69
80	0.73	0.76	0.71
100	0.75	0.76	0.72
200	0.75	0.77	0.73
500	0.75	0.78	0.73
800	0.74	0.78	0.74
1 000	0.73	0.78	0.75
2 000	0.75	0.78	0.75
3 200	0.75	0.77	0.75
5 000	0.75	0.76	0.76
6 000 **	0.74	0.75	0.74
6 400 *			
8 500 **	0.73	0.74	0.72
10 000 **	0.72	0.72	0.70
11 000 ***			
12 000 ***			
15 000 ***			

Noise: Psophometric noise 2.4 mV
Flat unweighted noise 19 mV

* Normal programme circuits, type B and old-type circuits.
** Normal programme circuits type A only.
*** Measurements at these frequencies will be made only if considered useful.

SECTION 6

LINING-UP AND MAINTENANCE OF LONG-DISTANCE TELEVISION TRANSMISSIONS

CHAPTER I

RECOMMENDATION N.50 *

DEFINITION OF THE CONSTITUENT PARTS OF AN INTERNATIONAL TELEVISION LINK. TECHNICAL RESPONSIBILITIES DURING AN INTERNATIONAL TELEVISION TRANSMISSION. GENERAL ORGANIZATION OF INTERNATIONAL TELEVISION TRANSMISSIONS

1. In order to apportion the responsibilities during a television transmission there is need to distinguish (see Figure 23 below):

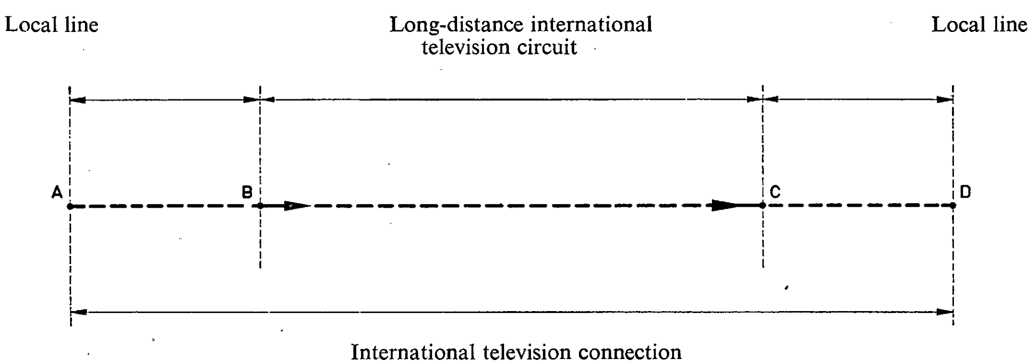


FIGURE 23

a) The point to be regarded as the origin of the television transmission (point A). This point is either the source of the programme (the originating studio or outside broadcast point), or a point such as a television switching centre or the location of a standards converter.

b) The outgoing local line, which connects point A to the first repeater station, point B.

c) The (long distance) *international television line* (line BC) consisting in principle of a chain of national and international *television transmission circuits*, the national circuits being of the same type as if they were international circuits.

* Recommendation N.50 is taken from Recommendation No. 267 of C.C.I.R. (Los Angeles 1959).

d) The incoming local line which connects the last repeater station (point C) to point D, the point of destination of the television transmission.

e) Point D, the point of destination of the television transmission. This point may be an incoming studio, a broadcasting station, a television modulation centre or the location of a standards converter.

2. The complete line between A and D, including the long-distance international television line BC and the local lines (AB and CD) is the " *international television link* ".

3. Points A and B are as a general rule under the authority respectively of the sending and receiving television authorities *.

Points B and C are under the authority of the telecommunication administrations of the countries concerned **.

In certain cases, the exact location of points B and C of a long-distance line may not be clearly evident. In such cases, the point to be regarded as the end of the long-distance line for a particular television transmission should be fixed by agreement between the telecommunication administrations and the television authorities concerned.

The long-distance international television line BC is, in almost all cases, the sole responsibility of the telecommunication administrations, but some parts of this line (national or international circuits) may be the property of the television authorities **.

The local lines may be the responsibility of either the telecommunication administration or the television authority, or of both jointly, according to the local arrangements in each country.

4. Control and sub-control stations

The *control station* (station directrice) of the international television line BC is Station C at the incoming end.

Station B at the outgoing end is the *sub-control station* (station sous-directrice) for the international television line BC.

Each transit country also designates a sub-control station for the international television line.

Each circuit forming part of the long-distance international television line retains its customary control station (station directrice).

5. Multiple television transmissions or broadcasts

A multiple television transmission occurs when the same programme is transmitted to several television transmitting stations or recording centres.

* If a telecommunication administration is responsible for a standards converter or a television switching centre or a broadcasting station, the administration is considered, in these Maintenance Instructions, to be a television authority.

** If a television authority has accepted responsibility for one or more repeater stations, it is treated in the present Maintenance Instructions as a telecommunication administration.

If the branching point of the television transmission circuits is at the originating point of the programme, each transmission channel to a receiving television authority is considered as an individual " international television link ".

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, programme circuits and television circuits, required for the transmission in question,
— to ensure that the programme transmission proceeds normally once the television circuits are handed over to the television authority for the relay concerned.

6. 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, switching centre or television transmitter). This circuit is paid for by the television authority.

The vision control circuit is additional to the control circuits associated with programme circuits set up for transmitting the sound of the television programme (see Recommendation N.3).

The conditions governing the provisions and lease of control circuits for television transmissions are given in Recommendations E.57 andE.58 in Volume II*bis* of the C.C.I.T.T. *Red Book.*

CHAPTER II

RECOMMENDATION N.55

CONSTITUTION, LINE-UP AND SUPERVISION OF THE INTERNATIONAL TELEVISION LINK

(It is supposed that the international television link AD is as shown in the diagram of Figure 23. It is also supposed that the various circuits to be interconnected to provide the international link are permanent circuits which have been regularly maintained.)

1. Definition of the line-up period and preparatory period

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 line before handing it over to the television authorities;

) the *preparatory period* during which the television authorities carry out their own adjustments, tests and other work before the television transmission itself commences.

2. Duration of the line-up period and the preparatory period

The lengths of the line-up period and the preparatory period are specified in Figure 24.

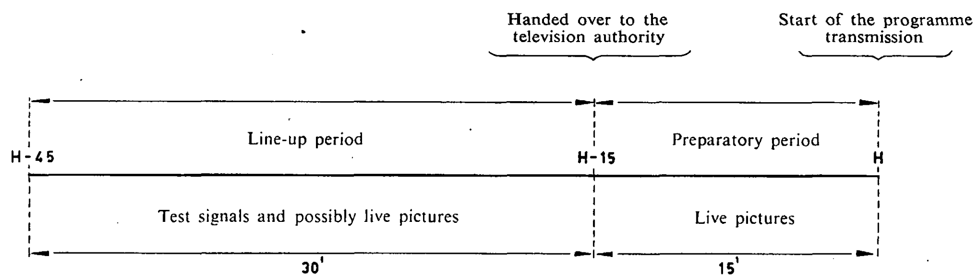


FIGURE 24

All the adjustments between H-45 and H-15, 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 only begins at H-15, the end of the line-up period and the beginning of the preparatory period.

Note on the subject of 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) forming part of an international television line are already in use for a programme transmission during the period immediately preceding the time when it is required to establish the international line.

In these circumstances a reduction in the duration of the line-up period may have to be contemplated. It will be assumed that because a programme 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 programme transmission over them.

3. Measurements during the line-up period and during the preparatory period

Measurements during the line-up period are carried out by the telecommunication administrations. They comprise adjustments made using Test Signals Nos. 1 and 2 (and where necessary by transmitting pictures).

When these preliminary adjustments have been made, the local lines are joined to the long-distance international television circuit at the terminal repeater stations. This is the end of the " line-up period " and the beginning of the " preparatory period " and is the moment when the complete link is handed over to the television authorities. The measurements during the preparatory period are carried out by the television authorities.

4. Monitoring television transmissions

4.1. *Technical control*

Technical control by the telecommunication administrations of a television transmission in progress should be possible at any time :

— at television modulation centres on the link;

— at the last station immediately preceding the frontier of each country (by providing demodulators if necessary).

These centres and stations should be equipped with an oscilloscope (the horizontal deflection of which is synchronized to the line frequency) for monitoring the electrical signal and a television " monitor " for monitoring the complete picture.

4.2. *Charging*

The monitoring of an international television transmission for charging purposes is carried out at the terminal repeater station of the international television line.

The technical staff of the designated repeater stations should come to an arrangement among themselves so that at the end of the television transmission they have accurate knowledge of:

a) the time of handing over the television line to the television authority (beginning of chargeable duration);

b) the time at which the television line 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 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 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.

CHAPTER III

RECOMMENDATION N.60

ESTABLISHMENT AND MAINTENANCE OF INTERNATIONAL CIRCUITS (PERMANENT) FOR TELEVISION TRANSMISSIONS

1. Establishment of the circuit

The conditions for establishing an international television circuit (i.e. the adjustments required before putting the international television circuit into service for the first time) are determined by agreement between the telecommunication administrations concerned.

2. Reference measurements on the circuit

The reference measurements are measurements, chosen from the lining-up measurements, which are made in detail at all useful points when establishing the circuit. These reference measurements will be used later when it is desired to check the line-up of the circuit or to localize a fault.

3. Routine maintenance measurements of the circuit

The results of measurements for preventive maintenance made on an international circuit for television transmission should be compared with the results of the reference measurements made when the circuit was first set up. If the difference obtained exceeds the permissible limits, the circuit should be considered as faulty and the fault localized.

The measurements and their periodicity will be as follows :

Measurement	Periodicity
1. Measurement of insertion gain using Test Signal No. 2	At least weekly
2. Noise measurements	Weekly
3. Measurement of non-linearity distortion using Test Signal No. 3	Monthly
4. Waveform tests using Test Signals Nos. 1 and 2	Monthly

Tolerances have been shown for the hypothetical reference circuit. The tolerances for actual circuits are still under study.

The measurement methods, the test signals to be used and the values specified for the hypothetical reference circuit are given hereafter.

ANNEX

(to Recommendation N.60)

Taken from Recommendation No. 267 of the C.C.I.R. (Los Angeles, 1959)

. . . .

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 Figure 23 above) and which may be of either radio or coaxial-cable type, are:

— the overall length between video terminal points is 2500 km (1600 miles approx.),
— 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 synchronizing-pulse regenerator.

Note. — The purpose of the hypothetical reference circuit concept is 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, in the case of a television circuit, a defined number of video-to-video sections. It is appreciated that at the present time international television circuits generally contain more than three video-to-video links in a 2500 km length but it is expected that the number will be reduced in the course of time.

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 section 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 $\pm$ 1 db.

The insertion gain should be measured using Test Signal No. 2 (described in Annex I) and is defined as the ratio, expressed 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, and having an internal impedance of 75 ohms (resistive), is adjusted so that if connected directly to a 75-ohm resistance it would produce a line-synchronizing signal of 0·3 volt combined with a picture signal of 0·7 volt* which may include 0·05 volt of pedestal. At the receiving end, the voltage between the black level and white level (bar amplitude) is measured, using an oscilloscope connected across

* 1 volt for the 525-line system used in Japan.

a 75-ohm resistance. The ratio of this voltage to 0·65 volt if pedestal is used, or 0·7 volt if it is not, expressed in decibels, is the insertion gain of the television circuit.

3.2 *Insertion gain variations*

For the hypothetical reference circuit, the variations of insertion gain with time should not exceed the following limits :

— short-period (e.g. 1 second) variations : ± 0·3 db;
— medium-period (e.g. 1 hour) variations : ± 1·0 db.

3.3 *Noise*

3.3.1 *Continuous random noise*

he signal-to-noise ratio for continuous random noise is defined as the ratio, expressed in decibels, of the peak-to-peak amplitude of the picture signal to the r.m.s.* amplitude of the noise within the range between 10 kc/s and the nomina 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.

For the hypothetical reference circuit, the signal-to-noise ratio should be not less than the values X given in the following table 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 second.

System	Number of lines	405	525	625	625	819	819
	Nominal upper limit of video frequency band f_c (Mc/s)	3	4	5	6	5	10
Signal-to-weighted-noise ratio X (db)		50		52	57		50

Note 1. — To obtain satisfactory transmission performance, television specialists believe that the signal-to-weighted-noise ratio should neither fall below X db for more than 1% of any month, nor below $(X-4)$ db for more than 0·1% of any month. This latter ratio might be reduced to $(X-8)$ db if desired by C.C.I.R. Study Group IX,** but any proposal for a greater reduction would need to be studied carefully.

Note 2. — One possible device for measuring signal-to-weighted-noise ratio is described in Doc. No. XI/25 (Moscow, 1958) and Doc. C.M.T.T./23 (Monte-Carlo, 1958) of the U.S.S.R.

3.3.2 *Periodic noise*

The signal-to-noise ratio for periodic noise is defined as the ratio, expressed in decibels, of the peak-to-peak amplitude of the picture signal to the peak-to-peak amplitude of the noise.

* 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.

** This value was adopted at the IXth Plenary Assembly of the C.C.I.R. (see Recommendation No. 289).

Remark. — This definition has so far been used in specification clauses dealing with single-frequency noise and with power-supply hum (including the fundamental frequency and lower-order harmonics), but it may prove to be useful also for any case in which two or more sinusoidal components are in harmonic relationship.

For the hypothetical reference circuit, the signal-to-noise ratio should not be less than the value given in the following table :

System	Number of lines	405	525	625	625	819	819
	Nominal upper limit of video frequency band f_c (Mc/s)	3	4	5	6	5	10
Signal-to-noise ratio (db) for power-supply hum (including the fundamental frequency and lower-order harmonics) *		30		30	30	30	30
Signal-to-noise ration (db) for single-frequency noise between 1 kc/s and 1 Mc/s		50		50	50	50	50**
Value (db) to which the signal-to-noise ratio for single-frequency noise may decrease linearly between 1 Mc/s and f_c		25		30	30	30	30***

3.3.3 *Impulsive noise*

The signal-to-noise ratio for impulsive noise is defined as the ratio, expressed in decibels, of the peak-to-peak amplitude of the picture signal 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 the 525-line system, on which no information is available.

3.4 *Non-linearity distortion*

Non-linearity distortion affects both the picture signal and the synchronizing signal.

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.

* 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.

** In the case of the 819-line system (10 Mc/s video bandwidth) for frequencies below 1 kc/s 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 kc/s and 45 db at 100 c/s, and between the values 45 db at 100 c/s and 30 db at 50 c/s.

*** In the case of the 819-line system (10 Mc/s video bandwidth), this figure is reached at a frequency of 7 Mc/s and remains constant between 7 Mc/s and f_c (10 Mc/s).

**** The corresponding terms in French are respectively : distorsion non-linéaire aux fréquences très basses, aux fréquences moyennes, aux fréquences élevées.

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 of frequency 0.2 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 sawtooth.

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 of the signal. The display then has the form indicated in Figure 3 ** and the line-time non-linearity distortion is indicated by changes in amplitude across the display.

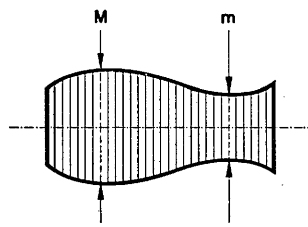


FIGURE 3

For the hypothetical reference circuit, the ratio m/M should not be less than 0·80 whether the intermediate lines are at black or white level.

3.4.3 *Short-time non-linearity distortion of the picture signal*

This matter is still under study ***.

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 irrespective of whether the intermediate lines are at black level (S_a) or at white level (S_b).

The ratio S_a/S_b therefore lies within the limits 0·64—1·57.

3.5 *Linear waveform distortion*

3.5.1 *Field-time waveform distortion — 405-line, 625-line and 819-line systems*

For the hypothetical reference circuit, using Test Signal No. 1 (described in Annex I) the received waveform displayed on an oscilloscope should lie within the limits **** of the mask shown in Figure 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

* Although this signal is agreed for international use, the United Kingdom proposes to use a " staircase " signal for testing its national television links.

** The numbers of the figures below are those of Recommendation No. 267 of the C.C.I.R.

*** In several countries such measurements are currently being carried out using Test Signal No. 3 with a higher value than 0·2 f_c for the frequency of the superimposed sine-wave (see Doc. C.M.T.T. No. 41—Chairman's report).

**** These limits correspond, for the 405-line system, to a rating factor (K) of 5% ($K = 0{\cdot}05$) as defined in Annex IV.

the mid-points of the 10-ms " black " and " white " portions coincide with A and B respectively.

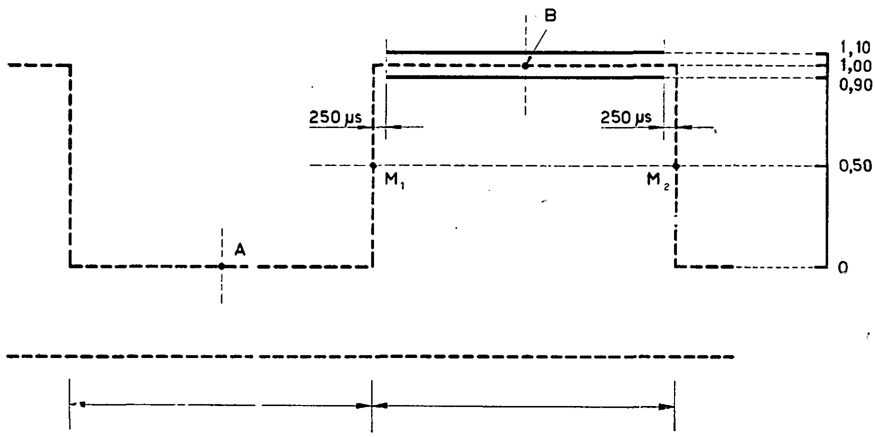


FIGURE 4

Waveform response to Test Signal No. 1

3.5.2 *Line-time waveform distortion*

405-line system

For the hypothetical reference circuit, using Test Signal No. 2 (described in Annex I) with a rise-time of 2 T (0·33 μs) and with an interval of 0·1 H between the bar and the succeeding synchronizing pulse, the received waveform displayed on an

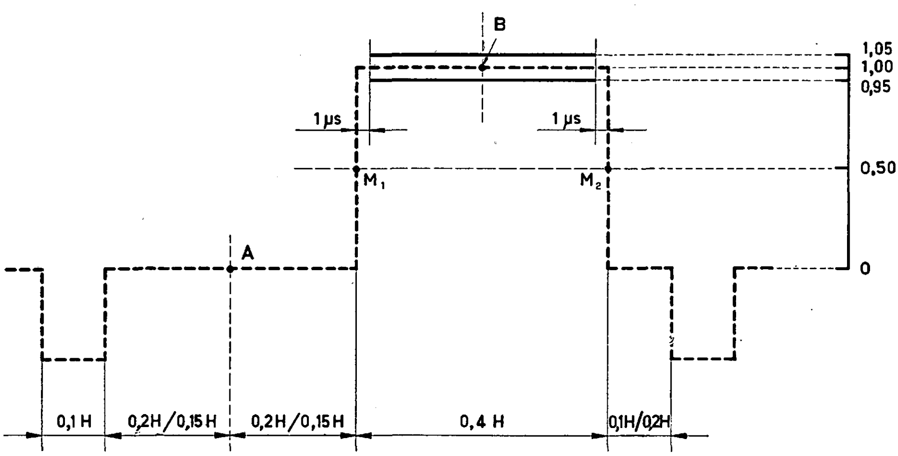


FIGURE 5

Waveform response to Test Signal No. 2

oscilloscope should lie within the limits * of the corresponding mask shown in Figure 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.

* These limits correspond, for the 405-line system, to a rating factor *(K)* of 5% (K = 0·05) as defined in Annex IV.

525-line system

Information not available.

625-line and 819-line systems

For the hypothetical reference circuit, using Test Signal No. 2 (described in Annex I) with a rise-time of T* the received waveform displayed on an oscilloscope should lie within the limits of the mask shown in Figure 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.

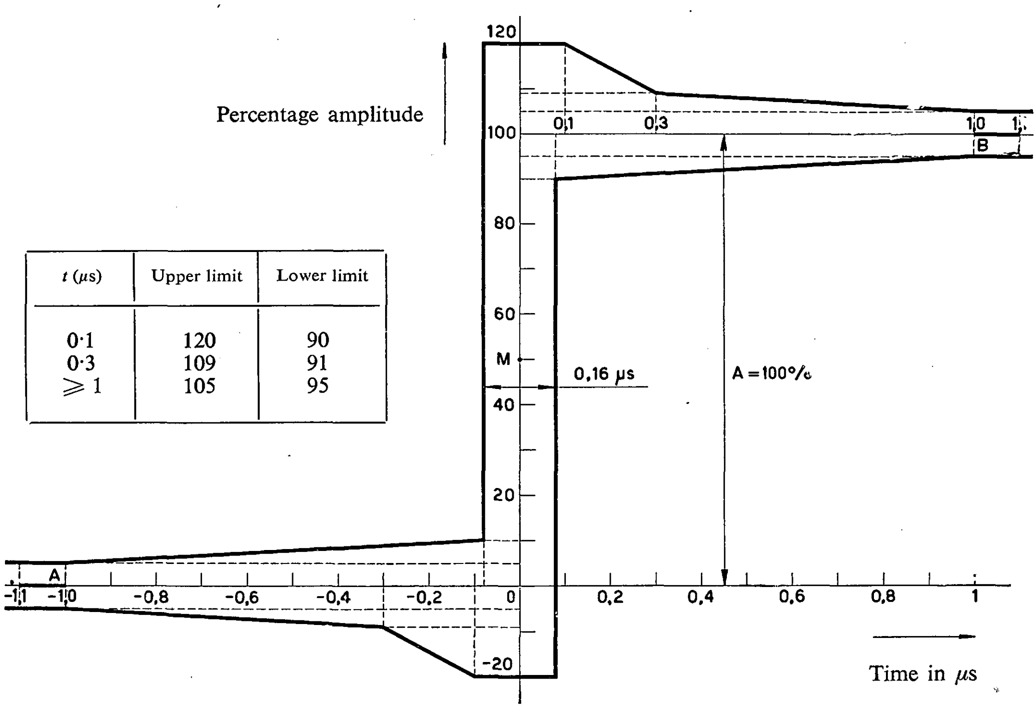
3.5.3 *Short-time waveform distortion*

405-line system

For the hypothetical reference circuit, the rating factor (K) as defined in Annex IV should not exceed 5% ($K = 0{\cdot}05$). For this measurement, Test Signal No. 2 (described in Annex I) should be used with an interval of 0·1 H between the bar and the succeeding synchronizing pulse and with a sine-squared pulse of half-amplitude duration T (0·17 μs) inserted in the interval "A ".

525-line system

Information not available.



t (μs)	Upper limit	Lower limit
0·1	120	90
0·3	109	91
$\geqslant 1$	105	95

FIGURE 6

Mask for waveform response, using Test Signal No. 2, for the 625-line and 819-line Belgian systems ($f_c = 5$ Mc/s)

* For circuits which cut off sharply close to the nominal upper video-frequency limit, it may be necessary to use a rise-time of $2T$.

625-line systems and 819-line systems

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 Figures 6, 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.

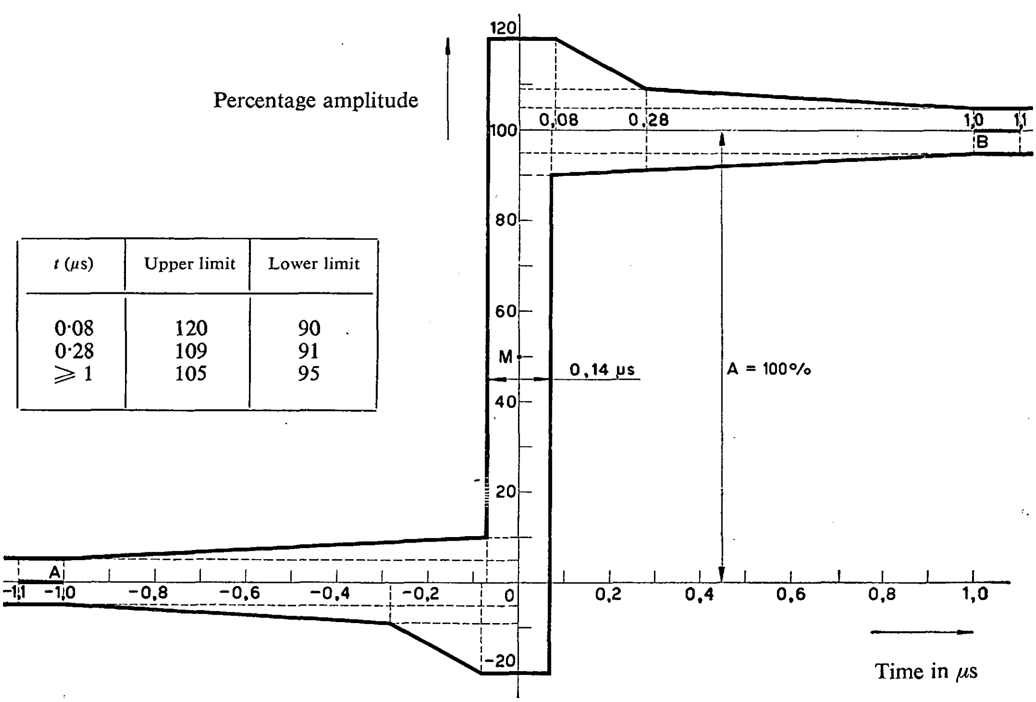
If ringing is present in the regions A and B, the peaks of the oscillations should be set symmetrically with respect to A and B.

For the hypothetical reference circuit, the response should lie within the limits of the appropriate mask as follows :

— Figure 6 for the Belgian 625-line system ($f_c = 5$ Mc/s), and the Belgian 819-line system ($f_c = 5$ Mc/s),

— Figure 7 for the 625-line system ($f_c = 6$ Mc/s),

— Figure 8 for the other 625-line system ($f_c = 5$ Mc/s) and the 819-line system ($f_c = 10$ Mc/s).

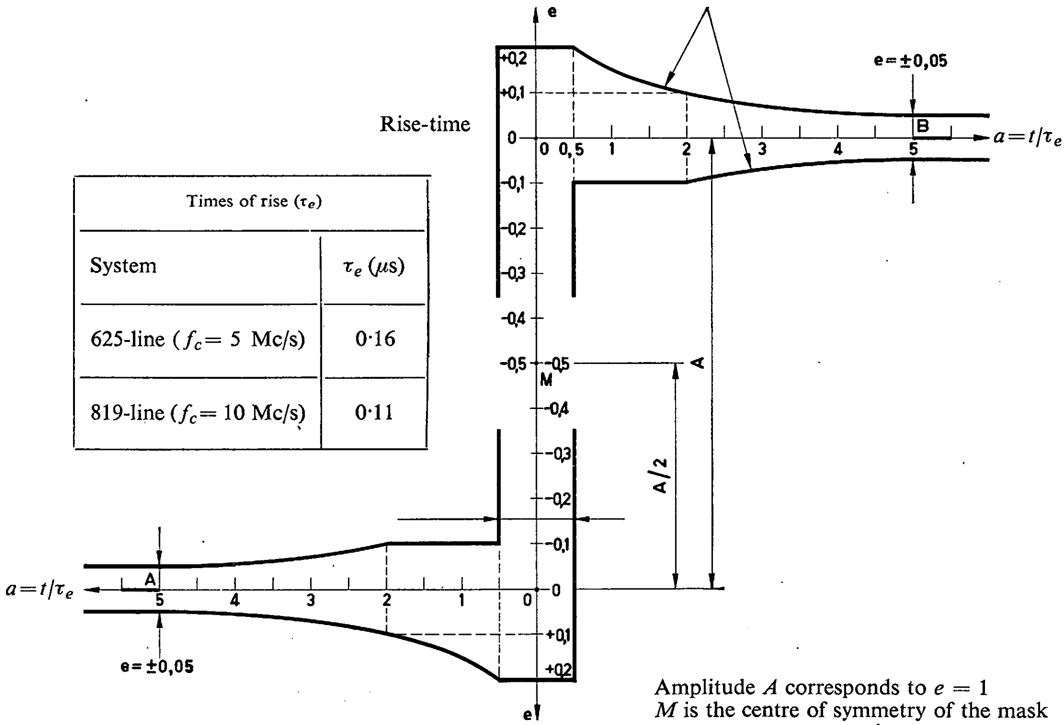


t (µs)	Upper limit	Lower limit
0·08	120	90
0·28	109	91
$\geqslant 1$	105	95

FIGURE 7

Mask for waveform response to Test Signal No. 2, for the 625-line system, in a 8 Mc/s radio channel ($f_c = 6$ Mc/s)

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



Times of rise (τ_e)	
System	τ_e (μs)
625-line (f_c= 5 Mc/s)	0·16
819-line (f_c= 10 Mc/s)	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 the 625-line (f_c = 5 Mc/s) and 819-line (f_c = 10 Mc/s) systems

3.6 *Steady-state characteristics*

3.6.1 *405-line system*

For the hypothetical reference circuit, as a precaution against possible overloading effects, the insertion gain at any frequency between the field-repetition frequency (50 c/s) and the nominal upper limit of the video-frequency band (3 Mc/s) should not exceed the gain at the line-repetition frequency (10 kc/s) by more than 5 db.

3.6.2 *525-line system*

Information not available.

3.6.3 *625-line and 819-line systems*

For the hypothetical reference circuit, the limits of the attenuation-frequency and envelope-delay/frequency characteristics given in Figures 9 and 10 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).

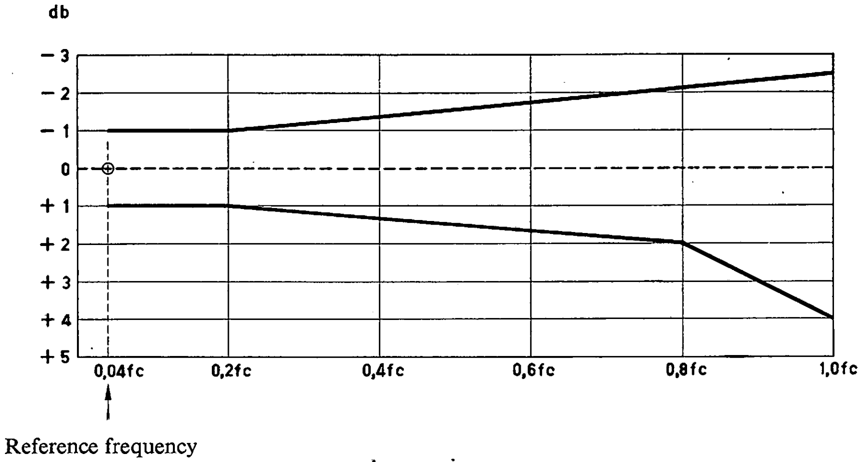


FIGURE 9

Limits for the attenuation/normalized-frequency characteristic for television systems with nominal upper limits of the video frequency band f_c = 5, 6 and 10 Mc/s respectively

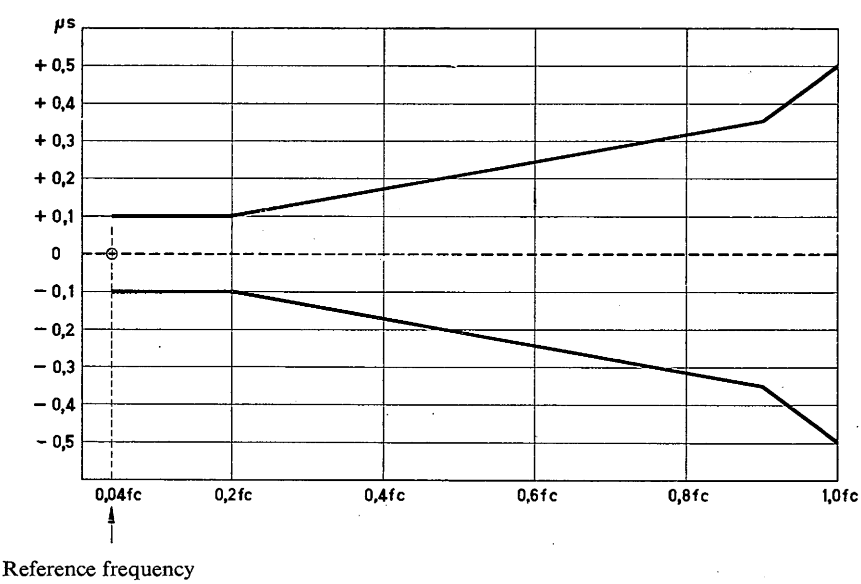


FIGURE 10

Limits for the envelope-delay/normalized-frequency characteristic for television systems with nominal upper limits of the video frequency band f_c = 5, 6 and 10 Mc/s respectively

ANNEX I

Test signals

Test Signal No. 1

Test Signal No. 1 is used in the measurement of field-time waveform distortion. As shown in Figure 11, 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.

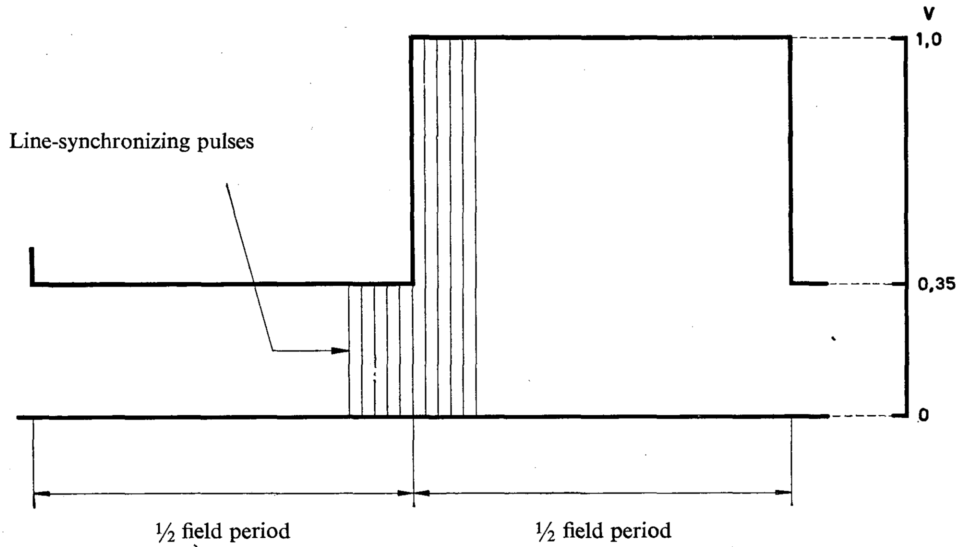


FIGURE 11

Test Signal No. 1

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 Figure 12, 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 $0{\cdot}1H$ or $0{\cdot}2H$, 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, 1952, Vol. 99, p. 373). Two alternative networks may be used giving rise-times of T and 2 T, where $T = 1/2f_c$, f_c being the nominal upper video-frequency limit of the system.

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* ".

Test Signal No. 3

Test Signal No. 3 is used in the measurement of non-linearity distortion. As shown in Figure 13 it is a signal in which the " picture " portion of every fourth line consists of a sine-wave of 0·1-volt 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.

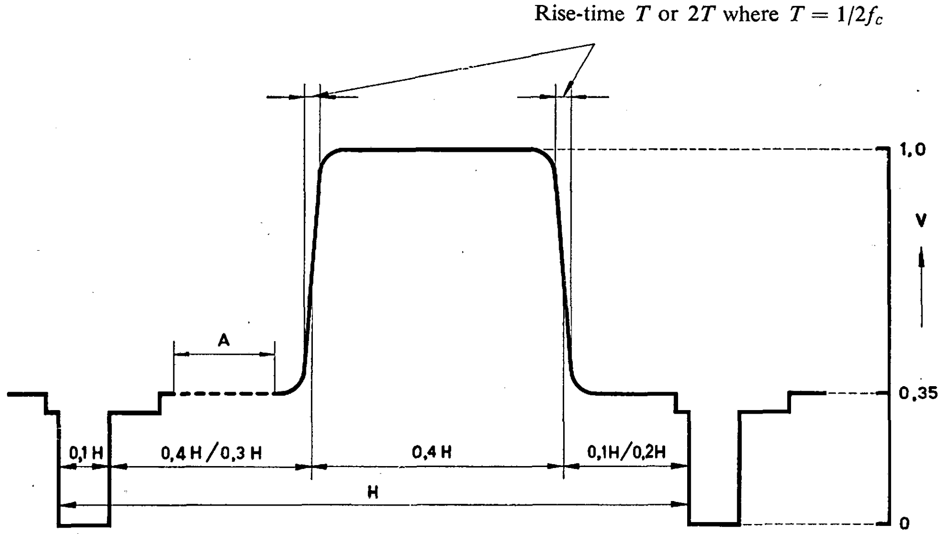
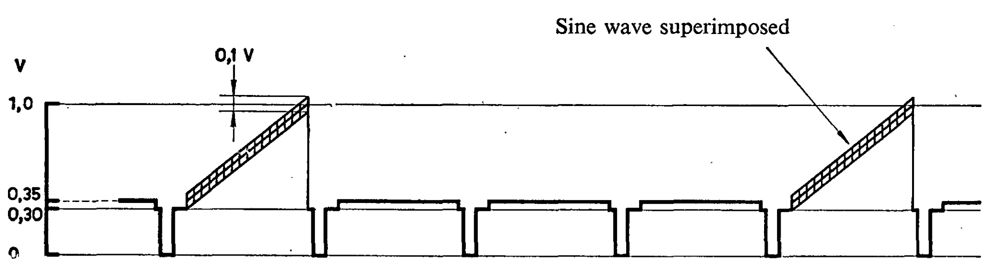
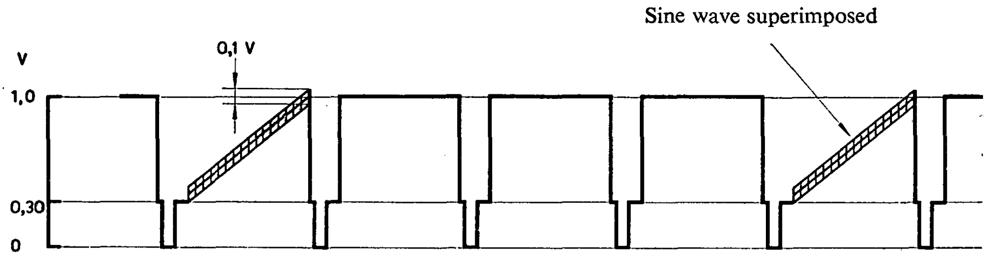


FIGURE 12

Test Signal No. 2



(a) Intermediate lines at black level



(b) Intermediate lines at white level

FIGURE 13

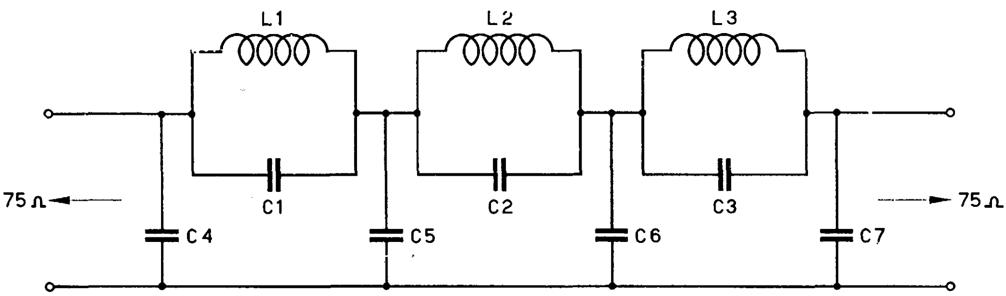
Test Signal No. 3

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.

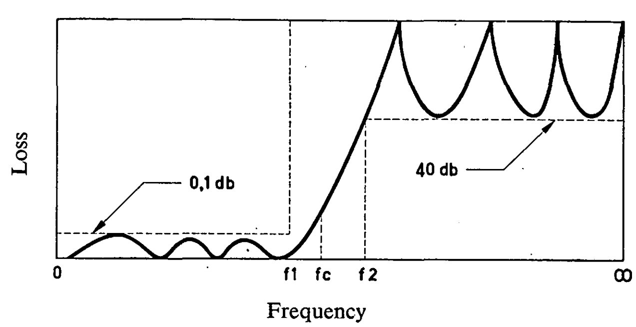
ANNEX II

Low-pass filter for use in measurements of continuous random noise



	Nominal upper video-frequency limit f_c (Mc/s)		
	L (μH)	C (pF)	f (Mc/s)
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		$1297/f_c$	

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

$f_1 = 0.9\ f_2$ by design

Ringing frequency $= f_c$ by design

$f_1 = 0{\cdot}9807\ f_c$

$f_2 = 1{\cdot}0897\ f_c$

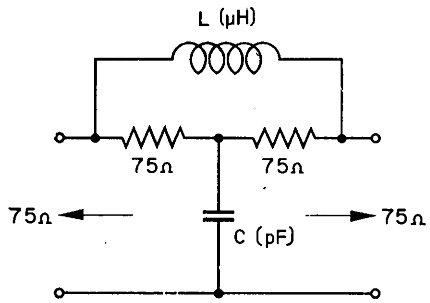
Note 1. — Each capacitance quoted is the total value, including all relevant stray capacitances and should be correct to $\pm 2\%$.

Note 2. — Each inductor should be adjusted to make the insertion loss a maximum at the appropriate indicated frequency, f (Mc/s).

Note 3. — The Q of each inductor measured at the frequency f_c should be between 80 and 125.

ANNEX III

Continuous-random-noise weighting networks



$$L(\mu\text{H}) = 75\,\tau(\mu\text{s});\ C(\text{pF}) = \frac{\tau(\mu\text{s})}{75} \cdot 10^6$$

$$\text{Insertion loss (db)} = 10 \log_{10} (1+\omega^2\tau^2)$$

Number of lines	f_c (Mc/s)	τ (μs)	τf_c	Theoretical weighting (db) for :	
				" White " noise	" Triangular " noise
405	3	0·33	1·0	6·5	12·3
525	4				
625	5	0·33	1·66	8·5	16·3
625	6	0·33	2·0	9·3	17·8
819	5				
819	10	0·166	1·66	8·5	16·3

f_c is the nominal upper video-frequency limit of the system (Mc/s)

PART II

MAINTENANCE QUESTIONS

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MAINTENANCE QUESTIONS ENTRUSTED TO STUDY GROUP IV IN 1961-1964

Question 1/IV

(Former question 1 of Study Group 4, studied in 1957-1960)

Stability in the European network

Transmission stability on European international circuits. Long-term variations in the circuit-equivalent as a function of time. Causes of these variations.

Note. — Reference should be made to the conclusions reached as a result of the observations made from 1957 to 1960. These appear in the form of supplements in the documentary part (Part III) of this volume.

Supplement No. 9 — Results of the sixth series of tests on the variation of overall loss of international circuits.

Supplement No. 10 — Results of observations of variation of overall circuit loss made in the U.S.S.R. (1956 to 1960).

Supplement No. 13 — Measurements made on batches of circuits in 1959 and 1960.

The following should be borne in mind :

a) the comments on the measurements made on batches of circuits;

b) the target objectives for the future.

These are dealt with in paragraphs 3 and 4 of Supplement No. 9

Question 2/IV

(Former question 2 of Study Group 4, studied in 1957-1960)

Short breaks in transmission

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 to a minimum the scale of short breaks, interruptions or level variations.

Note 1. — Study of this question should enable the telegraph services :

— to determine the scale 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 over a V.F. telegraph channel, by making a detailed analysis of the distribution of these incidents.

Note 2. — 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 this volume (investigations from 1956 to 1960).

Note 3. — Annex 1 gives the findings and comments of C.C.I.T.T. Study Group 4 as a result of the investigation made on question 2 of Study Group 4 between 1957 and 1960; this question was specially concerned with interruptions of short duration in transmission.

Note 4. — C.C.I.T.T. Study Group 4 has recommended that the procedure used by the Swiss Administration (see Annex 2) should be used for studying the duration of interruptions.

Note 5. — Annex 3 gives the commentaries of C.C.I.T.T. Study Group 9 (which was replaced in 1961/1964 by Study Group IX) concerning the study of level variations of short duration and the influence of these variations on telegraph transmission.

ANNEX 1

(to Question 2/IV)

Conclusions reached by S.G.4 * of the C.C.I.T.T. following the study of question 2 in 1957/1960

REPLY

1. The 6th series of tests of international circuits provided recordings of short breaks in transmission and sudden variations of overall loss, as well as observations of long-term variations of overall loss. Short breaks have been classified according to their causes. The report submitted by Mr. Billen's Working Party (see Supplement No. 9 in Part III (Documentary) of the present Volume of the *Red Book*) includes tables with the number and percentage of short breaks as a function of their duration and causes.

2. The report has been widely circulated among C.C.I.T.T. Study Groups, particularly S.G. 9.** The number of sudden variations which can be deduced from Annexes 20 and 21 to Mr. Billen's report appears excessive to Study Group 9 taking account of the value of three errors in 100 000

* Becomes Study Group IV in 1961/1964.

** Becomes Study Group IX in 1961/1964.

characters, which is the target figure for telegraph transmission, as defined in C.C.I.T.T. Recommendation F. 7. This value of 3 per 100 000 has to include not only disturbances in line transmission but also errors in the telegraph equipment itself.

3. Study Group 4 asked administrations which took part in the sixth series of tests on circuits to study the correlation between the frequency at which occur falls in level of a value above or equal to, in one case, 0.6 N and, in the other case, 1.5 N.

The Swiss Administration, aided by the Italian Administration, did a series of tests on one circuit (Lugano-Genova) lasting 18 weeks. The test frequency was transmitted and supervision of interruptions was effected from Lugano, while the circuit had a low-frequency loop at Genova.

There is an 85% correlation between the falls in level of 0.6 neper or more and those of 1.5 neper or more. More extensive observations should be undertaken to confirm this value.

A scrutiny of the recordings shows that :

a) in most instances, an abrupt reduction was shown in the 0.6 N recording as well as in the 1.5 N recording, it being noted that the length of the 0.6 N variation was slightly longer than the 1.5 N variation. This seems to show that the sides of the curve of the sudden change are not quite straight.

b) As was expected, the limited changes of level (between 0.6 and 1.5 N) were recorded only in the category $\geqslant 0.6$ N. This was checked from the recording of the overall loss.

c) In a few rare instances, for the same overall variation, a sudden variation of $\geqslant 0.6$ N was recorded with two shorter sudden variations of $\geqslant 1.5$ N. This is due to a variation in the depth of the overall sudden variation.

4. The Netherlands Administration made a complementary analysis of the recordings of sudden variations made during the 6th test series.

a) The Netherlands Administration noted that there was a close correlation between very short breaks (lasting less than 10 milliseconds) and long breaks (above 300 ms). This is explained by the fact that the ballistic recorders cannot distinguish between a long break and a large series of short breaks following one another at short intervals. This fact has already been pointed out by the Federal German Administration, and it also explains why, during the metering done in the U.S.S.R. with electronic counters which work more quickly than paper chart recorders, there was a considerably higher percentage (70%) of breaks of less than 20 ms than was found during the 6th series of tests.

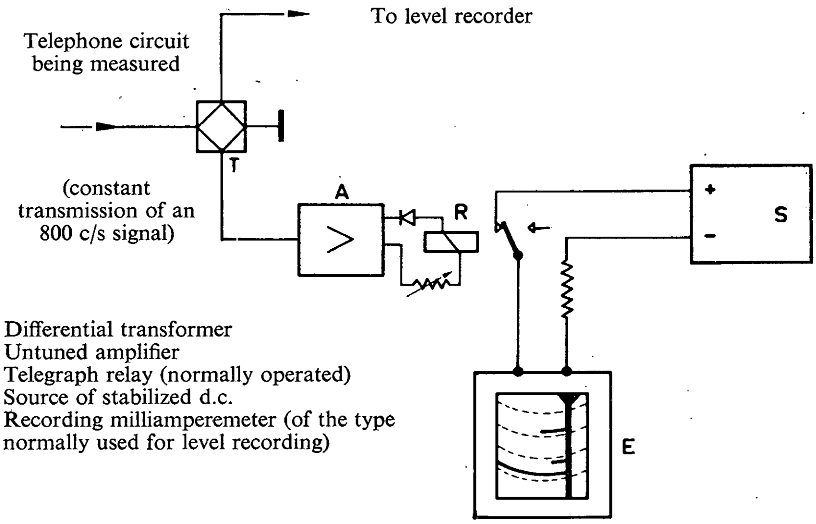
b) A statistical analysis has been made of the duration between two consecutive breaks. Converting the values obtained into a graph of probabilities, it is found that the duration between two breaks follows a Poisson's law.

5. According to the observations of the Netherlands, Swiss and Soviet Administrations, there is a close correlation between the sudden variations of a group pilot and variations of the 800 c/s measuring signal.

The next observations of sudden variations could be confined to recording on the pilots.

6. Study Group 4 took note of the results forwarded to it by the U.S.S.R. Administration concerning short-term breaks on national circuits in the U.S.S.R. (Contribution " COM 4-No. 85 "). These breaks were observed on the pilot signal of a 12-circuit group. The duration of the breaks was ascertained not by a ballistic method, but with thyratron counters.

The conclusions reached confirm those drawn as a result of the test series carried out in 1958/1959 the results of which are contained in " COM 4-No. 42 ". An improvement of maintenance quality means a reduction in the number of breaks in the pilot observed in 1959/1960.



T = Differential transformer
A = Untuned amplifier
R = Telegraph relay (normally operated)
S = Source of stabilized d.c.
E = Recording milliamperemeter (of the type normally used for level recording)

FIGURE 1

Device for recording interruptions in transmission

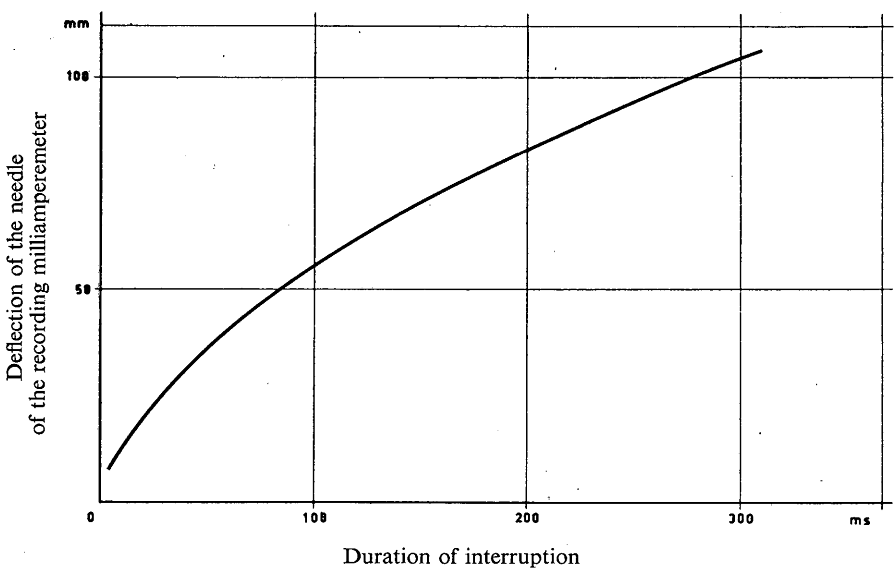


FIGURE 2

Calibration curve for the recording device

7. S.G. 4 considers that Question 2 should be kept under study. At present, S.G. 4 is not considering undertaking an international test programme with regard to sudden variations. However, it is possible that such a programme will be carried out in the interval between the IInd and IIIrd Plenary Assemblies to meet requests for information, from S.G. 9 for example. In this case, S.G. 4 noted that the ballistic recorders should be adjusted to a value of about 4 ms, so as to provide S.G. 9 with more accurate information about the distribution curve of short-term variations as a function of time than was possible with the 6th series of tests.

ANNEX 2

(to Question 2/IV)

Recording device used by the Swiss Administration for recording short breaks

1. *Recording device*

The recording device, which is as simple as possible, is indicated in Figure 1.

The 800 c/s signal, amplified and rectified, maintains the operation of a telegraph relay having a short transit time. The normal operating current of the telegraph relay is adjusted so that any fall in level greater than 1 N below the nominal value causes the release of the relay.

A stabilized d.c. source is applied to a recording milliamperemeter via the marking-contact of the telegraph relay. This d.c. is adjusted so as to obtain an almost full deflection of the milliamperemeter needle.

When an interruption to the transmission circuit occurs, the relay releases and the needle restores to zero. On termination of the interruption the relay re-operates and the needle again takes up its deflected position. When a short interruption occurs, the needle may not have sufficient time to return to zero : the length of the deflection traced by the needle bears a relationship to the duration of the interruption.

By producing circuit interruptions with different pre-determined durations, it is possible to establish a calibration curve as shown in Figure 2.

2. *Consideration of the recording system*

The interruptions are recorded on a chart calibrated in hours. It is therefore possible to establish the connection between the interruptions recorded and the work, operations, disturbances, etc., going on in the repeater stations.

The actual duration of an interruption is recorded, within the limits of accuracy of the system. It is thus possible to group the interruptions in any desired classes according to duration.

If several short-duration interruptions succeed one another very rapidly, they cannot be distinguished from a single interruption of longer duration.

Interruptions whose duration is less than 3 ms are not recorded : those of duration between 3 and 4 ms are not recorded accurately.

ANNEX 3

(to Question 2/IV)

Comments of Study Group 9 of the C.C.I.T.T. concerning the observations on short-term variations in overall circuit loss (6th series of observations)

1. The observations made show a satisfactory state of affairs as far as telegraphy is concerned as regards long-term variations in overall loss (results probably obtained by use of automatic group regulators). Thus it can be seen that, for the circuits least favourably placed as regards slow variations in overall loss, the variation in overall loss corresponding to three standard deviations is less than 0.6 N, that is to say, is unlikely to entail a major disturbance in voice-frequency telegraph systems.

2. On the other hand, Study Group 9 observed that as regards short-term variations, the situation is unsatisfactory as far as telegraphy is concerned. The figures show an average of twenty-nine isolated abrupt variations per thousand circuit-kilometres per week and 1.5 series of sudden changes (including series lasting more than an hour) which is too much.

3. Study Group 9 urges that effective action be taken to counteract the excessive number of sudden changes on circuits used in V.F. telegraphy. The report by the Working Party of S.G. 4 shows where the majority of these sudden changes comes from. These causes had already been recognized before and a text has been inserted in the Maintenance Instructions (Recommendation M. 15 of Volume IV of the *Red Book*) which lists the actions to be taken to reduce the number of sudden changes.

It is desirable that the C.C.I.T.T. should once more draw the attention of administrations to the appropriateness of these provisions.

4. Study Group 9 noted with interest the curve showing the frequency of these sudden changes in relation to their duration. From this curve can be read off the percentage of interruptions which can give rise to false clearing signals. It was noted, however, that the lack of precision in the operating threshold of the various devices used by administrations taking part in the tests is such that the curves cannot be guaranteed for durations shorter than 20 milliseconds.

Study Group 9 desires that for any new measurements to be made by means of this equipment the operating threshold should be adjusted to the value recommended by the Swiss Administration in the Annex 2 above, that is, approximately 4 milliseconds, so as to be able to draw more accurate conclusions for the distribution curve with time of short-term variations.

5. Study Group 9 believes that it would be desirable in future to record short reductions in level taking 0.6 neper instead of 1 neper as the operating threshold of the recording device. Falls in level of more than 0.6 neper are, in fact, liable to cause considerable distortion in amplitude-modulation systems.

6. It would also be interesting to observe the correlation between the frequency with which falls in level greater than or equal to the recommended value of 0.6 neper, on the one hand, and a fixed figure of 1.5 neper, on the other hand, appear on a given circuit.

These data would be particularly useful in showing the respective advantages of frequency-modulation voice-frequency telegraph systems and of amplitude-modulation voice-frequency telegraph systems of modern design which are unaffected by sudden changes in level. Administrations which participated in the tests might be able to carry out this correlation study fairly rapidly by using the devices mentioned on Annex 2 above to make simultaneous recordings of falls in level corresponding to thresholds of 0.6 and 1.5 neper.

7. The telegraph services meanwhile will continue to record interruptions on the alarm channels of international voice-frequency telegraph networks. Study Group 9 draws the attention of the telegraph services to the value of making periodic checks of the condition of telegraph channel equipment (bad contacts, dry joints, etc.).

8. Study Group 9 proposes that, when a new series of tests is made, records should not be limited to falls in level of 0.6 neper below the nominal value, but should also include short variations (both falls and *increases* in level), the amplitude of which might be greater than 0.6 neper and the duration of which might be less than 1 second.

Such a count could be made on a small number of (V.F.T.) circuits to see whether there is a significant difference between the number of short variations defined in this way and the number of falls in level measured in accordance with paragraph 6 above.

Question 3/IV

(Former question 3 of Study Group 4, studied in 1957-1960)

Sudden phase-changes

What are the actual values of sudden phase-changes observed under working conditions on carrier telephone circuits used for voice-frequency telegraphy?

Note 1. — This question is in response to a request made by the telegraph services for the purpose of forming recommendations for the use of frequency-modulated systems of voice-frequency telegraphy.

Note 2. — As a result of their study of this question in 1957/1960, S.G. 4 of the C.C.I.T.T. came to the conclusion that, *at the present time*, 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 4 nevertheless noted that, although the question of phase-changes was not pressing as regards the 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.

Question 4/IV

(New question)

Maintenance responsibilities of the two terminal stations of a link or circuit

The general use of group and supergroup pilots has brought a new trend to the organization of maintenance, by giving ever growing importance to the station at the receiving end of a circuit.

In view of this situation, should the present Maintenance Instructions be revised as regards the role of the two stations at the ends of a telephone circuit? Similarly, should the role of the two stations at the ends of a telephone circuit (control and sub-control station) be revised?

Question 5/IV

(New question)

Readjustment to the nominal value (Recommendations M.53, 56 and 65)

What are the results of applying the provisions for systematic readjustment to the nominal value advocated in Recommendations M.53, M.56 and M.65? Should the text of these recommendations be made more specific?

Question 6/IV

(New question)

Automatic regulation of groups and supergroups (Recommendation M.18)

What are the results of the application of the directives in Recommendation M.18 concerning group and supergroup regulation? Should amendments or additions be made to these directives?

Has experience revealed any problems related to the existence of several automatic level regulators in tandem on one connection (line, mastergroup, supergroup, or group regulators)? If so, what would be the best way of arranging the time constants?

Question 7/IV

(New question)

Definition of a " hypergroup " link

Is there a need to introduce the concept of a general type of transmission path having a defined bandwidth, being formed by interconnection of different types of systems, taking account of frequency translation and filtration at intermediate points, and analogous to the group, supergroup or mastergroup link, as suggested in the annex below?

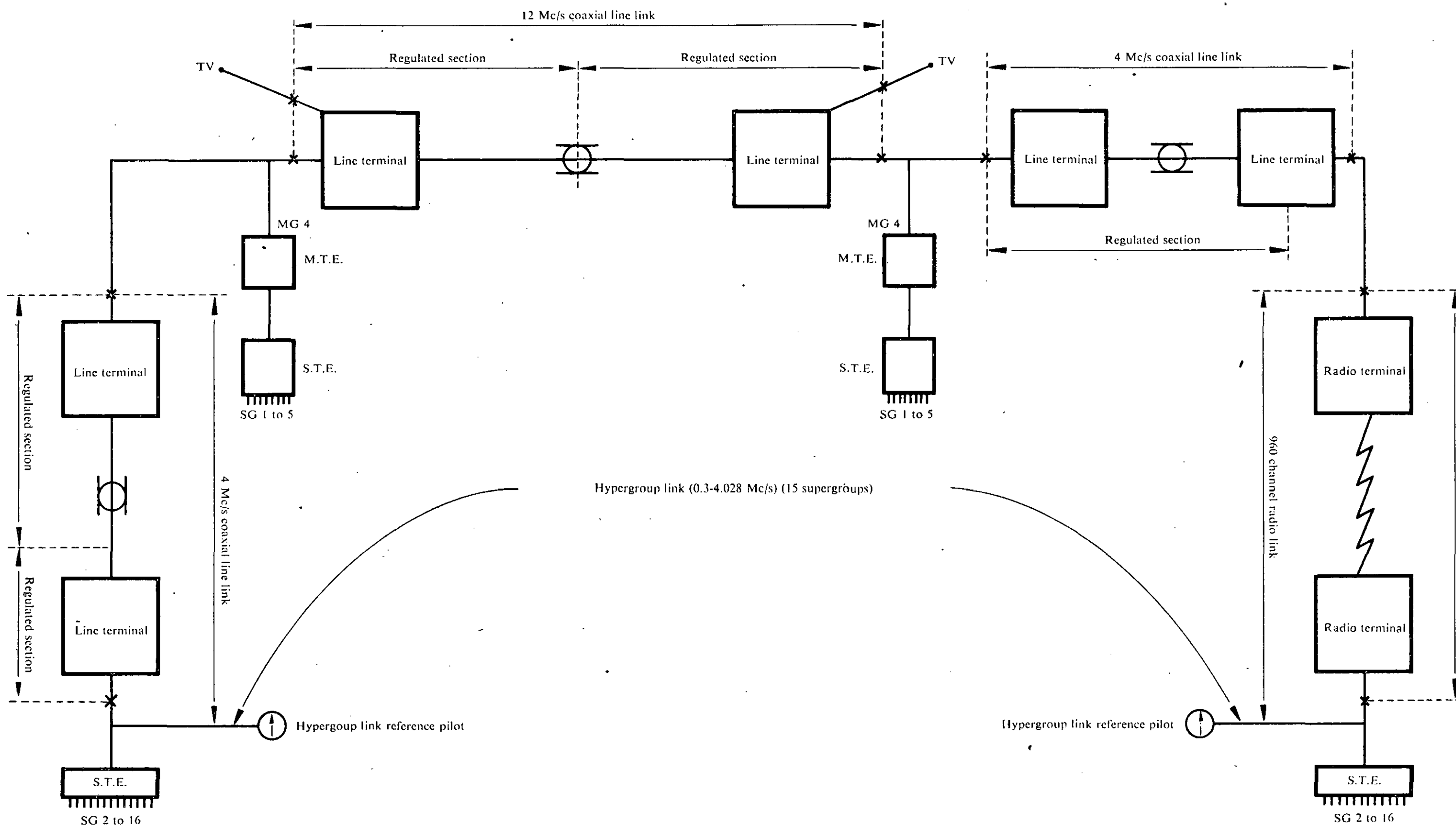


FIGURE 3

Hypergroup link composed of two 4 Mc/s coaxial line links, one 12 Mc/s coaxial line link (lower part of band), one 960-channel radio link: six regulated line sections

M.T.E. : Mastergroup translating equipment

S.T.E. : Supergroup translating equipment

ANNEX

(to Question 7/IV)

Proposal by the British Administration to introduce the concept of a " hypergroup " link

It is clear that there is a need for the concept of a more general type of transmission path of defined bandwidth, formed by interconnection between different types of systems, taking account of frequency translation and filtration at intermediate points and analogous to the through group, through supergroup or through mastergroup.

It is proposed that such a transmission path should be called a " hypergroup link f_1 to f_2 " (where f_1 and f_2 are the upper and lower frequency limits) and should extend from the point at which the band of frequencies is assembled to that at which it is broken down (by filtration or frequency translation) into constituent bands such as groups, supergroups, etc. (The term " hypergroup " is commonly used in the United Kingdom to mean block of frequencies forming a switching or flexibility unit).

The following definition is therefore proposed in the spirit of the analogous terms on page 29 of the present Volume :

" *Hypergroup link f_1 to f_2*

An assembly of the means of transmission of a large block of telephone channels, bandwidth nominally $f_1 - f_2$ kc/s, on symmetric pair or coaxial cable, radio relay or waveguide systems or any combination of these. It extends from the point where the channels are finally assembled (by filtration or frequency translation) into the link bandwidth to the point where they are first dispersed."

Further experience will probably show whether it is necessary to introduce an overall link reference pilot. Figure 3 shows how a 4 Mc/s link may be composed and the relation with line links and regulated line sections.

Question 8/IV

(Former question 8 of Study Group 4, studied in 1957-1960)

Measurement of a circuit between 4-wire ends

The recommendations for the overall loss of an international circuit (Recommendation G. 131, § B of Volume III of the *Red Book*) apply to its terminal conditions, i.e. to the circuit between two-wire points.

However, where circuits are used in automatic working and the circuits terminate on automatic switches or relay sets and do not have a four-wire terminating set, would it no be better :

— to specify the overall loss of a circuit as a four-wire loss between the points where the circuit is switched, and

— to test the circuit between these points?

Recommendation M. 66 specifies the arrangements to be made regarding the measurement of circuits between 4-wire ends.

Should these recommendations be completed or modified?

Question 9/IV

(New question)

I.M.C. for manual circuits

Extension to manual circuits of the organization defined for the I.M.C. (International Maintenance Centre) in the " Guiding principles for the maintenance of automatic circuits ".

Question 10/IV

(New question)

Routine measurements or batch tests

In view of the rapid growth in the number of international circuits, the increasing use of group and supergroup pilots, and the intended introduction of automatic measuring methods for circuits, is there a need to reconsider the present methods of routine maintenance testing for circuits in international networks?

Is it necessary to revise the existing arrangements for carrying out routine maintenance measurements?

Should the present methods be replaced by batch tests, and the form of the maintenance accordingly simplified?

Note 1. — See the Annex below, which describes tests carried out by the United Kingdom and Netherlands Administration in 1960 and Supplement no. 13 which gives the report of S.G. 4 in 1960 concerning the results of measurement on batches of circuits made in various European Administrations.

Note 2. — If the existing form of the Routine Maintenance Programme is to be altered, Study Group II should be informed, since the Programme at present replaces lists of circuits.

ANNEX

(to Question 10/IV)

Contribution by the Netherlands and United Kingdom Administrations on an experimental method of making routine test measurements using the " batch " principle

1. The present method employed for routine testing of international circuits is considered to be becoming cumbersome from an organization and efficiency point of view, and does not lend itself to an improved standard of performance of international circuits.

2. The existing method is based on spreading over the days of each week a small number of circuits to be tested on a number of different traffic routes. In London for example, on most days, routine tests are made on the average to about seven different centres in five different countries. This means that it is necessary to arrange and establish co-operation with all these

centres each day, and because of the increasing quantities of circuits to be tested, there is difficulty in organization, the loss of much time and effort, and a greater possibility of routine tests on some circuits not being made.

3. The experiment on the United Kingdom-Netherlands route is being conducted on the basis of measuring *all* circuits on a given traffic route on one day or during one period, and the object of this method is,

a) to enable a more accurate assessment of the variability of the circuits on a traffic route to be obtained;

b) to reduce the ineffective time and loss of man-power which inevitably occur with the existing method;

c) to direct the available maintenance effort to the best advantage as a result of analysis of the measurements on a traffic route as a whole. For example, Table I gives the values of the mean deviation from the nominal value, and the standard deviation of six traffic routes of circuits measured on a batch basis during one week. Of the six routes, clearly routes 1, 2 and 3 require attention and it would therefore be more advantageous to employ the maintenance effort on these routes.

d) to endeavour to establish a correct periodicity for such routine measurements.

TABLE I

Traffic route No.	Mean deviation from nominal db	Standard deviation db
1	—3.4	1.8
2	—1.1	2.4
3	—2.0	2.7
4	—0.3	1.6
5	—0.6	1.9
6	—0.3	1.8

4. *Method employed*

Since April 1960 a new maintenance method has been carried out on all direct circuits between London and Amsterdam/Rotterdam. The measurements at 800 c/s in accordance with the international maintenance programme were stopped, and instead, all circuits were measured together each fortnight. At the same time daily measurements on the group reference pilots were made at the terminal repeater stations and at the coastal stations.

Before the measurements were begun all the groups were relined. During the first measurements some additional corrections were carried out.

Question 11/IV

(Former question 11 of Study Group 4, studied in 1957-1960)

Automatic transmission measuring equipment for the maintenance of automatic circuits

To facilitate routine maintenance measurements, can an automatic equipment be used to find out whether the margins of the overall loss of a (semi-) automatic telephone circuit are exceeded?

(Q. 11/IV)

If so :

a) What recommendations should be established for such an automatic equipment (i.e., basic clauses of a model specification)?

b) Would it be possible to make routine maintenance measurements at 800 c/s less frequently or even to cease them and to make only the multi-frequency routine maintenance measurements at several frequencies, and if so, how often?

Note. — A working party on " Automatic transmission measuring equipment " (Chairman : Mr. Lindström, Sweden) was instructed by the Plenary Assembly of the C.C.I.T.T. :

a) To prepare specifications for a series of a limited number of automatic transmission measuring equipments intended for use in repeater stations.

b) To arrange for tests with these equipments similar to those carried out in the trials of international semi-automatic systems in the international testing polygon.

c) To prepare final specifications for the automatic measuring equipment based on the results of these tests.

The Plenary Assembly of the C.C.I.T.T. expected that the automatic transmission measuring equipment to be used in the test series would be designed by the middle or the end of 1962, it being assumed that the relevant specifications would be drawn up by the middle of 1961 by the working party.

In preparing the report, account will be taken of the comments submitted by the administrations on the draft specifications for the equipment (Contribution " COM.4 — No. 91 ")—these comments to be submitted by 1st April 1961.

Question 12/IV

(Former question 12 of Study Group 4, studied in 1957-1960)

Maintenance of television circuits

What kind of amendments and additions should be made to the " Instructions for the setting-up and maintenance of an international circuit for television transmissions "?

Question 13/IV

(New question)

Equipment for the maintenance of programme circuits

Can an arrangement consisting of an automatic device sending a series of consecutive measuring frequencies plus an appropriate measuring unit be used to facilitate routine maintenance measurements on programme circuits, and for making accurate measurements during the line-up period on an international programme link? If so, what recommendations should be laid down for such equipment (basic clauses of a model specification)?

Note. — See the annex below.

ANNEX

(to Question 13/IV)

Testing equipment used for radio circuits by the Netherlands Administration

General

In co-operation with the Netherlands Broadcasting Organization, the Netherlands P.T.T. Administration has evolved apparatus for making maintenance tests on radio circuits. It consists of an automatic signal generator and a measuring device.

The equipment can be used :

a) on the four national line-broadcasting distribution networks;

b) on radio circuits supplying the transmitters. (These networks are fed from a single central point, namely the Hilversum programme-circuit switching-centre);

c) on radio circuits used for commentaries.

The test equipment includes an automatic signal generator, and results in considerable economy, especially for circuits under *a)*.

Signal generator

The part of the generator which determines the frequency is varied automatically by a step-by-step device. The components governing the frequency have been so chosen that it is possible to measure the frequency characteristic of a radio circuit between 50 and 10 000 c/s.

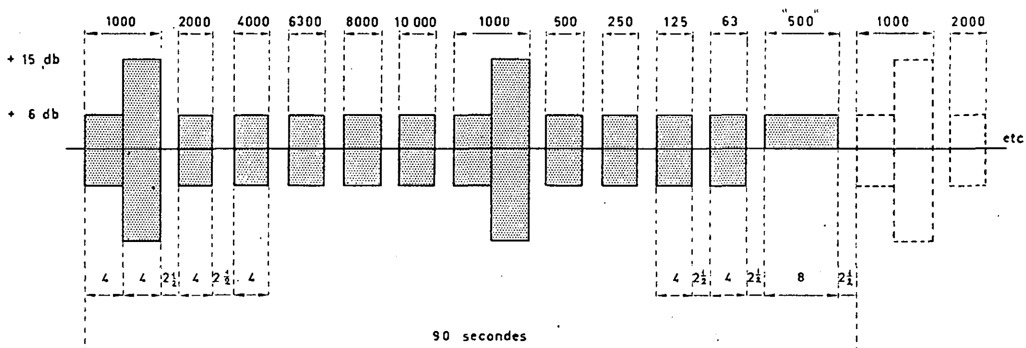


FIGURE 4

The level sent by the signal generator is 9 decibels below the maximum modulation level (modulation 100%). So that the radio transmitters can be adjusted to the maximum modulation and so that the radio circuit distortion can be observed at the same time (whence it can be ascertained whether the radio circuit can transmit the maximum level without difficulty) a level corresponding to 100% modulation is sent for a frequency in the range. At the end of the cycle is sent a rectified signal to an alternation of a clearly audible frequency. This signal makes it possible to define the polarity of the radio circuits, which is necessary in cases where, for stereophonic transmission, it is desired to set up two radio circuits over the same path. The cycle is composed as shown in Figure 4. With regard to the choice of frequencies, we took as a basis the system proposed by the " International Standardization Organization ", Technical Committee No. 43. The standardized system is based on a frequency of 10^n c/s (n = whole number) in which the spacing between the successive frequencies is an octave (or half or a third of an octave as the case may be). In the present case $n = 3$. Except for frequencies of 6300 and 10 000 c/s (separated by 8000 c/s, of one third of an octave) the interval between all the frequencies is an octave.

The characteristics of the generator are as follows:

transmitter level: + 6 db (100% — level + 15 db)

level tolerance: $\pm$ 0.2 db

internal resistance: $\leqslant$ 6 ohms for the frequency 10 kc/s

frequency stability: $\frac{\Delta f}{f} = 5.10^{-3}$

non-linear distortion:

— for 63 c/s, (6 db) and 1000 c/s, (15 db): $k < 3$ ‰

— for the other frequencies: $k < 2$ ‰

The characteristics are guaranteed between 10° C and 40° C.

Measuring equipment

This apparatus is equipped to measure:

a) the attenuation-frequency curve,

b) the non-linear distortion,

c) the noise, and

d) the polarity.

To this end, the apparatus is equipped with transistorized amplifiers, the advantage of which is that the measurements can also be made at places where there is no possibility of plugging in. Since the batteries are incorporated in the apparatus, it is of universal use.

a) Attenuation-frequency curve

By means of a rectifier, the needle directly indicates the attenuation. The indication desired is obtained by means of additional resistances connected in series. The level corresponding to the maximum modulation for a frequency of 1000 c/s is led, under automatic control, through an attenuation of 9 db. The needle then gives the same indication as for the other frequencies.

For cases where only the attenuation-frequency curve is of interest, it is planned to provide only the facility described for the measuring equipment, in which case the construction is very simple. In its more complicated form, the measuring instrument can measure distortion, noise and polarity.

b) Distortion

For measuring distortion, the apparatus is equipped with a high-pass filter and a three-stage transistorized amplifier. The filter cuts out the frequency of 1000 c/s and lets through the harmonics of 1000 c/s, which are then amplified independently of the frequency. Before the distortion is measured, the apparatus is calibrated in per cent of non-linear distortion. With an attenuation of 40 db and a three-stage amplifier, the apparatus is adjusted to 1% of the distortion for the frequency of 1000 c/s. Then the filter is put into circuit and the distortion is measured. If a measurement of the distortion for a frequency of 1000 c/s at a maximum modulation is required, it is necessary once more to apply the attenuation of 9 db at the input of the apparatus.

Since it is a question of being able to recognize serious distortion easily—i.e. of the order of 5% and more—this measurement does not call for a high degree of accuracy.

c) Noise

The noise is measured in an unbalanced manner with the aid of the three-stage transistorized amplifier.

d) Polarity

To measure the polarity of the radio circuit, the signal generator emits a test signal rectified to an alternation and composed of positive demi-periods of a sine wave. In the measuring apparatus the positive and negative parts of that signal are rectified separately. Then the values of the continuous voltages obtained are subtracted from one another. Depending on the polarity of the signal, the needle will swing to the right or the left, and it can thus be determined whether the radio circuit should be connected *a/b* or *b/a*.

In order to show which frequencies are emitted, the system is equipped with a one-stage transistorized amplifier and a loud-speaker. The order of the frequencies has been chosen in such a way as to avoid any doubt. The loud-speaker can also be used to obtain a physiological impression of the degree of inconvenience of the noise.

Question 14/IV

(New question)

Maintenance of intercontinental automatic circuits

Maintenance arrangements for intercontinental automatic and semi-automatic circuits.

ANNEX

(to Question 14/IV)

Proposals by the American Telephone and Telegraph Company submitted at New Delhi

(November 1960)

Uniform testing and maintenance methods and practices are needed to provide for effective, rapid and efficient testing and restoration of intercontinental and inter-regional circuits. These methods and practices should be established for both manual and automatic testing.

The following features should be considered :

a) Outgoing testing equipment in the four-wire part of the circuit.

b) Manual outgoing testing equipment arranged for :

1. Positive indication if circuit is busy (occupied).
2. Outgoing test calls.
3. Measurements of overall circuit loss.
4. Noise measurements.
5. Signalling tests.
6. Tests to incoming manual or automatic testing equipment.

c) Automatic outgoing testing equipment arranged for :

1. Automatic outgoing test call to incoming automatic testing equipment.
2. Overall circuit transmission loss measurement to incoming automatic testing equipment.

3. Overall circuit noise test to incoming automatic noise test termination.

4. Overall circuit signalling tests to incoming automatic testing equipment.

d) Four-wire terminations for incoming test equipment.
e) Patch-jacks, in addition to test jacks, for rapid restoration of services.
f) Maintenance objectives for transmission loss and noise.
g) Positive indication if the incoming test equipment is busy (occupied).
h) Uniform signals from automatic incoming and outgoing testing equipment to ensure compatible operation.

Question 15/IV

(New question)

Application of quality control to maintenance measurements

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.

ANNEX 1

(to Question 15/IV)

Scope of the question — Comments by Mr. A. D. Litton (Ireland)

When the number of circuits or groups of circuits becomes large, considerable time is required by maintenance staff in making and recording transmission measurements if each and every circuit has to be measured and tested on a routine basis for overall control purposes. Time and effort are also required to readjust such circuits whose equivalent may be found to be outside quite narrow limits. The question is, therefore, posed, can statistical sampling and control methods be used to lessen this work and, at the same time, give the controlling staff a clearer overall picture of the performance of circuits, groups of circuits or routes, with a known probability of sampling error in observations? Furthermore, can a statistical technique be recommended by which short-term, or random and non-significant fluctuations in equivalent, due for example to variations in power supply voltages, be separated from reasonably long-term trends which may be caused, for example, by valve ageing? If such be possible, a large amount of maintenance effort could be saved in carrying out readjustments in level, due to a cause which would correct itself in a short time. Such a readjustment necessitates another change in level when the transitory cause has disappeared.

In this study it would seem that two statistical methods merit special attention:

1. The method of *control charts*. In this method the average equivalent of a certain number of sample measurements on circuits in a group are recorded in time sequence on

a chart on which are drawn two lines. The first, termed the " action circuit ", determines where the number of the defective circuits is with a pre-determined degree of certainty not due to chance fluctuations. It is in general convenient to draw this line so as to indicate the number of defective circuits per sample which will be exceeded by chance only in one sample in a thousand. If an observation comes above this line, fault conditions can be assumed and immediate action is taken. A second line is drawn on the chart indicating, for example, the number of defective circuits which will be exceeded only in 25 samples in a thousand; such a line is termed a " warning limit " and if two or three samples come above this line, the cause of discrepancy merits investigation.

2. The method of *sequential testing*. In this method the process of observation or sampling is cumulative, and testing is continued (the results being plotted on a graph) until successive samples are outside the région of indeterminancy. The limits of this region being so set that the results are known within a given degree of certainty, testing may therefore be discontinued when this stage has been reached.

ANNEX 2

(to Question 15/IV)

A statistical approach to telephone transmission maintenance

Abstract of the Pringle-Gaudet article " Telephone Transmission Maintenance " published in *Communication & Electronics*, 1957, No. 33

This paper discusses the application of the Shewhart control chart, a statistical device extensively used in the control of quality of manufactured products, to the control of variations in telephone trunk losses.

The basic measurement used is the trunk-net-loss-deviation, or the departure of the measured trunk loss from the designed loss, in decibels.

This measurement is subject to variability, i.e., on a number of measurements made from time to time, on the same or different facilities, the results will form a distribution, approximating the normal shape. The mean of this distribution is ideally zero, and practically all observations will fall within a range of three standard deviations (3σ) from this mean.

It is the basic statistical problem to resolve this variability into two components:

1. that due to " chance ", or to a great many small independent factors which cannot profitably be analysed;
2. that due to significant factors (assignable causes) which can be found and corrected.

The Shewhart control chart provides criteria for rational action in the face of this variability, by directing attention when the presence of assignable causes is highly probable.

The procedure is as follows :

1. From a considerable number of " base-period " observations, the distribution of results is determined, and its standard deviation computed.
2. This standard deviation is taken to represent the limit of chance variability. From it, control limits for both *average* and *range** for rational sub-groups of 5 observations are computed, and marked on a chart.
3. Measurements are made on rational sub-groups of facilities and their averages and ranges computed. These are plotted in time sequence on the control chart.
4. If either of both average and range of any particular sample exceeds the control limits, action is taken to investigate and remove the cause. If the limits are not exceeded, no action is taken. It is important that compensating adjustments should not be resorted to.
5. After a period in which a number of assignable causes have been found and removed, new tighter control limits can be computed from the experience currently obtained. This procedure can be repeated until the minimum of chance variability is determined, and the process is then controlled at that level.

The main advantage of the control-chart approach to transmission maintenance is that it permits the concentration of effort in directions where it is practically certain that removable causes can be found, and saves effort by not expending it in directions likely to be unprofitable, that is, where chance alone, or many small and hard-to-identify causes, are operating. Moreover, by withholding action in such cases, and not resorting to compensating adjustments, better overall results are obtained.

Question 16/IV

(New question)

Maintenance of new systems specified by the C.C.I.T.T.

To keep the Maintenance Instructions established by S.G. IV always up to date, new instructions should be included for systems and equipment newly specified by other study groups.

The following specific points should be examined, from the maintenance aspect, during the period 1961/1964 :

a) coaxial systems with more than 960 channels;

b) systems on small-diameter coaxial pairs;

c) systems with more than 60 channels on symmetric pairs;

d) systems with less than 12 channels per group;

* The " range " of a set of variable values is the largest value minus the smallest value of the set.

e) use of compandors on telephone circuits;

f) programme circuits :

— use of compandors,

— use of pre-emphasis and de-emphasis networks;

g) data transmission over telephone circuits;

h) out-of-band signalling systems of a carrier telephone channel (how should it be ensured that the quality of the signalling channel is adequate ?).

Question 17/IV

(New question)

Effect on maintenance of the introduction of transistors

How may the general introduction of transistors into transmission equipment affect existing maintenance methods ?

Note. — This question is designed to supply information; its main object is to give rise to an exchange of information in the light of experience gained with national networks, and possibly to lead subsequently to appropriate amendments to the C.C.I.T.T. Maintenance Instructions.

Question 18/IV

(New question)

Earthing of equipment

What methods have been used by administrations for earthing carrier equipment? What theoretical or experimental factors have let to the adoption of these methods?

Note. — This question is designed to supply information; it is not intended to propose amendments to the C.C.I.T.T. Maintenance Instructions, but to give rise to an exchange of information in the light of experience gained with national networks.

PART III

SUPPLEMENTS

(Documentary texts)

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PART III

DOCUMENTARY PART

Supplements to Maintenance Instructions

PART III

SUPPLEMENTS TO VOLUME IV OF THE RED BOOK

(Documentary texts)

METHODS OF MEASUREMENT

SUPPLEMENT No. 1

MEASUREMENTS OF LOSS

1. General

In the day-to-day setting-up and maintenance of circuits in the international telecommunication network we are most concerned with measurements of:

— loss

— levels at various points of a circuit or a transmission system.

2. Measurement of loss

a) Insertion loss

" *Definition 05.22 of the I.T.U. List of Terms and Definitions*

The *insertion loss* of a 4-terminal 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 4-terminal network concerned."

This loss is given by the expression:

$$10 \log_{10} \left|\frac{P_1}{P_2}\right| \text{ decibels or } \tfrac{1}{2} \log_e \left|\frac{P_1}{P_2}\right| \text{ nepers}$$

If the result has a negative sign, an insertion gain is indicated.

The measurement of insertion loss is made in accordance with the upper diagram of the next page. The ratio of apparent power is usually based on the ratio of the voltages across Z_R *before* and *after* the insertion of the 4-terminal network.

b) " *Composite* " *loss*

" *Definition 05.20 of the I.T.U. List of Terms and Definitions*

Composite attenuation (or gain) (in apparent power) (G.B.)

Not used (Am.)

The *composite attenuation* of a quadripole inserted between two impedances Z_E (of the generator) and Z_R (of the load) is the expression in transmission units of the ratio

$$\frac{P_0}{P_2}$$

AFFAIBLISSEMENT D'INSERTION
INSERTION LOSS

A MESURER
TO MEASURE

REFERENCE

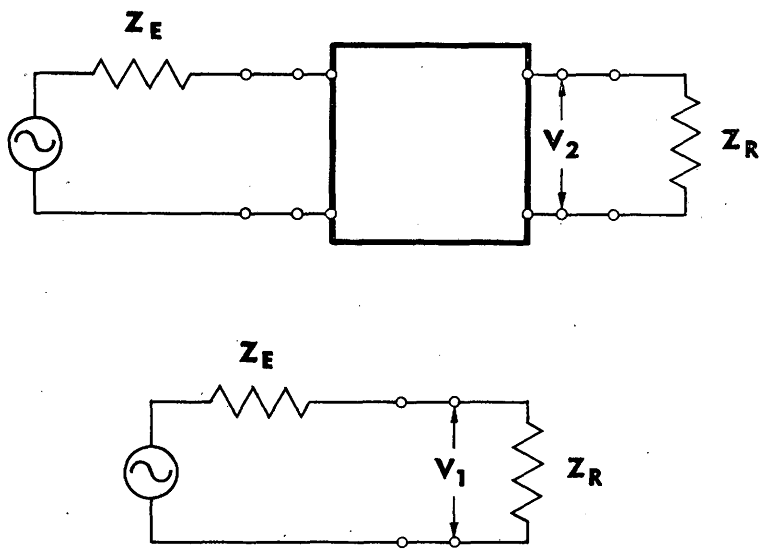


FIGURE 1

AFFAIBLISSEMENT COMPOSITE
"COMPOSITE" LOSS

A MESURER
TO MEASURE

REFERENCE

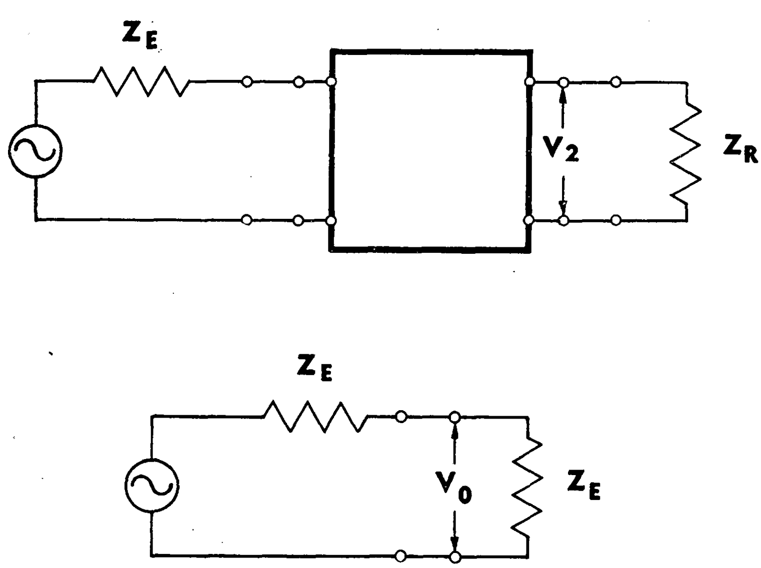


FIGURE 2

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 quadripole 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 the reference power against which the power delivered by the 4-terminal network into the receiving impedance Z_R is compared does not depend on Z_R in the case of " composite loss ". For composite loss, the reference power is constant and does not depend on the generator.

The idea of " composite loss " is convenient for theoretical calculations, but direct measurements of it are not usually made.

However, when the impedances Z_E and Z_R between which the 4-terminal network (or telephone circuit) is inserted have the same values, the " composite " loss and the insertion loss become the same *. For the special case in which the impedance is a pure 600-ohm resistance, which is taken as being the average impedance of a telephone circuit or of a subscriber's line when terminated with a subscriber's set, the insertion loss and the " composite " loss are then the same. In C.C.I.T.T. literature this is 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 (e.g. using a carrier cable pair of some 150-ohm impedance or a coaxial pair of some 75-ohm impedance).

3. 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 Chapter II, para. 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.

4. 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

* In the case of pure resistances, these two losses are also then the same as the " transducer loss " defined in 05.21 of the I.T.U. List of Terms and Definitions. Transducer loss refers to a ratio of real and not apparent powers. The idea of transducer loss is now little used in the field. The expression " composite loss " is little used in English-speaking countries.

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 quadripole are accessible at the same point, these measurements are carried out as follows (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).

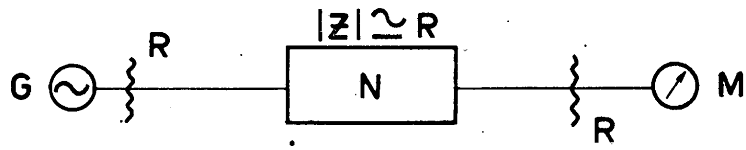


FIGURE 3

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 quadripole.

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 *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 (Fig. 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

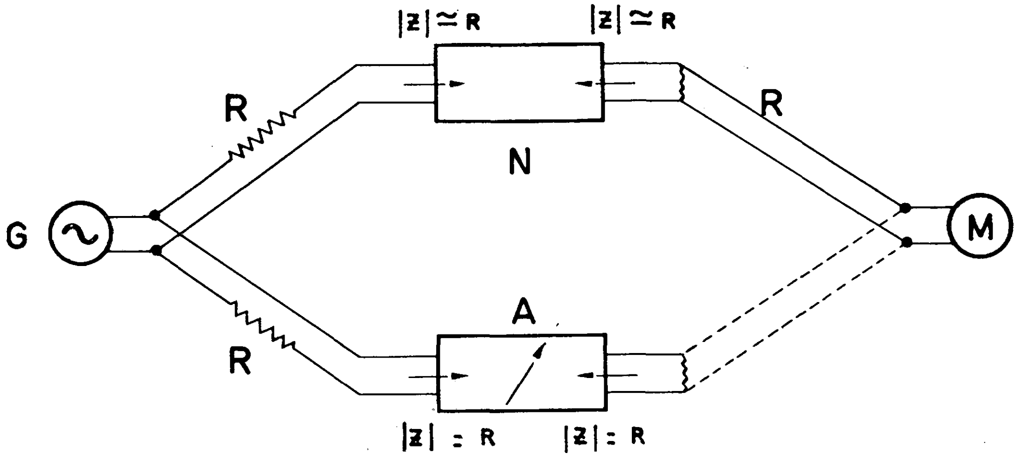


FIGURE 4

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.

SUPPLEMENT No. 2

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 measurements :

a) bridging measurements (through levels). The (high resistance) instrument is bridged across a circuit in its working condition, or

b) terminated measurements (terminated levels). 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 $10 \log_{10} \left| \frac{R}{Z} \right|$ 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 = meter reading + 9 db relative to 1 mW.

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 measurements), the instrument is calibrated to show " absolute voltage level ", i.e. the logarithm of the ratio to 0.775 volt * 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

$$\frac{1}{2} \log \left| \frac{600}{Z} \right| \text{ nepers}$$

to the reading.

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

$$\left(10 \log_{10} \frac{R}{600}\right) \text{ db or } \left(\frac{1}{2} \log_e \frac{R}{600}\right) \text{ nepers.}$$

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.

* Voltage at the terminals of a pure 600-ohm resistance when a power of 1 mW is dissipated in the latter.

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"	"140 OHM-METER"	"75 OHM-METER" DIFFERENT INSTRUMENT DEPENDING ON THE LINE IMPEDANCE
	GRANDEUR MESUREE QUANTITY MEASURED	PUISSANCE (lecture de "THROUGH LEVEL") POWER (reading of "THROUGH LEVEL")		
	LECTURE SUR L'APPAREIL METER READING	0db	0db	0db
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 N ou 0db	-0,7 N ou -6 db	-1,0 N ou -9db
	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		

FIGURE 5

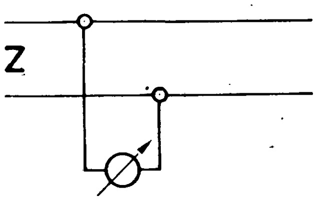
4. Differences in scales and terminology in different countries

Figure 5 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:*

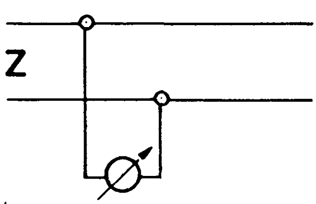
FRENCH METHOD



French term	*Corresponding English term*
Niveau absolu de tension	Voltage level (referred to 0.775 volt) or 600-ohm through level

U.K. METHODS

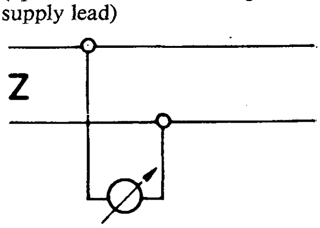
Normal line measurements



(Meter scale appropriate to circuit impedance)

English term	*Corresponding French term*
Through level	" Niveau absolu de puissance mesuré en dérivation "

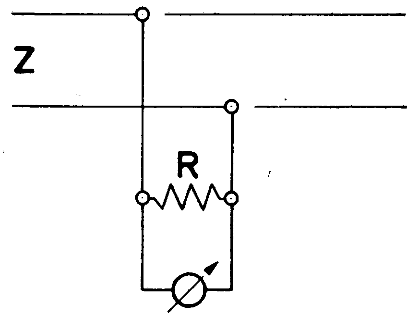
(Special measurement : e.g. carrier supply lead)



(Meter scale not appropriate to circuit impedance)

English term	*Corresponding French term*
R-ohm through level	No corresponding French term in all cases If the meter is a " 600-ohm meter ": niveau absolu de tension

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 levels**

In the I.T.U. List of Terms and Definitions, there are defined under 04.08, 04.09 and 04.10 the terms " relative power level ", " relative voltage level " and " relative current level ". These are stated to be the expression in transmission units of a ratio in which the numerator is in terms of the parameter (power, voltage or current) concerned in the relative level at the point considered, the denominator is in terms of the same parameter, at the point chosen as the origin of the transmission system.

(According to these definitions, there is a relative level of zero at the point chosen as the origin of the system.)

The idea of relative level is thus linked with a transmission system. It enables a reference value to be stated for all points in the system, so that any point can be specified. It provides theoretical information for inclusion on a level diagram. (In French, " diagramme de niveaux " or also " hypsogramme ", though the latter term is now less used.)

A theoretical distinction can be made between :

— *the* zero relative level point, which is, by convention, the origin of the transmission system, and

— *a* zero relative level point, which is any point shown on the level diagram of the transmission system as having a zero relative level. (In the case of a practical measurement, made for example by connecting an oscillator in circuit at such a point, errors may result from any departures from the theoretical levels that may exist on the system between the origin and that point.)

The origin of the system is a conventionally chosen point the position of which can be located arbitrarily. In practice, for a telephone circuit, the origin is usually chosen to be at either :

— the switchboard jack on the operators position serving the circuit, or

— the line side of the break jack on the test jack frame in the repeater station at the origin of the circuit.

Where a carrier system is concerned, the relative level is given by referring to a 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.

6. **Measurement of test level** (niveau composite)

In No. 12.20 of the I.T.U. List of Terms and Definitions, " test level " (the approximate French translation of which is given as " niveau composite ") is defined as :

> " The absolute level at a point in a (telephone) circuit when the origin (nominally the 2-wire termination) is fed by a generator having a resistance R equal to the nominal impedance at the origin and an e.m.f. equal to
>
> $$2\sqrt{\frac{R}{1000}}\text{ volts."}$$

(This means that test level is the value of the " absolute level " of power (referred to 1 milliwatt) at a point in a circuit when that circuit is fed at the origin by an oscillator sending a power of 1 milliwatt and having a non-reactive internal impedance R, equal to the nominal impedance of the circuit.)

Such an oscillator might be called a " matched 1 milliwatt generator ".

Measurements at audio-frequencies

A " matched 1 mW generator " used for audio-frequency measurements would be an oscillator having an internal resistance of 600 ohms that would send a power of 1 milliwatt into a load of the same resistance. This is then called a " *générateur normal* " or " standard generator ". Such a generator, which, to be exact, ought to be called a " generator adjusted to standard " is defined in Definition No. 12.18 of the I.T.U. List of Terms and Definitions as :

> " a generator having an internal impedance equal to a pure resistance of 600 ohms and having an e.m.f. of 2 $\times$ 0.775 volt ".

Such a generator delivers a power of 1 milliwatt into a 600-ohm resistive load.

The " standard generator " is the one regularly used as the source in transmission measurements in certain countries, particularly those where level measurements are made on a voltage basis. This generator is then used for measuring all circuits, even those having an impedance other than 600 ohms (e.g. 800 ohms).

The difference that arises when the circuit to be measured has an input impedance Z different from 600 ohms, is very small.

Level measurements on a voltage basis made on a circuit having a " standard generator " connected at the origin, are called " *dénivellement* " measurements (see Definition No. 12.17 in the I.T.U. List of Terms and Definitions). The values inserted on circuit " *hypsogrammes* " in those countries making level measurements on a voltage basis may be either values of " *dénivellement* " or relative voltage level.

SUPPLEMENT No. 3

APPARATUS FOR MEASUREMENT OF TRANSMISSION EQUIVALENT AND OF LEVEL

A. Generators for measurements on telephone circuits

a) *Frequency range and accuracy of frequency*

The generator should be adjustable to any frequency within the range 300 to 3400 c/s, any chosen frequency being accurate to ± 2% without a frequency meter being required.

It will usually be sufficient if the generator can give a certain number of discrete frequencies; in certain cases the frequency of 800 c/s alone will suffice.

b) *Internal resistance*

In the frequency range 300-3400 c/s, the generator should have a pure resistance of 600 ohms ± 2%. This resistance should be balanced about earth. The accuracy of balance should be at least 52 decibels (6 nepers).

c) *E.M.F.*

It should be possible to adjust the generator to give an e.m.f. of at least

$$2 \times 0.775 \text{ volt} = 1.55 \text{ volt}$$

[absolute voltage level of +0.69 neper (+6.0 decibels)]

Adjusted to this value, the generator is a " standard generator ". It will then deliver a p.d. of 0.775 volt and a power of 1 milliwatt to a pure resistance of 600 ohms (absolute level zero).

The adjustment of the e.m.f. (or the p.d. across a resistance of 600 ohms) may be determined by means of a level-measuring set.

The variation of the e.m.f. with frequency, relative to the value measured at 800 c/s, should not exceed ± 2% (0.02 neper or 0.2 decibel).

The harmonic distortion should be below 2%.

B. Generators for measurements on programme circuits

a) *Frequency band and accuracy of frequency*

The generator should be adjustable to any frequency within the band of 50 to 10 000 c/s at least.* It should be possible to adjust the chosen frequency to within about ± 2% without the aid of a frequency meter. (Sometimes the single frequency 800 c/s will suffice.)

b) *Internal impedance*

Within the frequency band of 50 to 10 000 c/s, the generator should have as low an internal impedance as possible. The modulus of this impedance should not exceed 30 ohms. The impedance should be balanced about earth.

* For very exact measurements, it is desirable to have generators with a wider frequency range.

c) *E.M.F.*

It should be possible to adjust the e.m.f. of the generator at least to the values :

2.2 volts and 4.4 volts

[absolute voltage level of 1.04 and 1.73 nepers = 9 and 15 decibels]

In this case the generator would deliver 8 milliwatts and 32 milliwatts respectively to a resistance of 600 ohms.

Adjustment of the e.m.f. can be made with the aid of a level-measuring set for programme circuits.

The variation of the e.m.f. as a function of frequency, relative to the value measured at 800 c/s, should not exceed ± 2% (0.02 neper or 0.2 decibel).

The harmonic distortion should be less than 2%.

Note. — A generator having an internal impedance equal to a pure resistance of 600 ohms is suitable not only for measurement of level but also (with adequate additional apparatus) for measurement of impedance, return-loss, gain and crosstalk.

C. Level-measuring sets for telephone and for programme circuits

a) *Frequency band*

The level-measuring set for telephone circuits should be suitable for measurements made in the frequency range 300 to 3400 c/s at least; the level-measuring set for programme circuits should be suitable for measurements made in the frequency range 50 to 10 000 c/s at least.*

b) *Input impedance*

The modulus of the input impedance should be high relative to 600 ohms, for example, greater than 20 000 ohms. It is sometimes desirable to alter, by means of a switch, the input impedance to a value of 600 ohms ± 2%.

In both cases, the input impedance should be balanced about earth. The degree of balance should be at least 6 nepers (52 decibels).

c) *Scale markings*

The level-measuring set should be graduated in values of absolute voltage level (in nepers or in decibels) by steps of not more than 0.05 N or 0.5 db. Calibration should be made with reference to the r.m.s. value of a sinusoidal voltage.

d) *Range and accuracy of measurement*

At a frequency of 800 c/s the accuracy of measurement of levels between + 2 and − 2 nepers (or + 20 and − 20 decibels) at least, should be ± 0.02 neper (or ± 0.2 decibel).

* For very exact measurements, it is desirable to have level-measuring sets of greater bandwidth.

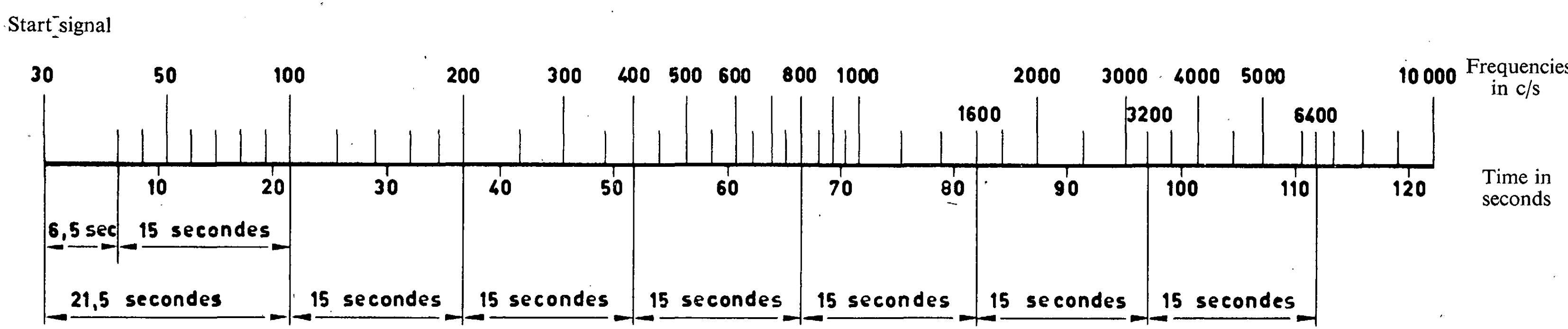


FIGURE 6

Law of succession of frequencies recommended for the automatic level recorder

Over the whole frequency band, the accuracy of measurement of levels between + 2 and − 2 nepers (or between + 20 and − 20 decibels) should be ± 0.04 neper (± 0.4 decibel).

Note. — For very precise measurements, it is desirable to use generators covering a wider frequency range.

D. Automatic level recorders (apparatus for the automatic recording of the absolute voltage levels at different frequencies)

Automatic level recorders used on international circuits (commercial telephone circuits and normal programme circuits) should satisfy the following conditions :

a) *Frequency band*

30-10 000 c/s at least *.

b) *Law of succession of frequencies with time* (see fig. 16)

from 0 to 100 c/s, linear scale,
from 100 to 10 000 c/s, logarithmic scale,

in a continuous manner from low to high frequencies.

c) *Duration of transmission and recording speed*

Duration of transmission of the band from 30 to 100 c/s, 15 seconds.

Duration of transmission of an octave in the band from 100 to 10 000 c/s, 15 seconds.

Speed of recording paper, 2 mm/sec. (7200 mm/h.) for example, with a tolerance of ± 2%.

Note. — In certain cases it may be convenient to reduce or increase the duration of transmission of an octave or the speed of the recording paper. The following supplementary values are typical :

time of transmission :	7.5 sec./octave and 60 sec./octave
speed of paper :	0.5 mm/sec. and 4 mm/sec.
in extreme cases :	30 mm/h.

It is convenient to arrange at the sending station for momentary suppressions of the sending voltage during the frequency sweep so as to facilitate identification of the frequencies at the receiving station.

d) *Start signal*

A signal is sent from the transmitting station 6.5 seconds before the frequency 30 c/s is sent on the line.

* For very precise measurements, it is desirable to have automatic level recorders with a wider frequency range.

The characteristics of this signal are :

frequency : 1300 c/s $\pm$ 2%;
duration : between 1 and 2.5 seconds.

The output voltage of this signal should be the same as the output voltage used for the measurements.

When the sensitivity of the receiver is adjusted in such a way that the highest level which may be encountered produces a full-scale deflection on the measuring instrument, the receiver so adjusted should operate immediately under the action of the start signal sent over a line having an attenuation of 2 nepers.

e) *Sending circuit*

For measurements on telephone circuits :

the sending circuit should have an impedance with a modulus of 600 ohms and zero argument and an e.m.f. of 1.55 volt.

For measurements on programme circuits :

the sending circuit should have a low internal impedance (modulus less than 30 ohms) and an e.m.f. between 2.2 and 4.4 volts * (1.04 and 1.73 nepers = 9 and 15 decibels).

f) *Range and accuracy of measurement*

The accuracy of measurements made with the automatic level recorder should be at least $\pm$ 0.05 neper (or $\pm$ 0.5 decibel) within the recording range for which the apparatus gives the greatest accuracy. In order to achieve this precision it is possible to provide facilities permitting readings being made, within the measuring range where the accuracy is greatest, of levels between + 2 and − 2 nepers (or between + 20 and − 20 decibels). Values of levels lying between − 2 and − 3.5 nepers (or between − 20 and − 30 decibels) should be considered as indications only.

The recording range of the receiving apparatus should extend over at least 3 nepers or 25 decibels without it being necessary to operate a key.

E. Level-measuring display sets (apparatus for immediate observation of the absolute voltage level at various frequencies)

Level-measuring display sets operate on the same principle as automatic level recorders (see page 185) but are distinguished by the higher speed of transmission of the band of frequencies and of recording. A cathode-ray tube is used for recording. The measured values appear on the screen as a luminous trace.

a) *Frequency range*

for telephone circuits : 300 to 3400 c/s at least;
for programme circuits : 50 to 10 000 c/s at least.

* At the present time, sending circuits giving different voltages are used.

b) *Law of succession of frequencies with time*

Periodic transmission of a continuous succession of frequencies from low to high frequency with a logarithmic time scale, and, if appropriate, return at the same speed to the low frequencies.

Duration of transmission of the total band of frequencies :

for telephone circuits :	about 0.5 second;
for programme circuits :	about 3 seconds.

c) *Sending circuit*

For measurements on telephone circuits :

the sending circuit should have an impedance with modulus of 600 ohms and zero argument and an e.m.f. of 1.55 volt.

For measurements on programme circuits :

the sending circuit should have a low internal impedance (modulus less than 30 ohms) and an e.m.f. of 2.2 and 4.4 volts (1.04 and 1.73 nepers = 9 and 15 decibels).

d) *Synchronization of sending and receiving equipments*

The receiving equipment has a frequency discriminator which gives a voltage approximately proportional to the logarithm of the frequency. This voltage—with sufficient amplification—is used for the horizontal deflection of the cathode ray trace.

The luminous screen of the oscilloscope has a transparent graticule with a horizontal frequency scale and a vertical neper or decibel scale.

e) *Range and accuracy of measurement*

The accuracy of measurements made with the level-measuring display set should be at least $\pm$ 0.05 neper (or $\pm$ 0.5 decibel), within the range for which the apparatus gives the greatest accuracy. In order to achieve this precision, it is possible to provide facilities permitting readings being made, within the measuring range where the accuracy is greatest, of levels between + 2 and − 2 nepers (or between + 20 and − 20 decibels). Values of levels lying between − 2 and − 3.5 nepers (or between − 20 and − 30 decibels) should be considered as indications only.

The recording range of the receiving apparatus should extend over at least 3 nepers or 25 decibels without it being necessary to operate a key.

SUPPLEMENT No. 4

MEASUREMENT OF PHASE DISTORTION

The significance of phase distortion is shown by the maximum value of the transient period, which is given by large difference in propagation time for different frequencies.

A relation exists between the phase characteristic and the propagation time (group delay) of the generalized quadripole which is defined as follows :

$$\tau = \frac{d\beta}{d\omega}$$

where : τ = propagation time (group delay)
β = phase as a function of angular frequency
ω = angular frequency.

This relation gives the possibility of expressing one of the two quantities in terms of the other.

1. A first method of measuring phase distortion consists in comparing the phase of a signal of frequency f at the input and at the output of a quadripole or a terminated line. To determine the phase-change, several methods are available :

a) by comparison by Lissajous figures on the screen of a cathode-ray oscilloscope;

b) by the wattmeter method; the indicated value is proportional to cos $(\varphi_1 - \varphi_2)$;

c) by a null method in which the phase and amplitude of one of the two signals are varied so that one signal is equal and opposite to the other;

d) by a vector sum and difference method. Two circuits are supplied from a common source : the first contains an attenuator and the second comprises the circuit producing the phase distortion. The two amplitudes being made equal, the phase angle can easily be determined from the vector sum and difference of the voltage.

2. A second method of measurement of propagation time (group delay) is given by Nyquist. This method consists in amplitude-modulating a signal of variable frequency f, by a constant frequency F and comparing the phases of the frequency F and the modulated envelope. The propagation time (group delay) of the modulated signal is given by the mean value of the wave-group (carrier and sidebands) which form the given envelope. The constant frequency F is made low enough for it to be small in relation to the phase/frequency relation of the circuit under test. The advantage of this method is that it is possible to determine the variation of propagation time (group delay) on a line which is not looped.

3. The third method of determining the attenuation and phase of a transmission circuit uses rectangular pulses. From the distortion of the pulses conclusions may be drawn regarding the different distortions. For example, in the case of television, the rise-time gives a measure of resolving power while under- or over-shoots have an influence on the gradation of the image. On sending into the transmission system a periodic signal of known waveform and rich in harmonics, and recording the received waveform and submitting it to Fourier analysis, the phase delay for the system in question can be determined at the pulse frequency; this is possible only when the transmission system is not affected by other, non-linear, distortions. At the receiving end, a pulse-generator identical to that at the sending end and adjusted to the fundamental signal received on the line, produces locally the original signal. By means of phase-shifters and adjustable attenuators, the various harmonics on the two signals are equalized so permitting the relative loss and phase characteristics of the transmission system to be determined.

Note. — See detailed bibliography on measurements of phase and propagation time on pp. 121-122 of the " Annexes to Volume III " of the C.C.I.F.'s *Green Book* (Geneva, 1956).

SUPPLEMENT No. 5

MEASUREMENT OF INTERMODULATION DUE TO NON-LINEARITY DISTORTION

A very good method of measuring used both for prototype tests of transmission systems and for equipment acceptance tests comprises the use of " white " noise. This method, illustrated in the diagram below, gives a value for intermodulation distortion and for the effect of noise. It is often used on radio relay links and, more generally, on all multi-channel systems. For the latter, the random noise signal is a fairly good equivalent to the total telephone signal, particularly where the statistical distribution of instantaneous voltage peaks is concerned; this is not the case when the " white " noise signal is applied to too few telephone channels, for example, to the channels of a basic group.

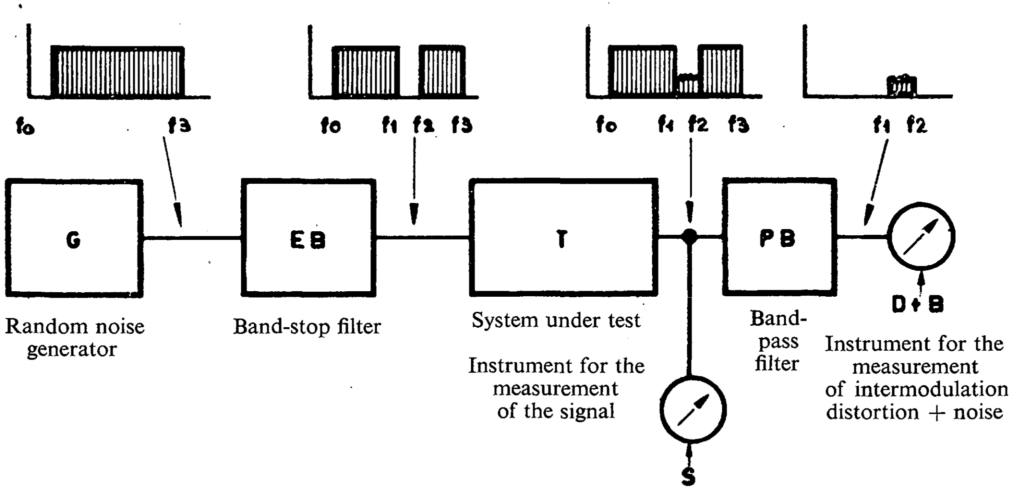


FIGURE 7

Block schematic of the arrangement of equipment used for the measurement of non-linearity distortion (intermodulation) by the application of a " white " noise

In the case of a measurement made to detect an intermodulation fault, the method described below is recommended for basic groups. It uses two signals and the effect of intermodulation is to give an easily measurable combination.

Measurement of non-linearity distortion of a carrier system on unloaded symmetrical pair cables

The method consists in applying 800 c/s test tones on channels 11 and 12 of each basic group and measuring on channel 10 the modulation product of the $2A$-B frequency, A corresponding to the frequency of the wave transmitted on channel 11 and B to the frequency transmitted on channel 12.

Other administrations prefer to apply 800 c/s tones on channels 6 and 4 of each basic group and measuring on channel 8 the $2A$-B modulation product, A corresponding to the frequency transmitted on channel 4.

To make the measurements on the principle outlined above a more or less selective voltmeter should be connected to the output of channel 10 (or channel 8). For instance one might use:

1) the C.C.I.T.T. psophometer with the new weighting network associated with a band-pass filter of which the mean frequency is 800 c/s and which gives a supplementary attenuation of 20 decibels for $800 - 400 = 400$ c/s and for $800 + 400 = 1200$ c/s.

2) a very narrow band-pass filter followed by an ordinary voltmeter.

If a psophometer is used, or a voltmeter which is not very selective, it is recommended to measure the basic noise of the system before applying the 800 c/s tones.

Note 1. — The above directions concerning these methods suppose that no basic group is placed in service before the others. If it is desired to place in service at different times the various groups of a 24, 36, 48 and 60 circuit system it is advisable to choose, if possible, the two channels of each group on which to apply the 800 c/s test frequencies, such that the test of non-linearity distortion does not affect the carrier channels already in service.

Note 2. — The measurement of the ($2A$-B) third order product is considered above. Nevertheless it may also be useful in certain cases to measure the (A-B) 2nd order intermodulation product in order to have a more complete picture of the non-linearity distortion conditions.

SUPPLEMENT No. 6

MEASUREMENT OF CROSSTALK

If, in Figure 8 :

a) AC is the disturbing circuit with disturbing source G at A, and a termination Z at C equal to the characteristic impedance of the disturbing circuit, and

b) BD is the disturbed circuit with measuring device M_1 at B and measuring device M_2 at D, the impedance at the terminals of which the measuring device is connected being equal to the characteristic impedance of the disturbed line Z_R, then, the noise measured in M_1 is the near-end crosstalk and the noise measured in M_2 is the far-end crosstalk.

The crosstalk attenuation is the logarithmic ratio of power delivered by source to power delivered to the measuring device M_1 or M_2. The crosstalk attenuation can be obtained by measuring the voltages at A and at B or D and computing the powers concerned from the relationship $P = V^2/Z$ but it is the usual practice to use either some form of potentiometer network to compare the source and received voltages or some form of attenuating network to attenuate the source voltage to that of the received voltage. The former method is usually used for measurements at audio frequencies and the latter for carrier frequencies.

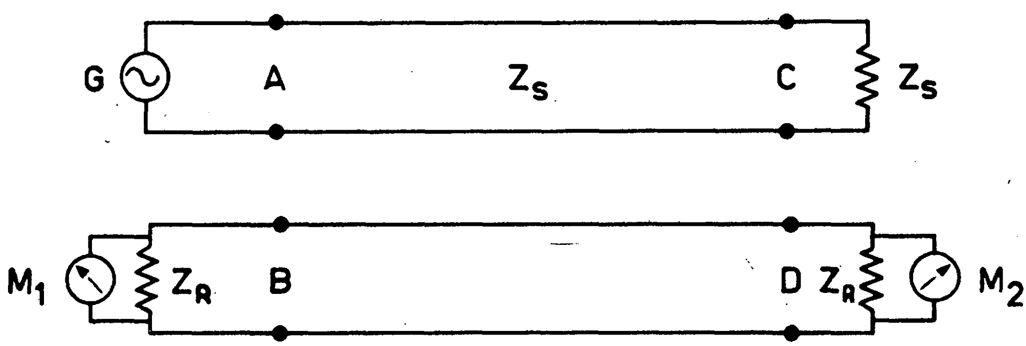


FIGURE 8

Diagram showing the principle of crosstalk measurements

SUPPLEMENT No. 7

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 persistance, many intermittent contact defects will cause a degradation of service over long periods, resulting in a series of fault reports before location and clearance is 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 week days 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 ".

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 or equalizer, 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 c/s but as the major components of valve microphonic noise lie below 1000 c/s it is best to avoid test frequencies in the range 300-1000 c/s.

For testing the transmission paths of carrier-frequency equipment in the group bands of 12-60 and 60-108 kc/s and the supergroup band 312-552 kc/s, for example, at least three frequencies are necessary. The arithmetic mean frequencies of 36, 84 and 432 kc/s 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 c/s and preferably 1000 c/s.

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 c/s 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 1) "Bridge", 2) "Demodulator", and 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 9 shows the principle for audio-frequency testing.

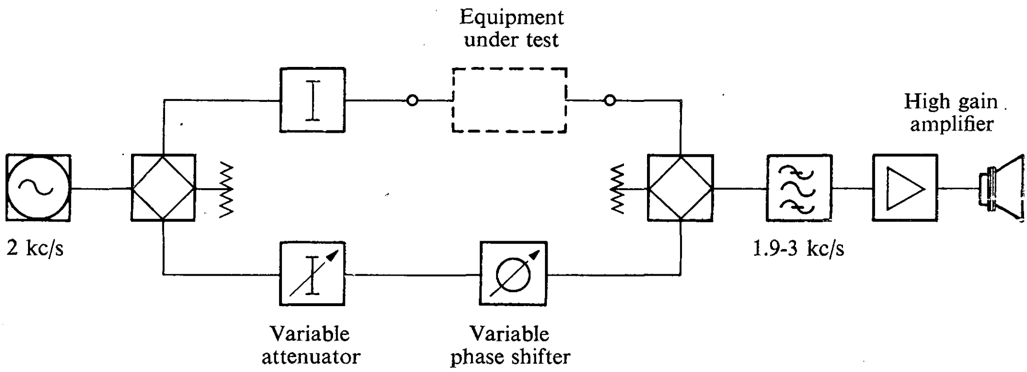


FIGURE 9

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 pass-band should be of the order of 1000 c/s.

c) The main considerations in the choice of test frequency are :

i) The range below 1000 c/s 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 c/s.

iii) The test signal frequency should be located near one end of the pass-band 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 10 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.

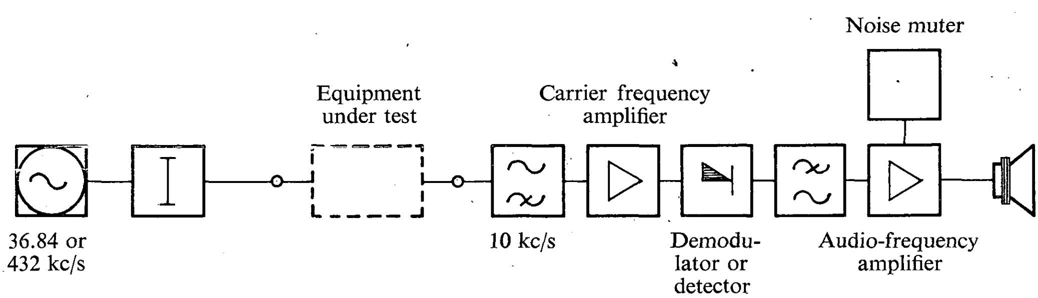


FIGURE 10

4.2.2 The main points of interest in this method are :

a) The 10 kc/s 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 c/s and by locating the test signal near one end of the pass-band, 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 10 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 c/s,

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 11 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.

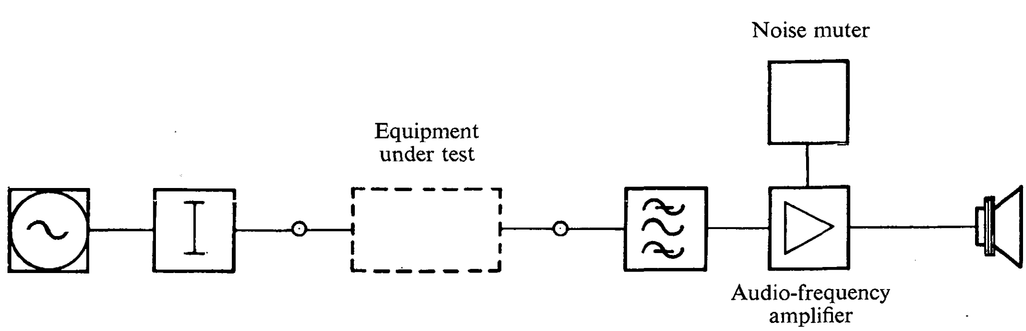


FIGURE 11

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 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.

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.

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 scaled crystal filters using pressure-contact crystal mountings are gently struck with the closed hand 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 bus-bar 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 a closed hand. 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 defect 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 ± 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**

Typical recorder traces

10.1 *Interpretation of chart records*

Typical specimens of recorder traces obtained on circuits in service are shown in Figures 12 to 16.

Figure 12 shows the recorder trace of a 400-mile looped audio V.F. telegraph circuit $2\frac{1}{2}$ years after overhaul using vibration testing.

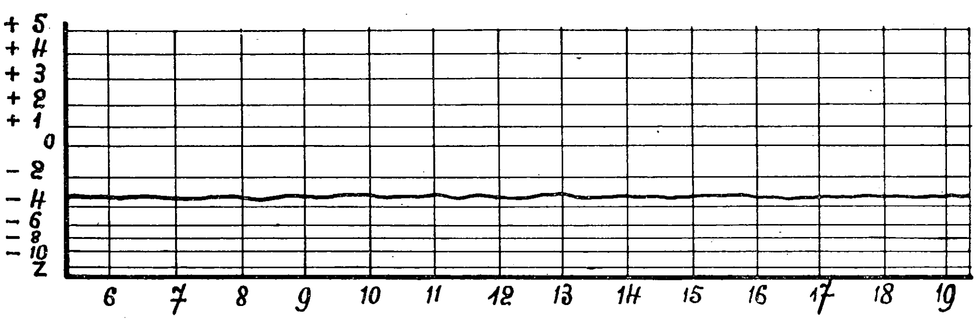


FIGURE 12

Typical trace recorded on a 400-mile looped audio V.F. telegraph circuit $2\frac{1}{2}$ years after vibration testing

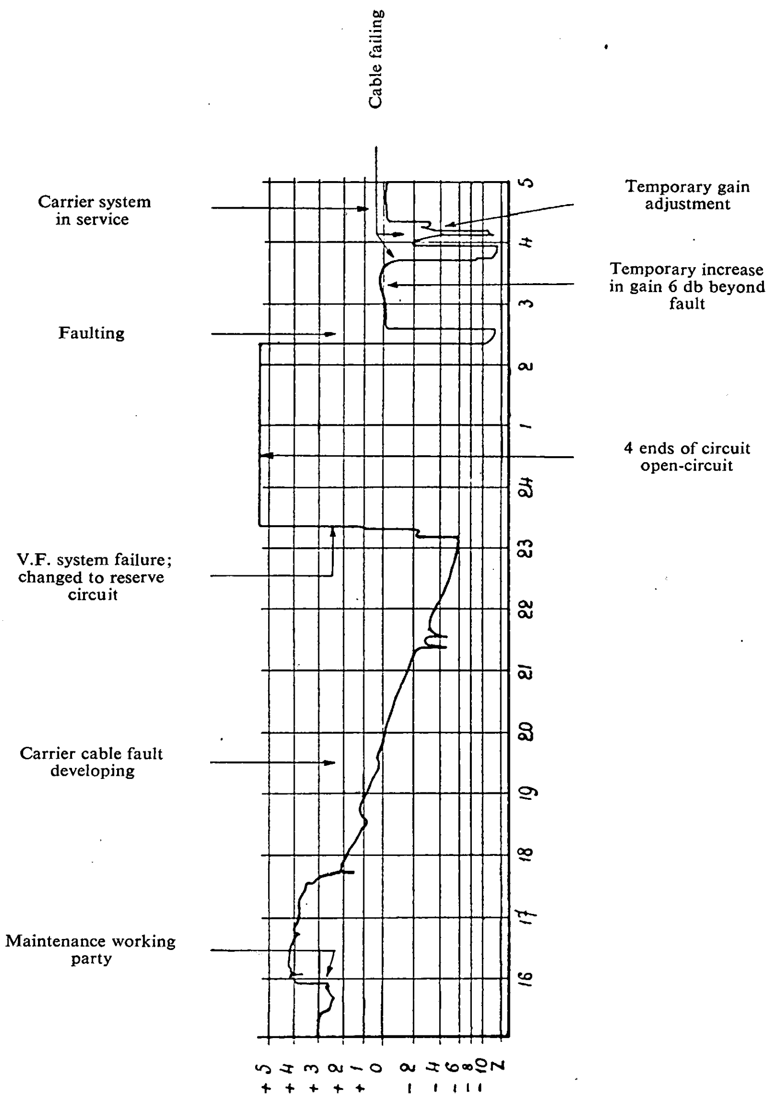


FIGURE 13

Typical trace taken on a 450-mile carrier circuit

Figure 13 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 kc/s 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 14 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

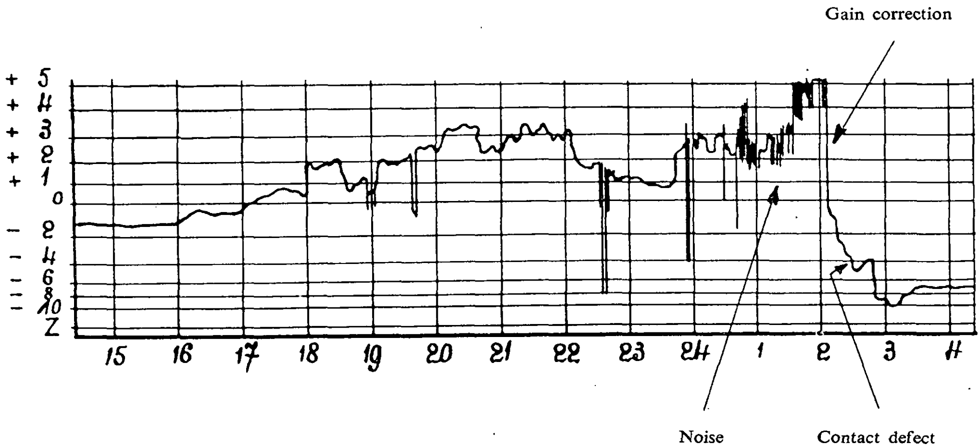


FIGURE 14

Trace on a 450-mile carrier circuit

fault was reported in both cases and in both cases the action recorded was " measured and found O.K. ".

Figure 15 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.

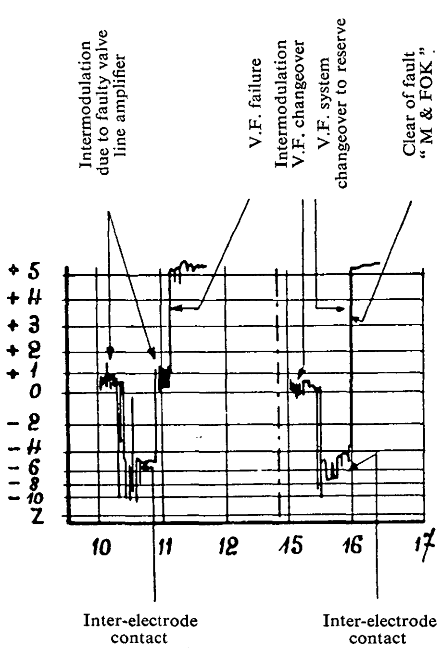


FIGURE 15

Traces produced by inter-electrode contact in valve in a carrier channel panel

Figure 16 shows the effect of a typical symmetric pair cable fault.

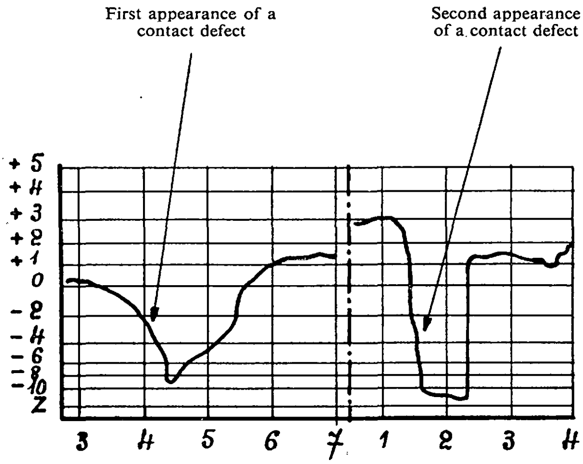


FIGURE 16

Traces produced by a contact defect

SUPPLEMENT No. 8

VARIATIONS OF OVERALL LOSS OF TELEPHONE CIRCUITS MATHEMATICAL PROCESSING OF THE MEASUREMENT RESULTS

(Note of the Administration of the U.S.S.R. and described in contribution COM 4 - No. 51)

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 in an Annex 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 N and 2.60 N (with a nominal value of $2N$).

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 $\left(\sum \frac{w_i}{n}\right)$. 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 eleven 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 $\frac{n}{2}$,

$$1503 + 408 = 1911.$$

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 :

$-n, -(n-1), \ldots -4, -3, -2, -1, 0 \qquad 1, 2, 3 \ldots + (m-1), + m$

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, 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 :

$$-0.5 < \frac{\sum w_i \,.\, x'_i}{n} < +0.5 \tag{2}$$

In the case mentioned

$$\frac{\sum w_i . x'_i}{n} = \frac{668}{3539} = 0.18$$

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 :

$$\bar{x} = A + \frac{\sum w_i . x'_i}{n} . K \tag{3}$$

where

A ist the conditional reference point and
K is the value of the range.

Hence, the results in the case of Example No. 1 are :

$$\bar{x} = 2.075 + \frac{668}{3539} \cdot 0.05 = 2.084 \; N.$$

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 :

$$\sigma = K \sqrt{\frac{\sum x'^2_i . w_i}{n} - \left(\frac{\sum x'_i \,.\, w_i}{n}\right)^2} \tag{4}$$

where

K is the value of the range.

Hence, the results in the case of Example No. 1 are :

$$\sigma = 0.05\sqrt{\frac{43\,130}{3539} - \left(\frac{668}{3539}\right)^2} = 0.17\ N$$

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 N 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 :

$$F(t) - \frac{\lambda_q}{\sqrt{n}} < \overline{F}(t) < F(t) + \frac{\lambda_q}{\sqrt{n}}$$

where

$F(t)$ is the distribution function of the given selection,
λ_q — the argument of the function $K(\lambda)$ in the table,
n — the number of measurements (in the selection),
$\overline{F}(t)$ — 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 No. 1).

The certainty of the estimate will then conform to the maximum value of the series.

TABLE I

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(λ) (q%) . . .	5	3	1	0.2	0.01
Argument λ of the function K (λ)	1.358	1.450	1.627	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 $d = \frac{\lambda}{\sqrt{n}}$. 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 N 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 N. i.e. the reduction in the equivalent in relation to the nominal value of 2 N will, with this probability of 0.97, be less than 0.45 N.

With a probability of 0.94 or $(1-0.03-0.03)$ the equivalent (the insertion gain) remains within the limits 1.55 N to 2.60 N (with a nominal value of 2 N).

The *reliability* of this estimate is 0.99 ($q = 1.0\%$).

Figures 17 and 18 represent the integral distribution curves for the example concerned.

As can be seen in Figure 17, we plot the random values as abscissae and the probabilities as ordinates. The scales of the two axes are linear.

Figure 18 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 19 shows the integral distribution curve for Example No. 2 with a probability scale.

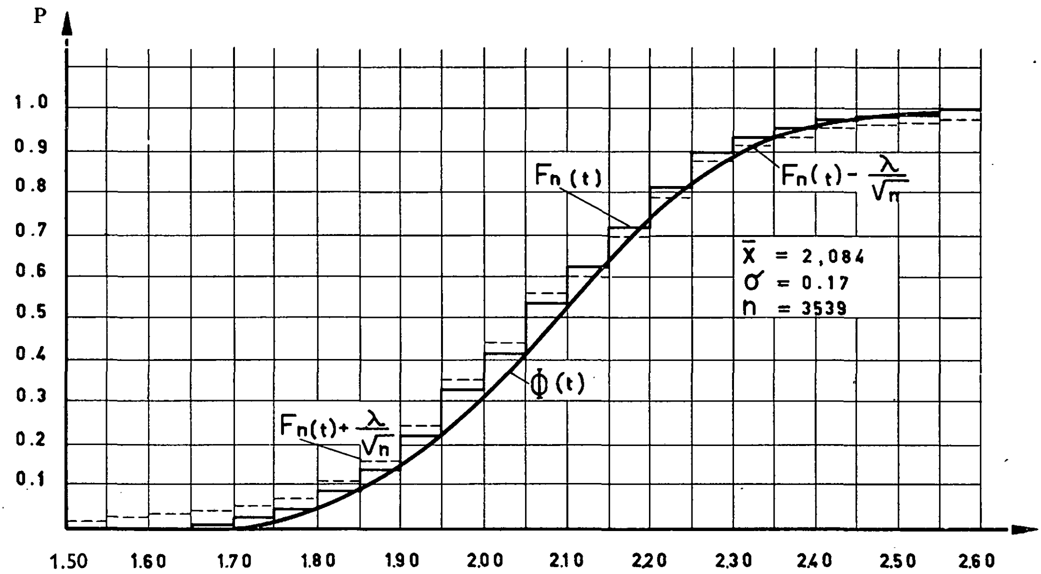


FIGURE 17

Integral distribution curve of the results of the development of example No. 1 (see Table No. 1)

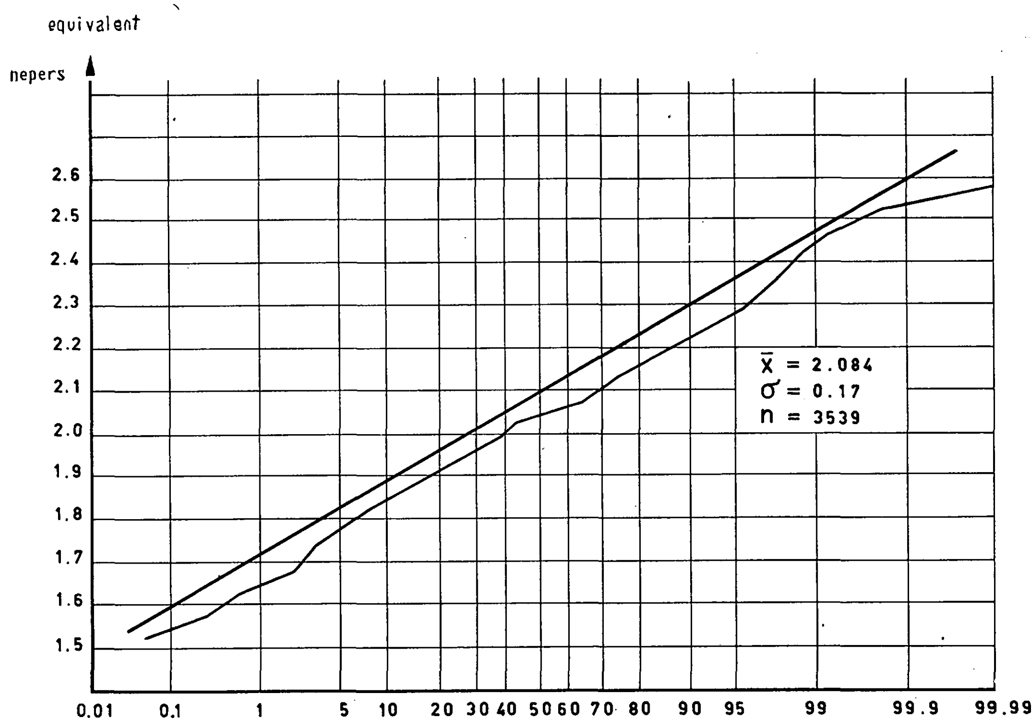


FIGURE 18

Integral distribution curve of the results of the development of example No. 1 (Probability scale) (see Table No. 1)

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FIGURE 19

Integral distribution curve of the results of the development of example No. 2 (probability scale)

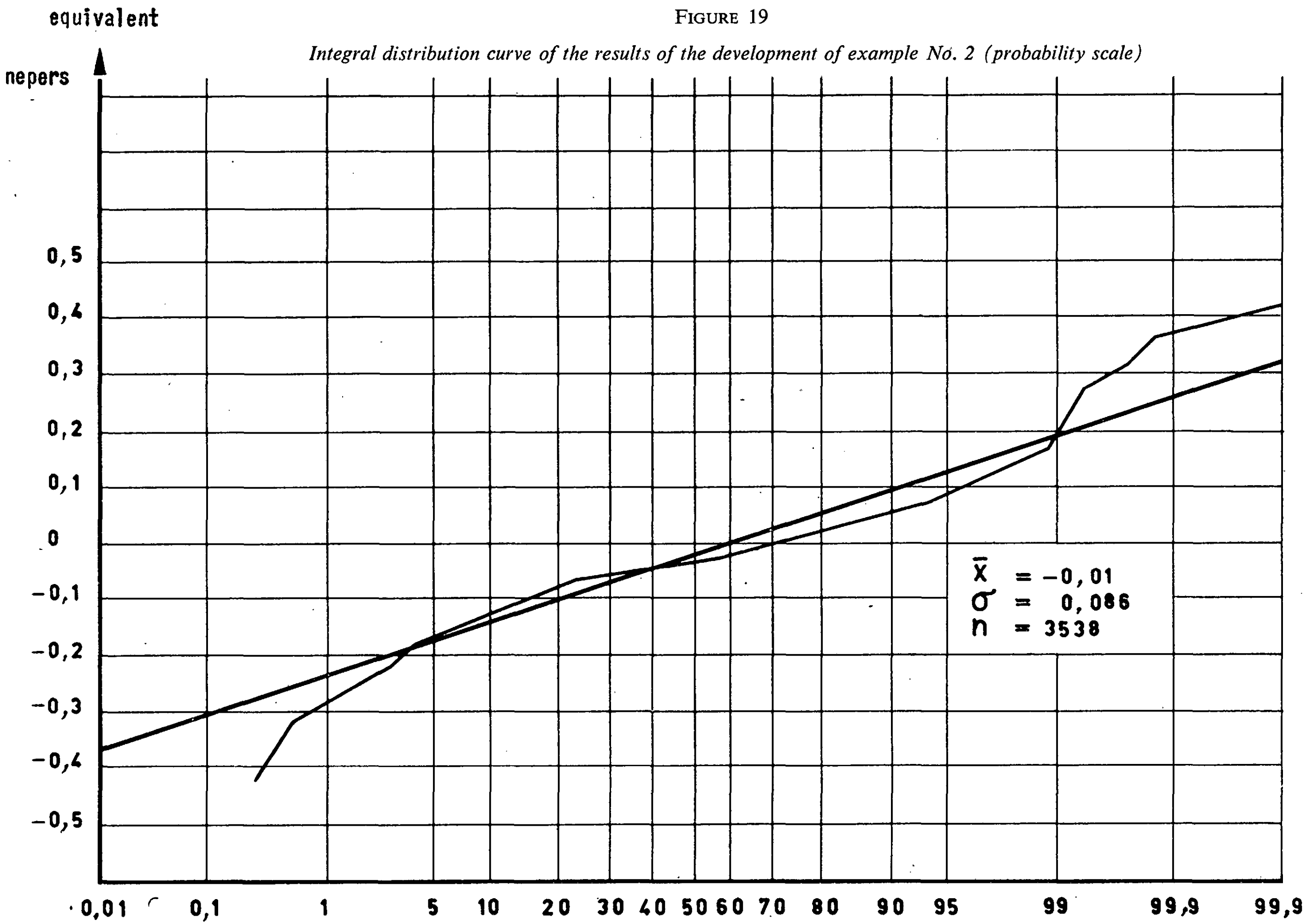


Table for example No. 1

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)

* $n = 3539$ $A = 2.075$ $K = 0.05$ $\overline{x'} = 0.18$ $\overline{x} = 2.084$ $\sigma = +0.17$

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—1.60	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).

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)

$n = 3537 \quad A = -0.025 \quad K = 0.05 \quad \bar{x}' = 0.31 \quad \bar{x} = 0.01 \quad \sigma = \pm 0.086$

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).

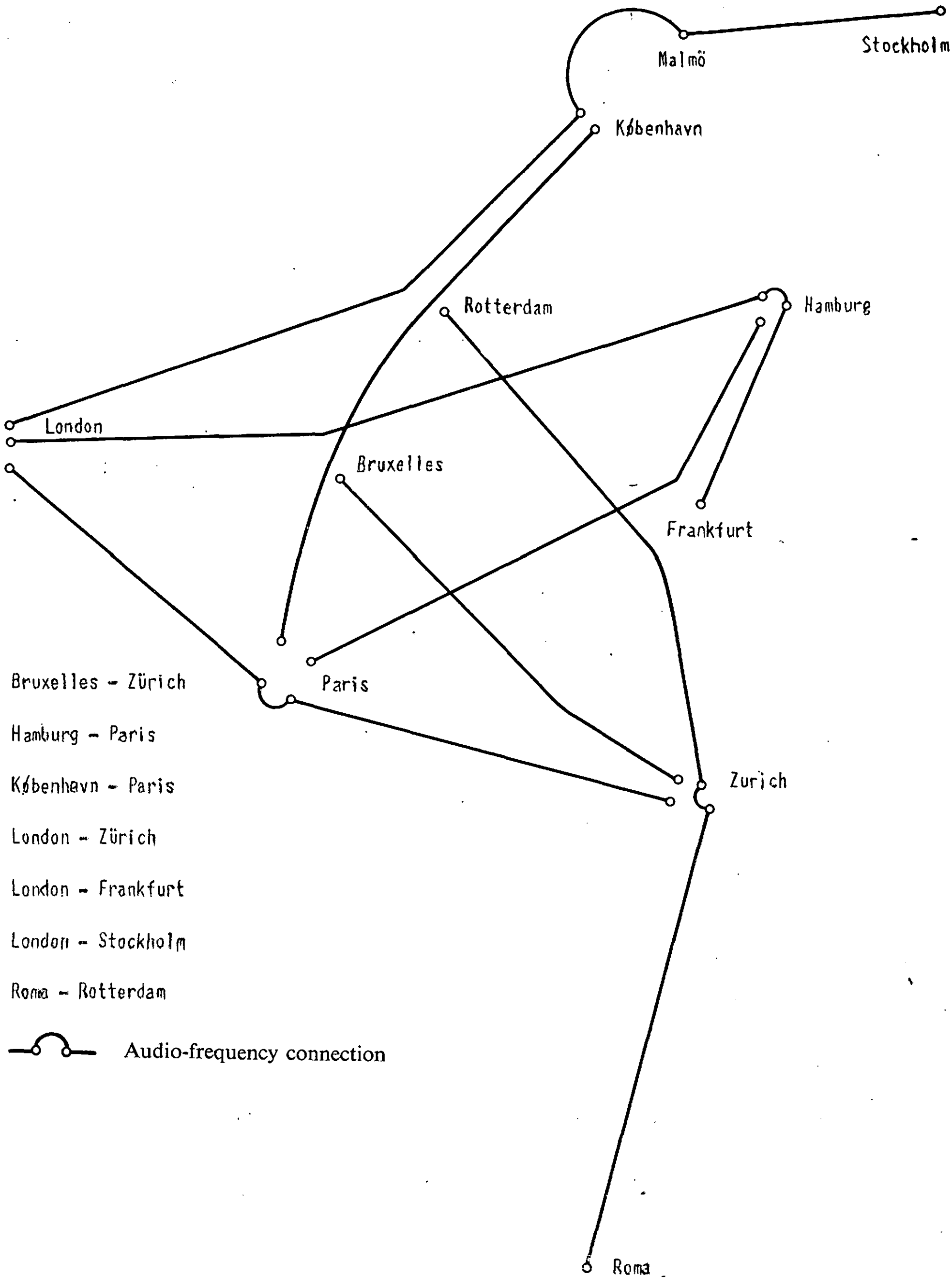


FIGURE 20

Test network for the sixt series of observations on international circuits

SUPPLEMENT No.9

6th SERIES OF TESTS MADE BY THE C.C.I.T.T. ON THE VARIATION OF OVERALL LOSS OF INTERNATIONAL CIRCUITS

(carried out from January to June 1958)

I. MEASUREMENTS AND RECORDINGS

1. The sixth series of tests by the C.C.I.T.T. on variations of overall loss of international circuits was made on the following circuits :

a) *Three circuits in direct groups, chosen from among the longest of this type in Europe*

- *Bruxelles* * — Zürich (843 km)
- Hamburg — *Paris* (1293 km)
- København — *Paris* (1600 km)

b) *Four circuits made up of two 12-circuit groups in tandem*

London — Zürich (1476 km long), set up with a group London — Paris (792 km long) and with a group Paris — Zürich (684 km);

London — Frankfurt (1616 km), set up with a group London — Hamburg (1016 km), and with a group Hamburg — Frankfurt (600 km);

London — Stockholm (2004 km), set up with a group London — København (1353 km), and with a group Malmö — Stockholm (594 km);

Roma — Rotterdam (2041 km), set up with a group Roma — Zürich (960 km) and with a group Zürich — Rotterdam (1081 km).

The network used is shown in figure 20.

2. The observations made on the circuits set up with two groups in tandem gave direct results for the first section and the overall circuit. Results for the second section were obtained by calculation from the direct results.

3. Observations began on Monday, January 27, 1958, and lasted eighteen weeks, ending on Monday, June 2, 1958.

4. Throughout this period, the ordinary maintenance procedure remained in force.

5. The conditions in which the tests were to be carried out were laid down in contribution COM. 4 — No. 1; they are summed up below.
The report on the 6th series of tests is contained in contribution COM. 4 — No. 23.

6. The observations took the form of recordings of measurements :

- of an 800 c/s test signal on the circuit,
- of the group and supergroup pilots and of the carrier system line-regulating pilot(s).

* The control stations are in italics.

7. *Tests on the circuit itself*

The tests were carried out on the 4-wire part of the circuit and for both directions of transmission.

A measuring signal of 800 c/s was sent from the transmitting end of the circuit with an absolute power of —0.7 neper or —6 db referred to 1 mW) at a zero relative level point. This level was not to vary by more than $\pm$ 0.3 db or $\pm$ 3 centinepers and an alarm was given as soon as these limits were exceeded.

At the receiving end of the circuit and, in the case of a circuit made up of two groups in tandem, at the intermediate audio-frequency points, the 800 c/s measuring signal was used to give :

— a permanent level recording,
— a record of level variations using a quick acting recording device of the type described in the annex to Question 2/IV.

This device was adjusted to operate when there was a drop in level of more than 10 db or 1 *N* with respect to the nominal value at the point where it was connected.

8. *Observations on pilot signals*

The levels of group, supergroup and line-regulating pilots were permanently recorded at the receiving end and at several intermediate points along the circuits.

9. *Attended and unattended periods*

A distinction was made between the following three periods in analysing the results of both long-term and short-term variations :

(i) the whole of the period of observations;
(ii) the attended or " day " period, i.e. from Monday to Saturday, between 8 a.m. and 8 p.m., periods when the maintenance staff is generally on duty in repeater stations;
(iii) the unattended or " night " period between 8 p.m. and 8 a.m. and Sundays, i.e. where there is generally no maintenance staff on duty in the repeater stations.

II. LONG-TERM VARIATIONS OF OVERALL LOSS. STABILITY OF THE NETWORK

Mean value and standard deviation of the variations observed

Table I hereafter gives, for the three periods considered in the analysis of the results :

— the mean variations in overall loss (expressed as a deviation from the nominal value);
— the standard mean deviation of these variations.

Where circuits consisted of two sections in series, with an intermediate audio-frequency point, the observations gave direct results for the first section and the overall circuit. Values for

TABLE I

Mean and standard deviation for 800 c/s measurements *

	Circuit A-B	Length km	Total period M dN	Total period M db	Total period σ dN	Total period σ db	Attended periods M dN	Attended periods M db	Attended periods σ dN	Attended periods σ db	Unattended periods M dN	Unattended periods M db	Unattended periods σ dN	Unattended periods σ db
1	Malmö - Stockholm	594												
	Stockholm - Malmö		+0.1	+0.1	0.5	0.4	+0.1	+0.1	0.5	0.4	+0.1	+0.1	0.5	0.4
2	Frankfurt - Hamburg	600	—0.3	—0.23	0.5	0.5	—0.3	—0.3	0.5	0.5	—0.3	—0.3	0.5	0.5
	Hamburg - Frankfurt	c	—0.6	—0.5	0.3	0.3	—0.4	—0.4	0.3	0.3	—0.6	—0.6	0.4	0.3
3	Paris - Zürich	c	—0.6	—0.5	1.0	0.8	—0.6	—0.5	1.0	0.8	—0.5	—0.4	1.0	0.9
	Zürich - Paris	684	—0.1	—0.1	1.1	1.0	—0.2	—0.1	1.1	1.0	—0.1	—0.1	1.2	1.0
4	London - Paris	792	+0.3	+0.3	1.1	0.9	+0.3	+0.3	1.1	0.9	+0.3	+0.3	1.1	0.9
	Paris - London	c	—1.0	—0.9	0.6	0.5	—1.0	—0.9	0.6	0.5	—1.0	—0.9	0.6	0.5
5	Bruxelles - Zürich	843	+0.2	+0.2	0.9	0.8	+0.2	+0.2	0.9	0.8	+0.2	+0.2	0.9	0.8
	Zürich - Bruxelles		+0.6	+0.5	0.6	0.5	+0.6	+0.5	0.6	0.5	+0.6	+0.5	0.6	0.5
6	Roma - Zürich	960	—0.3	—0.3	0.6	0.5	—0.4	—0.3	0.6	0.5	—0.3	—0.3	0.6	0.5
	Zürich - Roma	c	+0.3	+0.2	1.5	1.3	+0.3	+0.2	1.4	1.2	+0.3	+0.3	1.5	1.3
7	Hamburg - London	c	—0.9	—0.7	1.4	1.2	—0.4	—0.4	1.6	1.4	—0.8	—0.7	1.5	1.3
	London - Hamburg	1016	+0.8	+0.7	0.6	0.5	+0.7	+0.6	0.6	0.5	+0.9	+0.8	0.6	0.5
8	Rotterdam - Zürich	1081	+0.2	+0.2	0.5	0.4	+0.2	+0.2	0.4	0.4	+0.2	+0.2	0.5	0.4
	Zürich - Rotterdam	c	—0.8	—0.7	0.7	0.6	—0.8	—0.7	0.5	0.4	—0.8	—0.7	0.7	0.6
9	Hamburg - Paris	1293	—0.1	—0.1	1.6	0.5	0.0	0.0	0.6	0.5	—0.1	—0.1	0.6	0.5
	Paris - Hamburg		—0.1	—0.1	0.4	0.3	—0.1	—0.1	0.4	0.3	—0.1	—0.1	0.4	0.3
10	London - Malmö	1410	—0.6	—0.5	2.0	1.7	—0.6	—0.5	2.0	1.7	—0.6	—0.5	2.0	1.8
	Malmö - London	c	—0.6	—0.5	1.4	1.2	—0.7	—0.6	1.4	1.2	—0.3	—0.3	7.5	1.3
11	London - Zürich	1476	—0.3	—0.2	1.4	1.2	—0.3	—0.3	1.4	1.2	—0.2	—0.2	1.5	1.3
	Zürich - London		—1.0	—1.0	1.3	1.1	—1.2	—1.0	1.3	1.1	—1.1	—0.9	1.3	1.1
12	København - Paris	1600	+0.2	+0.2	1.6	1.4	+0.3	+0.2	1.5	1.3	+0.2	+0.2	1.6	1.4
	Paris - København		—0.8	—0.7	1.7	1.5	—0.9	—0.8	1.7	1.5	—0.8	—0.7	1.7	1.5
13	Frankfurt - London	1616	—1.1	—1.0	1.5	1.3	—0.7	—0.6	1.7	1.5	—1.1	—1.0	1.6	1.4
	London - Frankfurt		+0.3	+0.2	0.6	0.6	+0.3	+0.3	0.6	0.6	+0.2	+0.2	1.7	0.6
14	London - Stockholm	2004	0	0	1.8	1.5	+0.1	+0.1	1.7	1.5	—0.1	—0.1	1.8	1.6
	Stockholm - London		—0.4	—0.4	1.5	1.3	—0.6	—0.5	1.5	1.3	—0.3	—0.2	1.6	1.4
15	Roma - Rotterdam	2041	—1.2	—1.0	0.9	0.8	—1.2	—1.0	0.8	0.7	—1.2	—1.0	0.9	0.8
	Rotterdam - Roma		+0.5	+0.4	1.5	1.3	+0.5	+0.4	1.5	1.3	+0.5	+0.4	1.6	1.4

* 1) For all circuits the values for M are differences between the mean of the measured and nominal values.
2) c denotes results computed from measurements on two circuits in tandem.

the second section, which are marked with a "c" in Table 1, were obtained by calculation from these direct results by taking:

$$M_2 = M_T - M_1$$
$$\text{and } \sigma_2 = \sqrt{\sigma_T^2 - \sigma_1^2},$$

where M_1 = mean for first section

M_2 = mean for second section

M_T = mean for whole section

σ_1 = standard deviation for first section

σ_2 = standard deviation for second section

σ_T = standard deviation for whole section

The above two formulae would only be strictly applicable if there was no correlation between the variations of the first and second sections of the circuit. It was considered that such correlation was in any case small, but that it might however explain certain discrepancies in the results.

Table II below gives the mean value and the standard deviation of variations in the group pilot level for the whole duration of the observations.

Comments on the results obtained

1. *Differences between the "day" and the "night" observation periods*

There is no appreciable difference between the standard deviations of the long-term variations observed during the day and the night periods, i.e. between periods with maintenance personnel and periods without such personnel.

However, it was pointed out by the Netherlands Administration that the standard deviation of the measured values in itself is not a sufficient quality-figure for the intrinsic stability of the circuit or group link. Computation of the standard deviation of the differences (between, for example, successive hourly readings) shows that there exists in fact some difference between the attended and unattended periods.

2. *Correlation between the variations of the overall loss of a telephone channel of a group and the variation of the group pilot level*

It seems possible to establish a relationship between the σ values for the 800 c/s measurements on the telephone channel and the group pilot measurements.

For the 6th series of tests, this relationship was closer because the circuits observed were in the middle of the group frequency band, and therefore near to the pilot.

A study was made by the Netherlands and the United Kingdom Administrations of the relationship existing between the results obtained. Although there were too few results to permit firm conclusions to be reached, this study showed that it was possible to estimate the standard mean deviation of the variations in overall loss of a telephone channel in a

TABLE II

Mean and standard deviation measurements for 84+δ kc/s pilot

12-circuit group		Length km	M dN	M db	σ dN	σ db
Malmö - Stockholm		594	+0.2	+0.2	0.7	0.6
Stockholm - Malmö			—0.5	—0.4	0.8	0.7
Frankfurt - Hamburg ø		600	—0.1	—0.1	0.4	0.3
Hamburg - Frankfurt ø			+0.0	+0.0	0.2	0.2
Paris - Zürich		684	—0.1	—0.1	0.2	0.2
Zürich - Paris			—0.2	—0.1	0.9	0.8
London - Paris	905	792	—	—	—	—
Paris - London			—0.2	—0.2	0.9	0.8
Bruxelles - Zürich ø		843	—0.0	—0.0	0.0	0.5
Zürich - Bruxelles ø			+0.3	+0.3	0.6	0.5
Roma - Zürich ø		960	—0.2	—0.2	0.5	0.5
Zürich - Roma			+0.1	+0.1	1.3	1.1
Hamburg - London	901	1016	+1.0	+1.0	1.5	1.3
London - Hamburg ø			+0.3	+0.2	0.3	0.3
Rotterdam - Zürich ø	901	1081	—0.1	—0.1	0.3	0.2
Zürich - Rotterdam			+1.1	+1.0	0.8	0.7 *
Hamburg - Paris ø	901	1293	0	0	0.4	0.4
Paris - Hamburg			+0.2	+0.2	0.3	0.3
København - London	901		+0.9	+0.8	1.4	1.5
London - København			—0.7	—0.6	1.2	1.0
København - Paris		1600	—	—	—	—
Paris - København			—0.6	—0.5	1.3	1.1
ø A G C Group * Zürich - Rotterdam : A G C for part of time			+0.1	+0.1	0.3	0.3

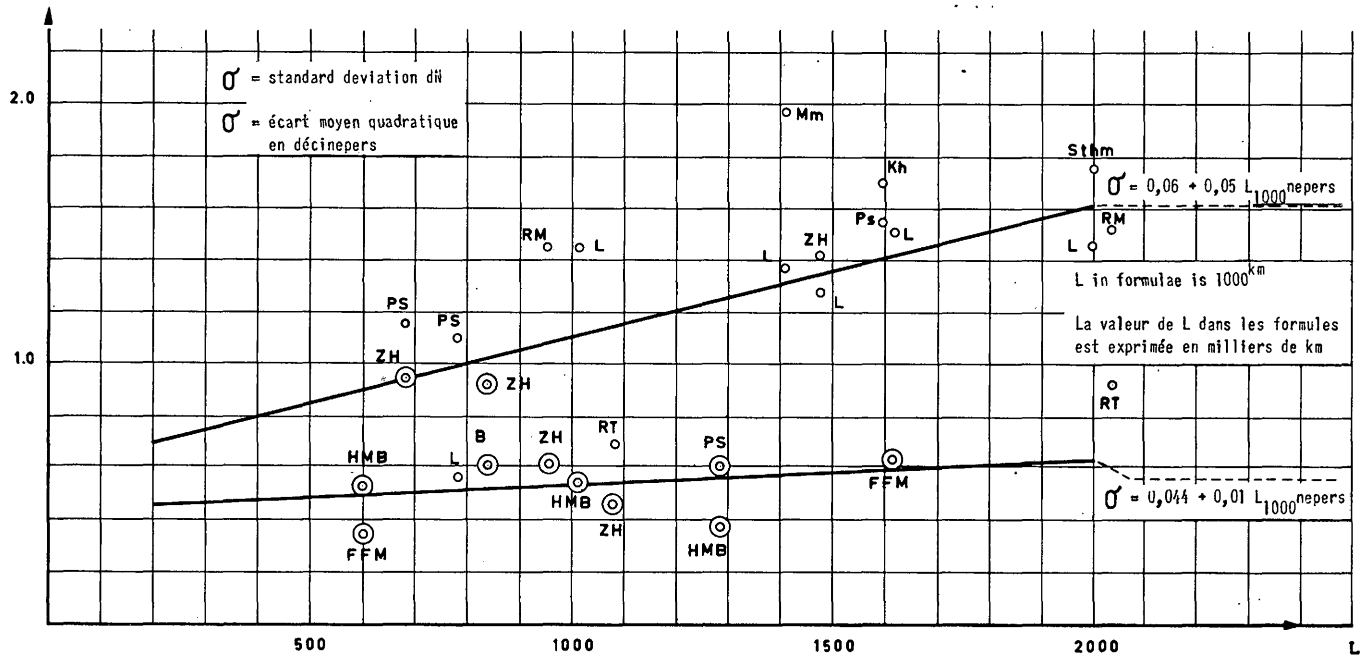
Graph 1

Standard deviation for 800 c/s measurements as a function of circuit length

B	Bruxelles	PS	Paris
FFM	Frankfurt	RM	Roma
HMB	Hamburg	RT	Rotterdam
Kh	København	Sthm	Stockholm
L	London	ZH	Zurich
Mm	Malmö		

◎ indicates circuit with automatic gain control on group link

◎ indique un circuit avec régulation automatique de la liaison en groupe primaire



group with a reasonable degree of accuracy, provided the standard mean deviation of the group pilot were known, by applying one of the following formulae :

$$\sigma_c = \sigma_g + 0.19 \text{ db}$$
$$\sigma_c^2 = \sigma_g^2 + 0.16 \text{ db}$$

in which

σ_c = is the standard deviation of variations in overall loss of the telephone channel of a 12-circuit group,

σ_g = is the standard deviation of the variations in the 12-circuit group pilot level.

3. *Representation of results*

3.1 The standard deviation σ of the variations in

— the equivalent of circuit (graph 1), and
— the 12-circuit group pilot level (graph 2)

have been shown on graphs as a function of the length L of the circuit or 12-circuit group link.

On both of these graphs, the various points fall into two well defined groups depending on whether there is automatic 12-circuit group regulation or not. Most of the obvious departures from this general grouping can be satisfactorily explained.

3.2 *Variations of the standard deviation when there is no automatic regulation*

The 5th series of tests had led to the relationship :

$$\sigma = 0.06 + 0.05\,L \text{ } (\sigma \text{ in nepers and } L \text{ in 1000 km})$$

to represent the standard deviation of variations in the overall loss of carrier circuits (without automatic group regulation) of 350-1000 km length.

It was observed that this relationship was also the best curve for representing the results of the 6th series of tests. This observation was based on calculation, using the method of least squares.

Since measurements made in the 4th and 5th series of tests were made under the same conditions as the 6th series, it was decided that these could be included in the determination of the line to be chosen to represent σ in terms of L for circuits of 200 to 2000 km length.

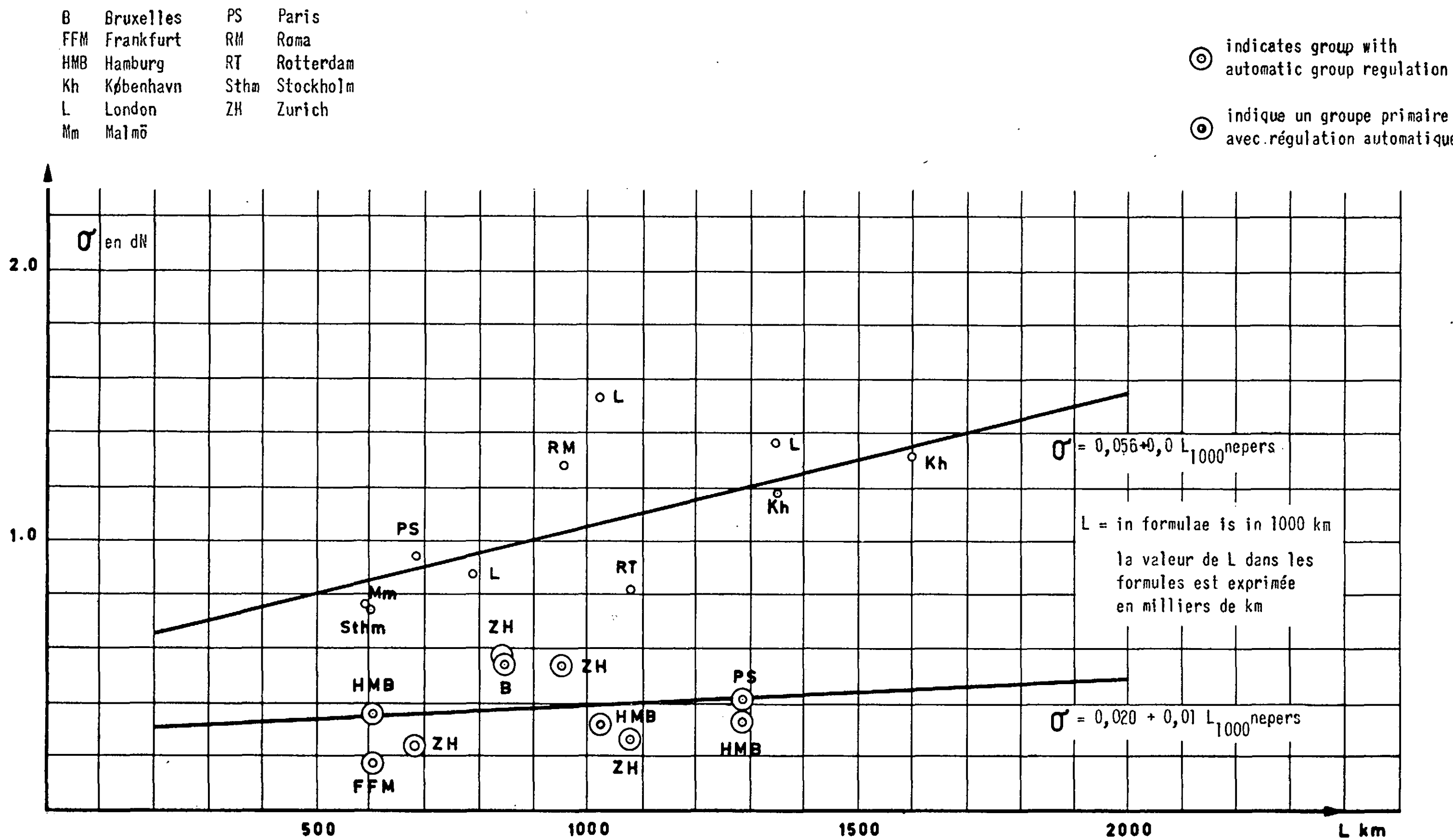
There is a difference in the two series of tests in that, for the 4th and 5th series, the circuits were of 200-1000 km length, while for the 6th series they extended to 2000 km.

It is stressed that the best fitting line cannot be extended for circuits below 200 km length, because the relationship between σ and L may no longer hold, and for the same reason should not be extended above 2000 km length.

This relationship also applies to variations of group pilot level in view of the correlation already observed between these variations and that of a telephone circuit of 12-circuit group link.

Graph 2

Standard deviation for 84 + δ kc/s measurements as a function of length of group link



Erratum = for the lower curve, read $\sigma = 0.029 + 0.01\ L_{1000}$ nepers.

3.3 *Links having automatic regulation*

The most striking fact that emerges from the 6th series of tests is the considerable improvement which has resulted from the use of automatic group-regulators. In fact, when there is automatic regulation, the length of a group has almost no effect on circuit stability.

For regulated groups and for circuits on them, it might be expected that the relationship between σ and L would be shown by a horizontal straight line. However, some slope might exist due to modulating equipments, and it might be expected then that the degree of slope would be more related to the number of modulating equipments than to circuit length alone, but from an examination of the constitution of the circuit, it has not been possible to separate the effects of length and number of modulations.

The straight line of best fit for the results obtained for the groups with automatic regulation and the circuits on them has been entered on Graphs 1 and 2; this line has been plotted solely to bring out the general difference in the behaviour of these circuits or groups and that of circuits or groups without automatic regulation.

The automatic regulators used were of three main types. Switzerland and Belgium used continuously acting regulators. France used step-by-step regulators with a relatively quick action (20 seconds). Germany also used step-by-step regulators which were slow acting, and which regulated in 1 centineper steps.

III. Short-term variations (sudden changes)

Analysis of the results for sudden changes

1. The sudden changes in level concerned in this analysis are those that operated the quick acting recording device which, it will be remembered, responded to a drop in level of more than 10 db or 1 *N*, i.e. to what may be considered as an interruption in transmission.

When there were a number of sudden changes in rapid succession (for example, more than five at a time), which were difficult to separate from one another, they were classified as " series of sudden changes ". It was found that this distinction had been made differently by different Administrations and some inconsistency in the results occurred in consequence.

2. There was an exceedingly great amount of information contained in the documents submitted by the Administrations taking part in the tests and in the recorder charts held by them. The information contained in the records could have been presented in many ways. Study Group 4 chose to present its summary in the manner adopted in contribution COM. 4 — No. 1, i.e. in the form of tables indicating the durations of the sudden changes and their cause. These tables have been drawn up for the following three periods :

— total duration of observations,*

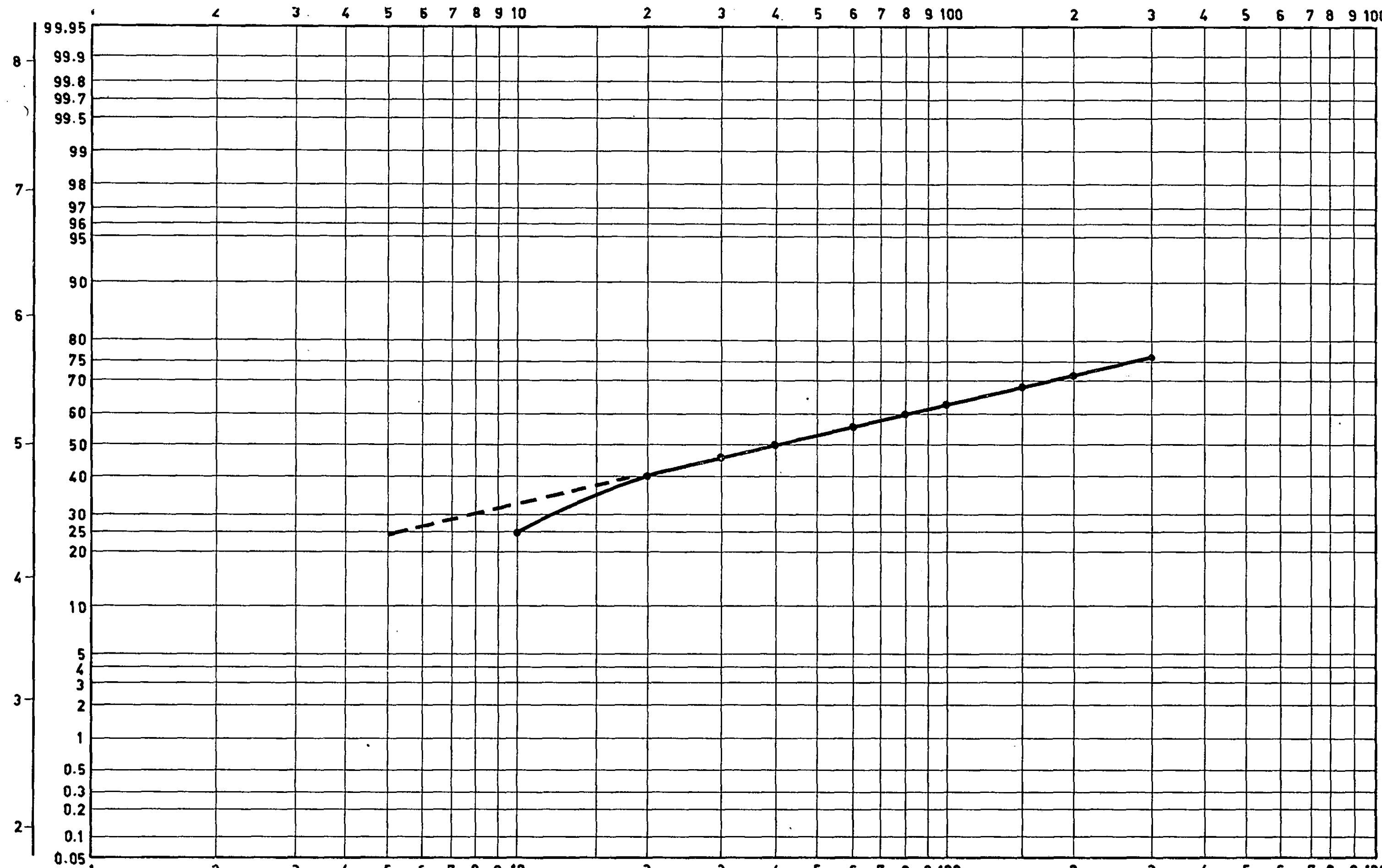
— period with maintenance personnel, or attended period, *

— period without maintenance personnel, or unattended period. *

* These tables have been published as Annexes 19, 20 and 21 in contribution COM. 4—No 23.

Graph 3

Integral curve showing the percentage frequency of sudden changes having a duration less than the values shown on the OX axis



3. The results obtained can also be plotted on logarithmic probability paper. On such paper the ordinates give the percentage of the total number of observations whose durations are less than the duration time shown on the abscissae. The three curves for the attended, the unattended and the whole period respectively differ only slightly from each other. The curve shown in Graph 3 is that for the whole period, and it will be seen that the points plotted fall very nearly on a straight line.

From this graph, the following tentative values may be obtained for the percentage number of sudden changes which have less than certain time durations.

25% of the sudden changes are less than 10 msec.	
15% ,, ,, ,, ,,	have a duration 10-20 msec.
22% ,, ,, ,, ,,	have a duration 20-100 msec.
13% ,, ,, ,, ,,	have a duration 100-300 msec.
25% ,, ,, ,, ,,	exceed 300 msec.

It may be that the deviation from the lognormal distribution over the lower time durations in the graph is due to deficiencies in the apparatus used to record the sudden changes and to differences in the way the recorder charts have been interpreted. If this is so, it may be valid to extend the graph to the 5 msec. points as shown by the dotted line in order to determine the percentages down to the 5 msec. point. However, the results of the observations of sudden changes are not considered to be sufficiently reliable for conclusions to be attempted below the 10 msec. point.

Comments on the analysis of sudden changes

1. It should be remembered that the information on sudden changes is a by-product of the study of variations in equivalent since it was provided in addition to the basic information on long-term variations sought by Study Group 4.

2. *Attended and unattended periods*

For all circuits included in the tests it could be seen that the number of sudden changes was greater for the attended periods than for the unattended periods.

3. *Causes of sudden changes*

3.1 In all cases the number of sudden changes for which no cause could be determined was a major percentage of the grand total. This percentage was less for the sudden changes having the longest durations.

The results showed that power equipment and working parties gave rise to an appreciable number of sudden variations, particularly in respect of isolated sudden changes of more than 300 milliseconds duration, and series of interruptions of all classes.

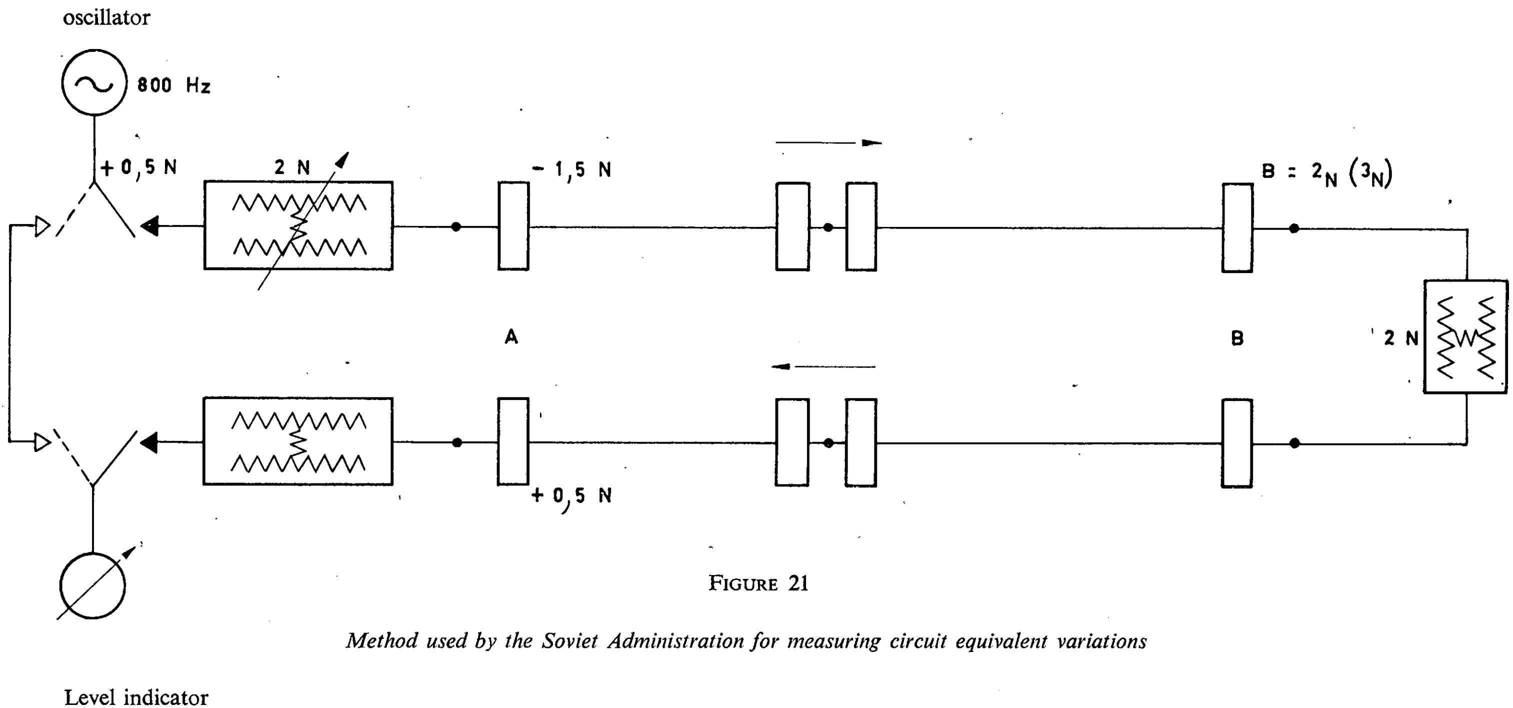


FIGURE 21

Method used by the Soviet Administration for measuring circuit equivalent variations

Particularly in respect of common equipment, e.g. power equipment, frequency generating equipment, this emphasizes the importance of proper organization of work in repeater stations and of education of personnel to a greater awareness of the need to restrict possible interruption to working circuits. Whenever possible, such work should be carried out during periods of light traffic, e.g. at night.

3.2 Detailed study of sudden changes gives the impression that at least two main classes can be distinguished. Class A, formed by the very short interruptions (<10, 10-15, 15-20 ms) and Class B, formed by the short interruptions (100-150, 150-200, 200-300 and > 300 ms).

Class A is presumably largely due to bad connections (e.g. dry joints). They are correlated with the presence of personnel, who may cause vibrations.

SUPPLEMENT No. 10

RESULTS OF OBSERVATIONS OF VARIATIONS OF OVERALL CIRCUIT LOSS MADE IN THE U.S.S.R. FROM 1956 TO 1960

Observations have been carried out in the U.S.S.R. since 1956 regarding the stability of the equivalent of circuits in the Soviet network. Five series of measurements were carried out in that period, as described in contributions 13, 24, 42, 50 and 85 of S.G. 4.

The measurements consisted of comparison tests with a loop across the 4-wire part of the opposite terminal station, as shown in the diagram opposite. The comparison test method eliminates errors in the generator and level indicator and appreciably reduces subjective errors during the measurements.

For the purposes of the tests, the switch is changed from position 1 to position 2 and the deviation of the level indicator is kept constant by means of the variable complement inserted in the generator output. The attenuation value of the variable complement corresponds to the gain of a looped circuit.

On the basis of the results obtained from these five series of observations, the Soviet Administration has drawn the following conclusions :

1. The mean of the values obtained during the long-term observation is in practice equal to the nominal value.

2. It was not possible to determine the interdependence of the standard deviation and the position of the circuit in the group spectrum.

3. In connections using automatic level adjustment, the standard deviation does not depend on the length.

4. The stability of the equivalent, measured during one hour per day and calculated for each measurement according to the deviation from the initial value, is appreciably

higher than the stability calculated with respect to the nominal value during the whole measurement period.

This shows that in actual operating conditions adjustments have an adverse effect on stability.

5. The output level stability of pilot generators at terminal stations satisfies specifications, i.e. it does not exceed 0.01 N.

6. The standard deviation characterizing equivalent stability *during the whole measurement period* lies within the following limits :

for connections operated with B-3	equipment :	0.08 + 0.24 N
,, ,, ,, ,, B-12	,,	0.08 + 0.22 N
,, ,, ,, ,, B-12-2	,,	0.12 + 0.13 N
,, ,, ,, ,, K-24	,,	0.03 + 0.19 N
,, ,, ,, ,, K-24, B-12	,,	0.07 + 0.19 N

The standard deviation characterizing equivalent stability *during one hour* lies within the following limits :

for connections operated with B-3	equipment :	0.01 + 0.9 N
,, ,, ,, ,, B-12	,,	0.04 + 0.13 N
,, ,, ,, ,, B-12-2	,,	0.04 + 0.06 N
,, ,, ,, ,, K-24	,,	0.01 + 0.07 N
,, ,, ,, ,, K-24, B-12	,,	0.05 + 0.09 N

SUPPLEMENT No. 11

VARIATIONS IN 1956/1957 OF THE OVERALL LOSS OF THE U.S.A. - UNITED KINGDOM TRANSATLANTIC CIRCUITS

(Note by the British Administration)

1. General

This note gives some information on the overall transmission performance of circuits in the first transatlantic telephone cable during the first 6 months of service from October 1956 to March 1957.

2. Routing of the transatlantic telephone circuits

The transatlantic system provides two 12-circuit groups between London and New York over a route length of 4078 miles. The third 12-circuit group is split at Sydney Mines, Nova Scotia (the terminal station of the Newfoundland - Canada submarine cable system) to provide six telephone circuits between London and Montreal over a route length of 4157 miles.

The circuits are routed from London over two alternative 24-circuit carrier cables to Glasgow and thence to Oban on a coaxial cable. Between Oban and Clarenville in Newfoundland the two submarine cables working as a four-wire system are each equipped with 51 submerged repeaters. Between Clarenville and Sydney Mines in Nova Scotia a single submarine cable is provided, equipped with 16 submerged repeaters, and the two directions of transmission pass over this one cable in different frequency bands. From Sydney Mines, transmission is by radio relay link at about 4000 Mc/s via 17 intermediate stations to Portland, Maine. From Portland the circuits are routed over 12-circuit carrier and coaxial cables to New York. The circuits to Montreal leave the radio relay route at Spruce Lake, New Brunswick, near the United States - Canada border and are routed to Quebec on a 12-circuit open-wire carrier system and thence to Montreal on a 12-circuit carrier cable system.

3. Maintenance facilities

Each of the transatlantic groups is provided with an end-to-end group reference pilot of 84.08 kc/s. In general, following Bell system maintenance practice, individual group sections are provided with section pilots. The overall loss of each group section is maintained within specified limits by daily adjustments based on measurements of the section pilot. Individual regulated line sections of the various systems on which the groups are routed are provided with line regulation control devices appropriate to each particular system, e.g. the London - Glasgow 24-circuit line link is provided with automatic gain control equipment operating from a 60 kc/s line regulating pilot and the Glasgow - Oban coaxial line link is provided with automatic gain control using a 4092 kc/s regulating pilot.

Overall maintenance of the transatlantic group links is based on the measurement of the 84.08 kc/s group reference pilot both at the terminal stations and at intermediate stations where the groups are through-connected in the basic group frequency range (60-108 kc/s). In addition to measurements using frequency-selective level-measuring sets for the group reference pilot and the section pilots, extensive use is made of recording decibelmeters at terminal and intermediate stations to obtain a continuous record of the performance of the groups. This technique has proved invaluable in rapidly locating intermittent troubles to a particular section of the route.

4. Transmission stability

The following information on the overall transmission performance of the transatlantic system has been obtained from observations made at London on the West-East direction provided by :

a) Recorder charts of the received 84.08 kc/s group reference pilots at London for the two New York groups and the Montreal group.

b) Recorder charts of the 84.08 kc/s group reference pilot at Sydney Mines, Clarenville and Oban.

c) Weekly measurements of the overall loss of the channels.

5. Measurements on group reference pilots

The mean difference in the received level at London relative to the line-up (reference) level of the group reference pilot and the standard deviation for each week of the period October 1956 to March 1957 is shown in Table 1.

Table 2 shows, for a typical week (16-23 March 1957), the mean differences from the reference level (M) of the group reference pilot and the standard deviation (S) at Sydney Mines, Clarenville, Oban and London.

6. Measurements of the overall loss on circuits

Table 3 summarizes the mean difference and standard deviation of the measured overall loss of the circuits relative to the nominal value, over the period October 1956 to April 1957.

7. Summary

The transmission performance of the transatlantic system may be summarized as follows :

a) The two London - New York groups have a standard deviation of about 1 db in the West-East direction.

b) The London - Montreal portion of the split group has a standard deviation of nearly 1.5 db in the West-East direction.

c) Somewhat higher values of standard deviation are obtained for the circuit loss.

8. Comment

The stability of transmission obtained on the first transatlantic system is regarded as very satisfactory for groups which exceed 4000 miles in length. We consider that factors which have contributed to this performance are:

a) Sound design of the equipment used in each part of the overall system.

b) Sound manufacturing and inspection techniques.

c) Careful installation and very thorough testing of all items of equipment after installation.

d) A thorough overhaul of all existing plant which was to be used in the make-up of the overall groups.

At all stages of testing, vibration testing techniques were freely used. Sections of route to be used for the system were, where possible, set up well in advance of the provision of the overall groups and subjected to reliability tests with the extensive use of recording decibelmeters. Nothing fundamentally new has been introduced into the maintenance techniques provided on the system and the performance rests primarily on a well co-ordinated system design employing known techniques to the best advantage. The use of

TABLE 1

Week ending	Group 1 Montreal - London		Group 2 New York - London		Group 3 New York - London	
	Mean difference from reference level (db)	Standard deviation (db)	Mean difference from reference level (db)	Standard deviation (db)	Mean difference from reference level (db)	Standard deviation (db)
7.10.56	+0.82	0.66	—1.0	0.64	+0.55	0.57
14.10.56	+1.0	0.4	+0.4	0.56	—0.15	0.79
21.10.56	—0.6	0.78	+0.46	0.65	—0.07	0.73
28.10.56	+0.4	1.41	+0.64	0.98	+0.12	0.74
4.11.56	—0.7	2.1	+0.41	0.71	—0.75	0.5
11.11.56	—0.5	0.98	+0.1	0.41	+0.35	1.34
18.11.56	—1.7	1.12	—0.7	0.7	—0.86	0.9
25.11.56	+1.0	0.45	—0.5	0.8	+0.45	0.7
2.12.56	+1.0	0.48	—0.14	0.6	+0.48	0.73
9.12.56	not available				—0.3	0.63
16.12.56	+1.14	0.52	+0.5	0.94	+0.5	0.8
23.12.56	+0.6	0.71	—0.1	0.86	—0.1	0.46
30.12.56	—0.4	0.56	—0.2	0.62	+1.1	0.98
6. 1.57	+0.1	1.73	—0.4	0.7	+0.8	0.87
13. 1.57	+0.3	1.11	+0.4	0.64	+1.1	0.73
20. 1.57	—0.3	1.07	+0.6	0.65	+0.8	0.9
27. 1.57	—2.1	0.58	—0.3	0.87	+0.3	0.56
3. 2.57	—1.7	1.29	—0.6	0.67	+0.8	0.58
10. 2.57	—1.7	0.72	—0.8	0.73	+1.3	0.88
17. 2.57	—1.0	0.69	—0.7	0.5	+0.4	0.49
24. 2.57	—1.0	0.74	—0.7	0.43	+0.8	0.37
3. 3.57	—0.6	1.56	—0.5	0.59	+1.5	0.42
10. 3.57	—0.7	0.78	—1.2	0.88	+0.2	0.98
17. 3.57	—0.3	1.4	—1.0	1.26	+1.0	0.87
24. 3.57	—1.5	1.26	—1.9	0.82	—0.1	0.86
31. 3.57	—0.4	0.87	+0.9	1.14	+0.8	0.48
Cumulative	—0.31	1.4	—0.29	0.99	+0.42	0.95

TABLE 2

Station	Sydney Mines		Clarenville		Oban		London	
	M	S	M	S	M	S	M	S
Group 1 Montreal	+0.28	0.84	+1.75	0.87	+1.36	0.88	–0.72	1.005
Group 2 New York	–0.1	0.69	–1.3	–0.78	–0.4	0.81	–2.7	0.805
Group 3 New York	+0.33	0.73	+0.73	0.75	–0.06	0.788	–0.75	0.825

TABLE 3

Circuits in group	Direction of transmission	Mean difference from reference level (db)	Standard deviation (db)
1	London - Montreal	—0.9	0.98
	Montreal - London	—0.16	1.22
1	London - New York	—0.06	1.3
	New York - London	—0.32	1.87
2	London - New York	—0.34	1.51
	New York - London	—0.1	1.51
3	London - New York	—0.76	1.43
	New York - London	—0.19	1.76

section pilots and an overall group reference pilot, together with facilities for continuously recording their levels using recording decibelmeters at appropriate points, are important features of the maintenance technique.

SUPPLEMENT No. 12

RELATIONSHIP BETWEEN CIRCUIT AND GROUP VARIATIONS

(Joint study made by the Administrations of the Netherlands and the United Kingdom and described in " COM. 4—No. 49 ")

The following question was put :

What is the best estimate that can be given of the standard deviation of the loss variations of a channel if only the standard deviations of the variations of loss of group reference pilots on the group links over which it is routed are known?

* * *

The variations of overall loss (or gain) of any channel are a function of the variations of the channel translating equipment and the group link variations. Hence the accuracy with which the channel performance can be estimated is dependent upon:

1. the relative magnitude of the group and channel translating equipment variations;
2. the correlation if any between the channel equipment and group link loss variations;
3. the variations of the group link loss at the line frequency of the channel relative to the group link loss at the group reference frequency.

As far as channels near the middle of the group band are concerned 3 is negligible and it is therefore proposed to discuss 1 and 2 only in this paper.

Symbols:

let σ_g = standard deviations of the variations in loss of the group links,

σ_t = standard deviations of the variations in loss of the translating equipment,

σ_c = standard deviations of the variations in loss of the overall channel,

R_{gt} = coefficient of correlation between the variations of loss of the group and the channel translating equipment,

R_{gc} = coefficient of correlation between the variations of loss of the group and the overall channel,

R_{tc} = coefficient of correlation between the variations of loss of the channel translating equipment and the overall channel.

By definition the correlation coefficients must lie in the range $\pm$ 1

$$\text{i.e. } |R_{gt}| <1; \ |R_{gc}| <1 \text{ and } |R_{tc}| <1$$

The relationships between σ_c, σ_g and σ_t can be expressed in three main forms as follows :

$$\sigma_c^2 = \sigma_g^2 + \sigma_t^2 + 2R_{gt}\,\sigma_g\sigma_t \qquad \text{(i)}$$

$$\sigma_g^2 = \sigma_c^2 + \sigma_t^2 - 2R_{tc}\,\sigma_c\sigma_t \qquad \text{(ii)}$$

$$\sigma_t^2 = \sigma_g^2 - \sigma_t^2 - 2R_{gc}\,\sigma_g\sigma_c \qquad \text{(iii)}$$

Consider the equations in turn and assume the correlation coefficients and σ_t to be constant for all values of σ_c and σ_g we then find :

1) If R_{gt} constant, rearranging

$$\sigma_c^2 = \sigma_g^2 + \sigma_t^2 + 2R_{gt}\,\sigma_g\sigma_t \qquad \text{i)}$$

gives
$$\sigma_c^2 - (\sigma_g + R_{gt}\sigma_t)^2 = \sigma_t^2\,(1 + R_{gt}^2)$$

This is an orthogonal hyperbola with asymptotes making angles of 45° with the axis and intersecting in point $(-R_{gt}\ \sigma_t,\ 0)$

2) If R_{tc} constant, rearranging

$$\sigma_g^2 = \sigma_c^2 + \sigma_t^2 - 2R_{tc}\,\sigma_c\sigma_t \qquad \text{ii)}$$

gives
$$\sigma_g^2 - (\sigma_c - R_{tc}\sigma_t)^2 = \sigma_t^2\,(1 - R_{tc}^2)$$

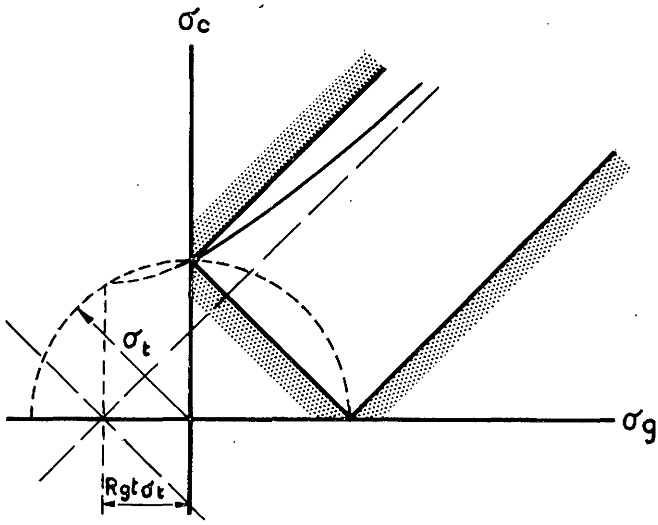


FIGURE 22

This is again an orthogonal hyperbola with asymptotes making angles of 45° with the axis. The asymptotes now intersect in point $(0, R_{ct}\,\sigma_t)$ and the openings of the hyperbola are now situated on the σ_g axis.

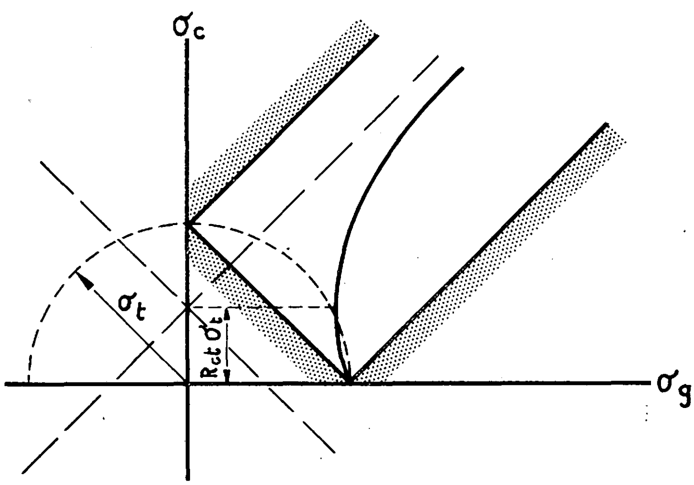


FIGURE 23

3) If R_{gc} constant, let us consider

$$\sigma_t^2 = \sigma_g^2 + \sigma_c^2 - 2R_{gc}\,\sigma_g\sigma_c \qquad \text{iii)}$$

If we substitute

$$x = \frac{\sigma_g}{\sqrt{2}} + \frac{\sigma_c}{\sqrt{2}} \text{ and } y = \frac{\sigma_g}{\sqrt{2}} - \frac{\sigma_c}{\sqrt{2}}$$

we have

$$x^2(1-R_{gc})+y^2(1+R_{gc})=\sigma_t^2$$

This is the equation of an ellipse with main axis having lengths $\dfrac{2\sigma_t}{\sqrt{1-R_{gc}}}$ in the x directions and $\dfrac{2\sigma_t}{\sqrt{1+R_{gc}}}$ in the y direction.

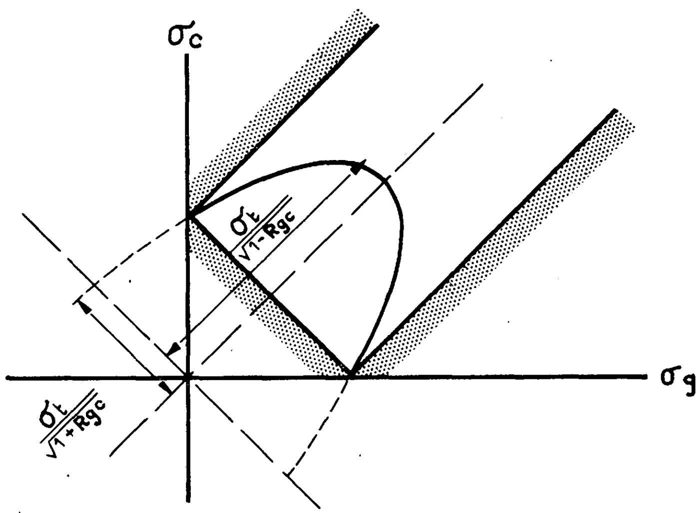


FIGURE 24

Dependent on the choice of coefficient considered constant, curves of different shape are thus obtained but all fall within the rectangle bounded by the lines :

$$\sigma_c=\sigma_g+\sigma_t$$

$$\text{and}\quad \sigma_c=\sigma_g-\sigma_t$$

shown shaded in Figures 22 and 24.

There is no exact relationship that will perfectly relate σ_g and σ_c since σ_t and the correlation coefficients are *not* constant. There are, however, two assumptions that can be made which lead to good approximations to the $\sigma_c(\sigma_g)$ function.

1. Assuming R_{gc} constant and equal to unity

If with these assumptions we consider equation (iii)

$$\sigma_t^2=\sigma_g^2+\sigma_c{-}^2\,2R_{gc}\,\sigma_g\sigma_c$$

rearranging gives

$$\sigma_g^2+\sigma_c^2=\sigma_t^2+2R_{gc}\,\sigma_g\sigma_c$$

Hence plotting $\sigma_g^2+\sigma_c^2$ against $\sigma_g\,\sigma_c$ we expect a straight line with intercept σ_t^2 and slope of 2. The results of the series of C.C.I.T.T. tests are plotted in Figure 23.

The equation of the line can be rewritten in the form:

$$\sigma_c = \sigma_g + 0.192 \qquad \text{(iv)}$$

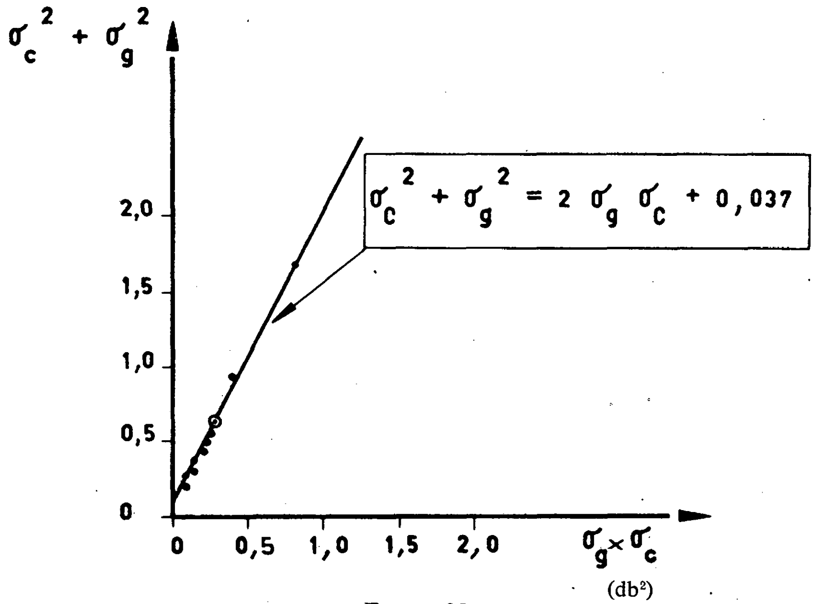


FIGURE 25

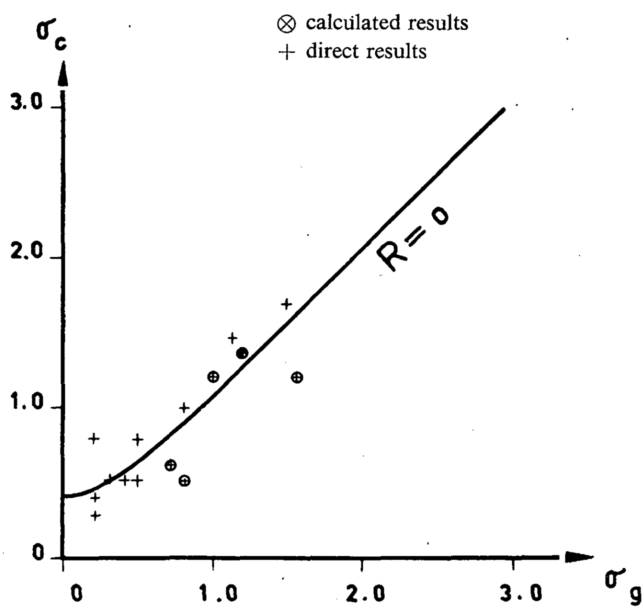


FIGURE 26

2. **Assuming $R_{gt} = 0$**

From equation (i) this immediately gives

$$\sigma_c^2 = \sigma_g^2 + \sigma_t^2$$

Fitting this curve to the measured results of the C.C.I.T.T. series tests are plotted in Fig. 24

This gives $\sigma_t = 0.4$, which gives the formula

$$\sigma_c = \sqrt{\sigma_g^2 + 0.4^2} = \sqrt{\sigma_g^2 + 0.16} \tag{v}$$

Tandem links

So far only links having directly measured σ_g and σ_c have been used in determining the coefficients in these formulae. However, it is desirable to be able to compute the results of tandem group connections. If equation (iv) is used, then the method of calculating tandem link performance is to compute σ_c for each group and to add the two calculated on a root sum of squares basis, i.e.

$$\sigma_c\,(1+2) = \sqrt{(\sigma_{g^1} + 0.19)^2 + (\sigma_{g^2} + 0.19)^2} \tag{vi}$$

Comparison of results

Table 5 compares the measured results together with the calculated results using formulae (iv) & (vi) and (v) & (vii)

Route	measured		calculated		differences		square differences	
	σ_g	σ_c	formula (iv)&(vi)	formula (v)&(vii)	measured formula (iv)&(vi)	measured formula (v)&(vii)	measured formula (iv)&(vi)	measured formula (v)&(vii)
Bruxelles-Zürich	0.5	0.79	0.69	0.612	+0.10	+0.18	0.01	0.0324
Zürich-Bruxelles	0.49	0.52	0.68	0.63	—0.16	—0.11	0.0256	0.0121
Paris-Hamburg	0.3	0.33	0.49	0.50	—0.16	—0.17	0.0256	0.0289
Hamburg-Paris	0.35	0.52	0.54	0.53	—0.02	—0.01	0.0004	0.0001
Zürich-Paris	0.8	1.0	0.99	0.90	+0.01	+0.10	0.0001	0.0100
Paris-København	1.14	1.48	1.33	1.22	+0.15	+0.26	0.0225	0.0676
London-Hamburg	0.27	0.48	0.46	0.48	+0.02	+0.00	0.0004	0.0000
Frankfurt-Hamburg	0.3	0.45	0.49	0.5	—0.04	—0.05	0.0016	0.0025
Rotterdam-Zürich	0.22	0.39	0.41	0.46	—0.02	—0.07	0.0004	0.0049
Roma-Zürich	0.46	0.53	0.65	0.61	—0.12	—0.08	0.0144	0.0064
Stockholm-Malmö	0.65	0.42	0.84	0.76	—0.42	—0.34	0.1764	0.1156
							0.2774	0.2805
Zürich-London	0.8 +0.76	1.12	1.37	1.2	—0.25	—0.08	0.0625	0.0064
London-Frankfurt	0.27+0.18	0.56	0.59	0.65	—0.03	—0.09	0.0009	0.0081
Frankfurt-London	0.3 +1.32	1.32	1.59	1.46	—0.25	—0.12	0.0625	0.0144
Rotterdam-Roma	0.22+1.15	1.32	1.42	1.30	—0.12	+0.02	0.0144	0.0004
Roma-Rotterdam	0.46+0.7	0.8	1.10	1.11	—0.30	—0.31	0.09	0.0961
London-Stockholm	1.03+0.64	1.54	1.48	1.4	+0.06	+0.14	0.0036	0.0196
Stockholm-London	0.65—1.2	1.28	1.63	1.48	—0.35	—0.2	0.1225	0.04
							0.3564	0.1850

If equation (v) is used then

$$\sigma_c(1+2) = \sqrt{\sigma_{g^1}{}^2 + \sigma_{g^2}{}^2 + (2+0.16)} = \sqrt{\sigma_{g^1}{}^2 + \sigma_{g^2}{}^2 + 0.32} \qquad \text{(vii)}$$

Remark. — It may happen in some cases that the standard deviation computed for two circuits in tandem is lower than that for the corresponding groups. It is considered that this apparent inconsistency may sometimes be due to correlation in the variation occurring at the two measuring points concerned.

Conclusions

The foregoing considerations are based on a small number of test results the accuracy of which we do not know. However, it has been shown that the standard deviation of the variations of the overall loss of the mid-channel of a group can be estimated with reasonable accuracy if the standard deviations of the group link or links concerned are known by using either formula

$$\sigma_c = \sigma_g + 0.19$$

or $$\sigma_c{}^2 = \sigma_g{}^2 + 0.16$$

SUPPLEMENT No. 13

MEASUREMENTS MADE ON BATCHES OF CIRCUITS IN 1959 AND 1960

1. In 1959 and 1960, tests on batches of circuits were carried out by a number of administrations in Europe. These " batch tests " are measurements, made all at one time, on groups of circuits between international exchanges. The object of such tests is to obtain a more comprehensive picture of the transmission performance of groups of circuits than is possible by the present routine maintenance tests.

A study was also made of the results of measurements made before and after routine maintenance tests by a number of administrations in 1959.

2. Results of the tests on batches of circuits

The results of the tests made on batches of circuits are summarized in Table 1. Where possible the results of the measurements between each pair of countries have been separated into three categories :

a) circuits on direct groups with overall automatic group regulation,

b) circuits on direct groups without automatic group regulation,

c) all other circuits.

The final row of the table shows the combined results for all the circuits which were tested.

In this table the first entries are the results of measurements made in 1960 and the figures which follow in brackets are the results of measurements made in 1959.

Table 1 — Summary of results of tests made in 1960 (1959) on batches of circuits

	Contribution No.	Route	Circuits on direct groups						Other circuits			All circuits		
			With AGC			Without AGC								
			n	M(cN)	σ(cN)	n	M(cN)	σ(cN)	n	M(cN)	σ(cN)	n	M(cN)	σ(cN)
BATCH TESTS	70	B-CH	35	—4.0	9.2	6(40)	— 7.8(—1.0)	17.1(27)	8	— 0.8	25	49	— 3.9	13.8
	73	CH-B				44(39)	—14.2(—9.6)	13.6(35)	5	+12	11.0	49	—10.4	13
	65	B-D	23	0	9.9	—(132)	— (—9.5)	— (19)	27(14)	+ 1(—6.5)	27.8(30)	50	+ 0.5	21.5
	73	D-B				93(132)	—15.8(—19.6)	16.6(28)	11(14)	— 4(—30)	12.2(24)	104	—14.7	16
	69	B-F				218(205)	+ 2.9(—0.2)	16.2(20.2)	34.(41)	+ 7.1(—7.3)	19.2(21.0)	252	+ 3.5	16.7
	73	F-B				209(198)	—10(—14.8)	15.0(23.6)	32(31)	— 9.0(—8)	16.8(11.2)	241	— 7.7	15.7
	T3	B-GB				91	— 1.2	21.5	7	—18.9	19.4	98	— 2.4	21.3
	73	GB-B				92	— 7.7	20.0	6	—17.2	23.6	98(115)	— 8.2(—2.5)	20.1(23.3)
	65	CH-D	210(85)	+ 1.0(—1)	10.3(17)	—(125)	— (0)	— (20)	7(11)	—12(—4)	0.4(24)	247	+ 0.6	10.5
	70	D-CH	168(81)	— 4.6(—13)	14.5(18)	30(128)	—12.4(—18)	17.9(22)	68(11)	— 1.5(—34)	17.9(16)	266	— 4.7	16.0
	69	CH-F	66(63)	— 0.3(—2.6)	12.7(13.8)	89(91)	— 6.9(—6.8)	17.4(20.5)	44(48)	— 0.3(—11.8)	16.0(16.4)	199	— 3.2	16.0
	70	F-CH	124(149)	— 5.5(—2)	11.9(14)	32(5)	— 7.6(—6)	12.1(9)	43(29)	— 2.9(—6)	13.1(12)	199	— 1.9	11.9
	T3	CH-GB				37(26)	—29.7(—14)	16.8(21)	25	—20.6	19.2	62	—25.8	18.3
	70	GB-CH	29(10)	— 5.4(+11)	12.1(19)	4(16)	+16.3(—3)	18(20)	19	—15.6	25.0	52	+ 7.7	19.5
	61	CH-I				111	— 3.6	19	44	— 6	20.6	155	— 4.2	19.7
	70	I-GH				111	— 0.9	14.8	43	+ 1.4	17.2	154	— 1.6	15.3
	69	D-F	27(67)	— 6(—2)	13.2(11.6)	187(115)	—10.3(—2.3)	16.7(19.3)	101(98)	—14(—8.5)	18.3(22.8)	315	—11.1	17.1
	65	F-D	59(33)	0(—8.3)	12.2(19)	— (151)	— (—1.4)	— (20.5)	25(96)	—16(—7)	13.3(23.5)	84	— 4.8	14.5
	T3	D-GB				69	—13.2	28.9	17	—14.1	29	86	—13.4	29.0
	65	GB-D	53	—11	15.6	32	—12	15.5	10	—10	30.8	95	—11.2	17.8
	T3	F-GB				134	—15.4	20.4	35	—16.6	13.7	169	—15.7	19.2
	69	GB-F	18	— 5.3	9.2	116(118)	— 4.9(—0.4)	25.2(28.3)	30(39)	—10.0(—2)	18.5(28.8)	164	— 5.3	23.1
	61	F-I				60	+ 3.3	23.9	31	— 0.4	26.4	91	+ 2.1	25
	69	I-F				55	+ 8.0	22.3	51(116)	— 0.5(—8)	24.1(26.7)	106	+ 3.9	23.6
	73	NL-B				404(348)	— 6.9(—12.6)	17.3(18.3)	23	— 3.9	15.8	427	— 6.9	17.2
	78	B-NL				400(334)	—13.1(—2.0)	16.7(17.8)	11(13)	—15.6(—4.0)	11.0(14.6)	411	—13.2	16.0
	70	NL-CH	35(29)	— 2.0(0)	9.8(8)	15(26)	—16.0(—13)	13.3(20)	6(7)	— 1.3(—10)	14.7(18)	56	— 5.7	12.6
	78	CH-NL				51(51)	— 4.6(—21)	18.4(40)	6(18)	—12.4(—9.2)	17.7(17.8)	57	— 2.9	19.1
	65	NL-D	314	— 2.0	9.5	21(259)	+ 2(—0.1)	15.2(17.6)	23(46)	— 4(—0.9)	18.7(15.5)	358	— 1.9	10.8
	78	D-NL				365(259)	— 2.2(—2.6)	15.3(14.8)	37(46)	+ 2.8(+0.1)	11.0(15.0)	402	— 1.8	15.4
	69	NL-F	6	—11.0	15.3	40(50)	—11.8(—5.6)	19.0(18.1)	23(16)	+ 14.1(—8)	27.5(26.7)	69	— 3.1	25.1
	78	F-NL				47(50)	+ 1.5(—3.5)	12.3(18.6)	23(16)	0(—8)	14.8(24.5)	70	+ 1.1	19.4
	T3	NL-GB				136	+ 2.5	10.7				136	+ 2.5	10.7
	78	GB-NL				138	+10.6	17.6				138	+10.6	17.6
	73	B-L				31	— 6	21.0	8	—12	7	39	— 7.2	20.7
	73	L-B				31	— 6.6	24.0	8	+ 8	3	39	— 3.4	20
	61	I-D				113	— 8	19.4	10	—11	17.7	123	— 8.3	19.3
	61	D-I				84	— 6.8	21.3	40	— 3.1	23.3	124	— 5.5	22.1
Batch tests on the same routes as 1959 . . .			1197(547)	—2.6(—4)	11.9(16)	3100(3436)	— 6.0(—6.8)	19.3(21.8)	732(780)	— 6.7(—7.5)	19.8(22.0)	5029	— 5.3	18.0
All batch tests . . .			1197	— 2.6	11.9	3696	— 5.5	19.5	967	— 4.9	20.6	5860	— 4.8	18.5

The results of the measurements made in 1959 and in 1960 are also shown in graphical form in Figures 27, 28 and 29 below.

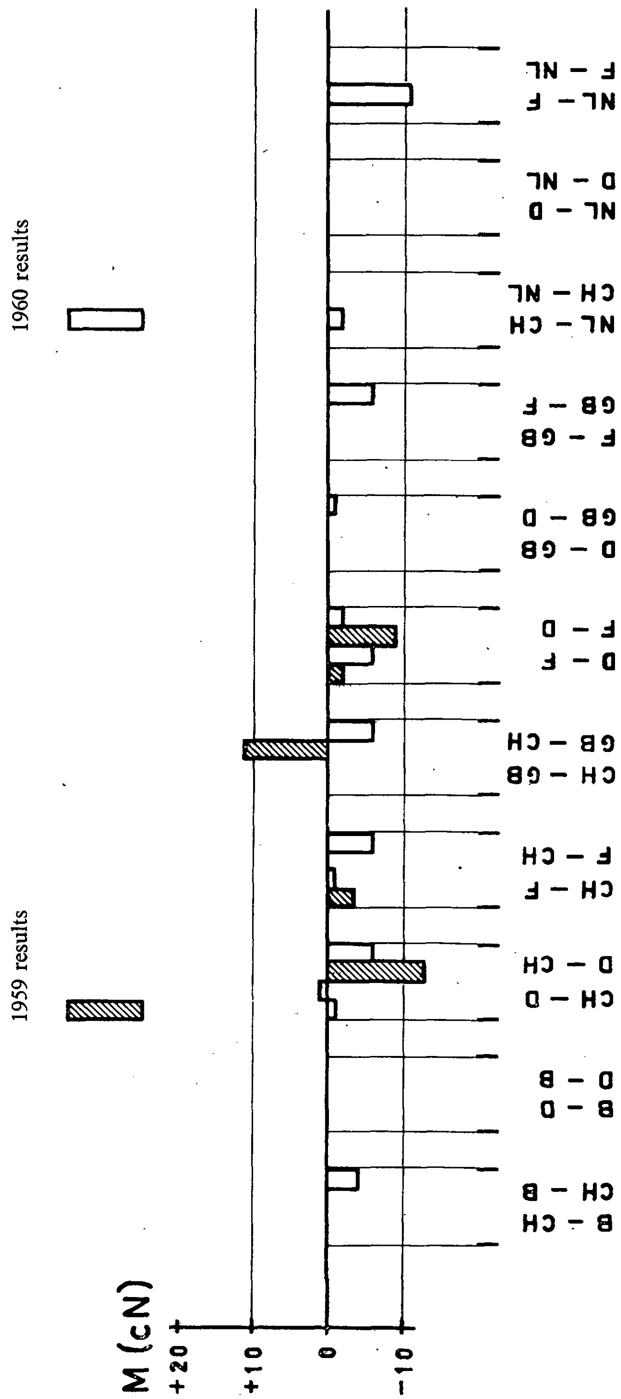


FIGURE 27

Circuits on direct groups with A.G.C.

Mean deviations from nominal value (cN)

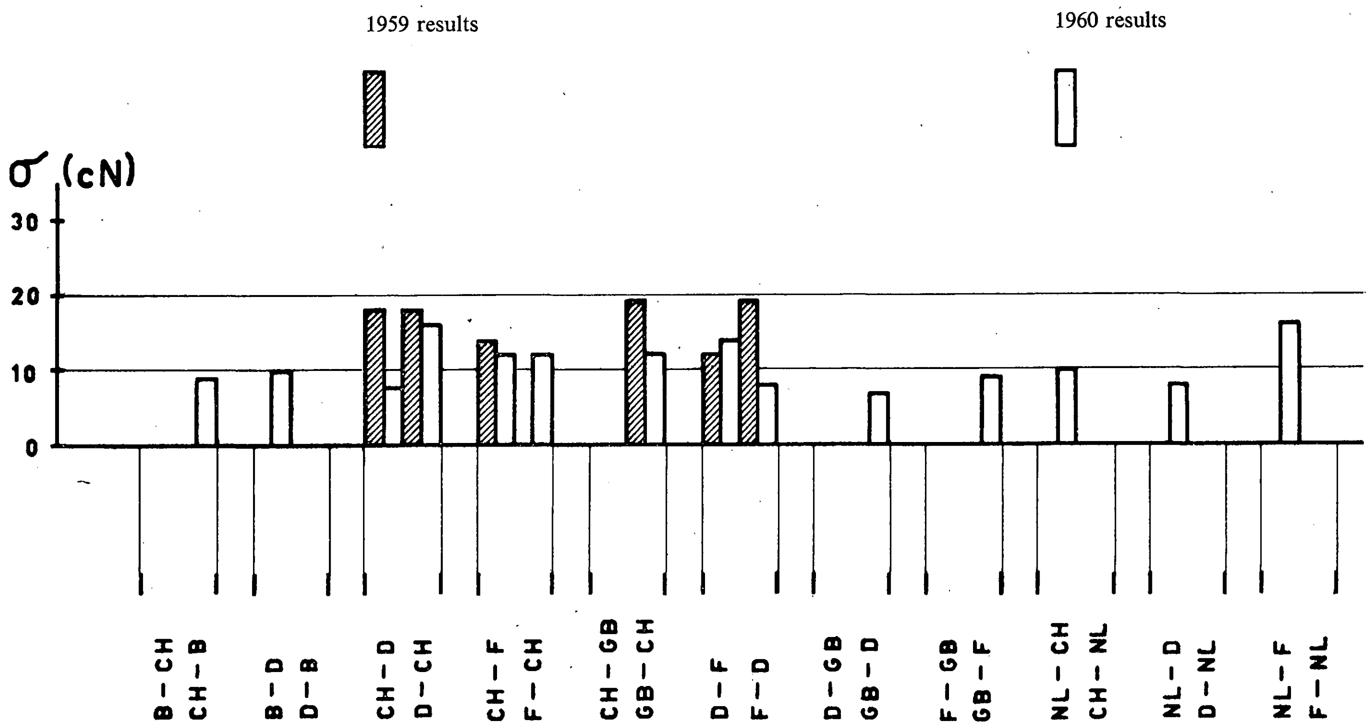


FIGURE 27

Circuits on direct groups with A.G.C.
Standard deviations (cN)

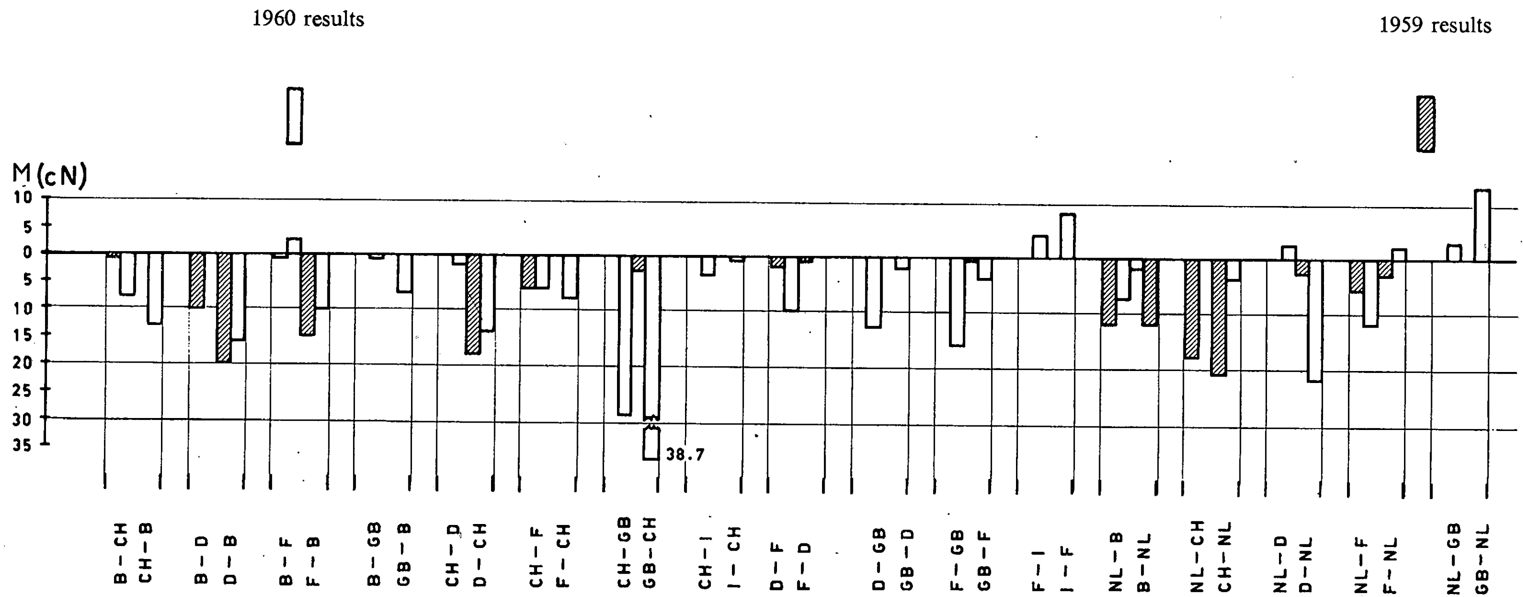


FIGURE 28

Circuits on direct groups without A.G.C.

Mean deviations from nominal value (cN)

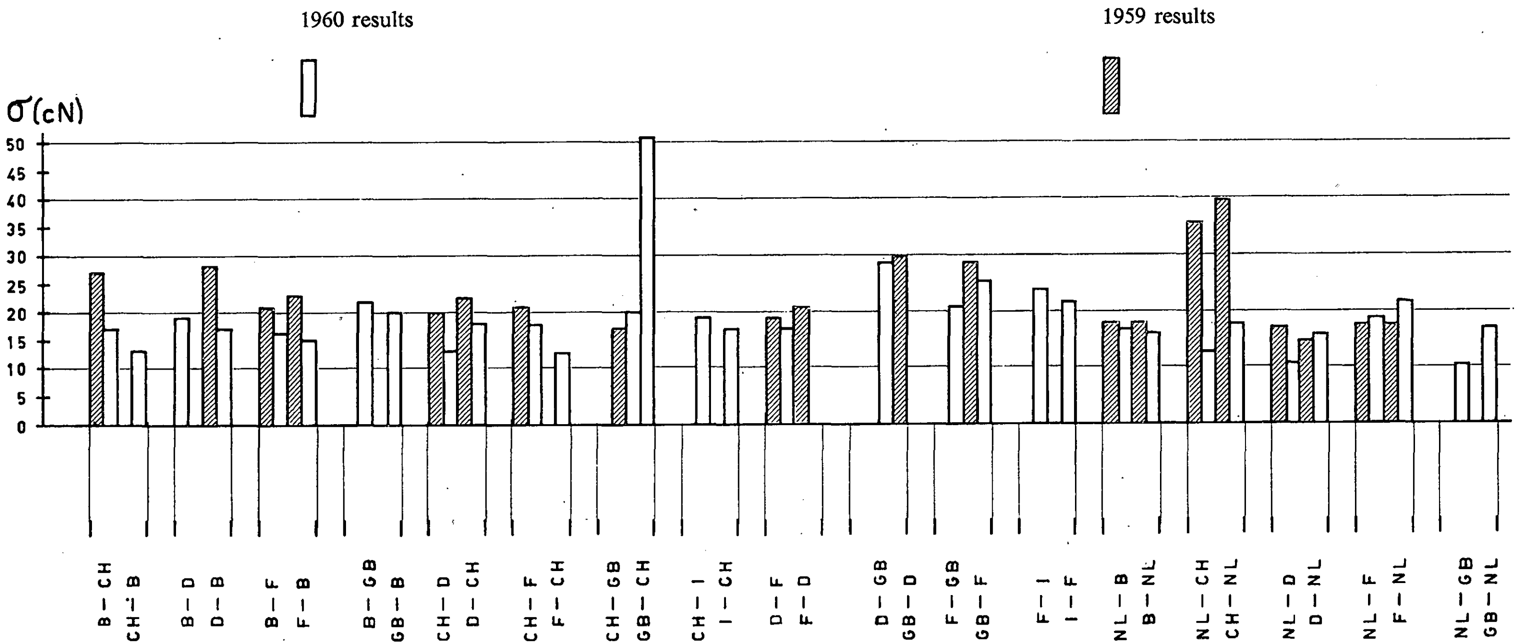


FIGURE 28

Circuits on direct groups without A.G.C.
Standard deviations (cN)

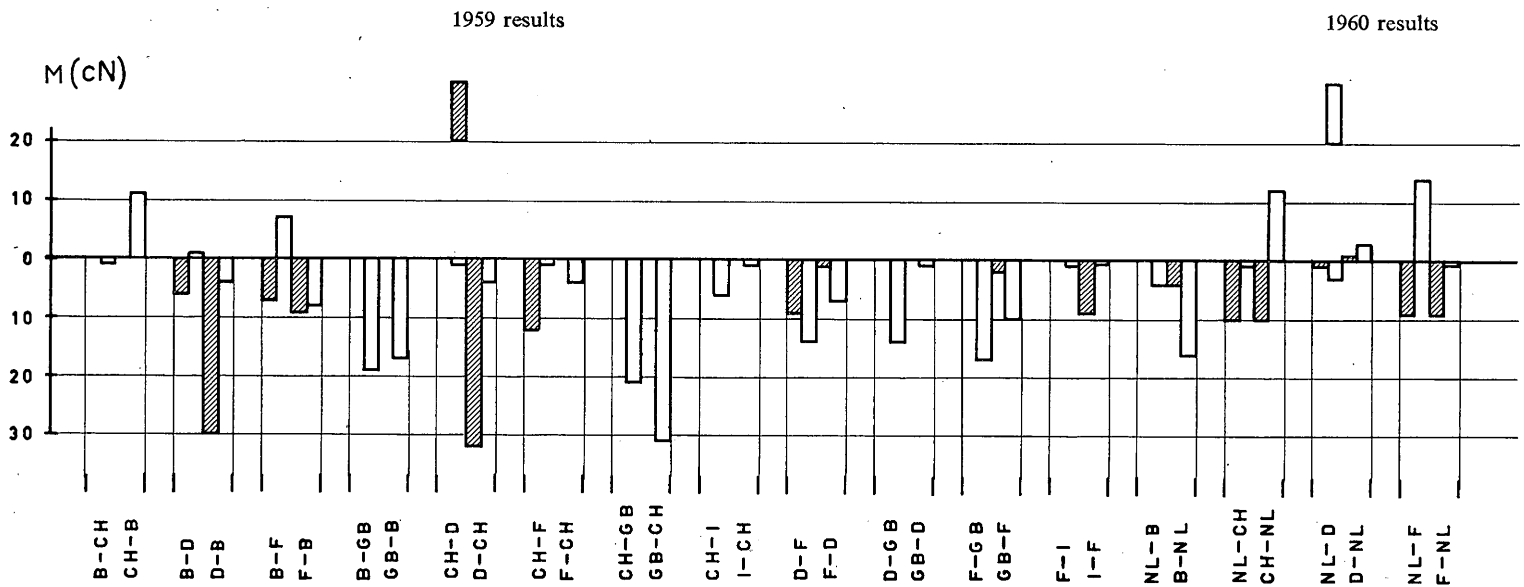


FIGURE 29

Other circuits

Mean deviations from nominal values (cN)

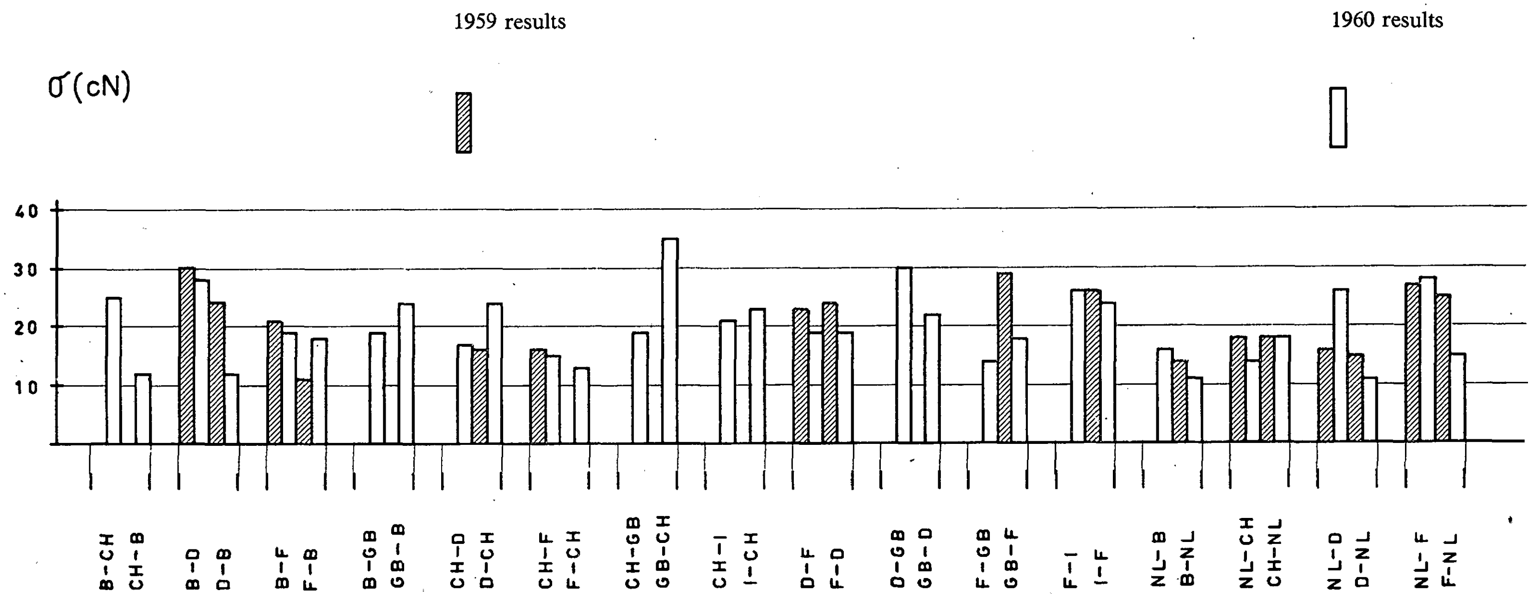


FIGURE 29

Other circuits

Standard deviations (cN)

3. Comments on the results of tests on batches of circuits

The chief conclusions drawn by Study Group 4 in 1959 and 1960 are as follows :

3.1 The results of the measurements made on groups of circuits confirm the fears expressed by Study Group 4 at the Munich meeting in 1958 that the performance of the general network in Europe is not as good as would be expected from the sixth series of tests.

3.2 In some cases the mean values are appreciably different from the nominal values. Possible causes are incorrect adjustments following routine maintenance measurements and after clearance of faults, incorrect lining-up when the circuits are first set up and inaccuracies in measuring equipment.

3.3 It was noted that in most cases the mean values of the measured overall loss are greater than the nominal value (the negative values in Table 1 apply to level measurements and indicate that the mean loss is greater than the nominal). The reasons for this difference are being studied.

3.4 Batch tests must be continued to enable the performance of individual routes to be checked and to keep the state of the general network under review.

3.5 Batch measurements have been carried out in Europe for only two years and it is too early to expect to see any clear indication of the trend in the performance of the network. The United Kingdom have summarized the results of batch measurements made on a number of routes from London in 1957, 1958, 1959 and 1960. The mean values of circuit loss relative to nominal and corresponding values of standard deviation for all the measurements are as follows :

	Number of measurements	*Mean*	*Standard deviation*
1957	860	–0.63 db	2.18
1959	902	–0.56 db	1.96
1960	1045	–0.54 db	1.89

Corresponding figures for the C.C.I.T.T. measurements made in 1959 and 1960 are as follows.

	Circuits on directs groups						*Other circuits*		
	With A.G.C.			*Without A.G.C.*					
	n	M(cN)	σ(cN)	n	M(cN)	σ(cN)	n	M(cN)	σ(cN)
1959	547	–4	16	3436	–6.8	21.8	780	–7.5	22
1960	1197	–2.6	11.9	3696	–5.5	19.5	967	–4.9	20.6

It appears that there has been a small improvement in the general situation. However, it is considered that batch tests should continue with the object of keeping the transmission performance of the European network under review.

4. Objectives for the future

The studies by the C.C.I.T.T. of variation of circuit loss and the measurements made on batches of circuits in recent years should enable objectives to be set for the performance of the international network.

In studying the results of measurements on batches of circuits, the following are suggested as provisional objectives for the immediate future :

a) Reduction of the standard deviation of variation in circuit loss relative to the measured mean :

— 10 cN or 1 db for circuits on direct groups with A.G.C.;

— 17 cN or 1.5 db for other circuits.

b) Reduction of mean deviation from nominal loss to $\pm$ 5 cN or $\pm$ 0.5 db.

The above objectives are to be regarded as provisional and subject to review and modification as a result of further work by Study Group 4.

Power supply arrangements for preventing interference on neighbouring racks under fault conditions

SUPPLEMENT No. 14

EFFECT OF FUSE RESISTANCE ON THE VOLTAGE DROP IN NEIGHBOURING RACKS

(Study by the Federal Administration of Germany)

The Federal German Administration has carried out tests to throw light on the effects noted by the Netherlands Administration and mentioned in the question studied in 1957/1960 (Sudden breaks in transmission due to short-circuits in neighbouring racks). The carrier current equipment power supply which was examined is designed to supply an alternative heating voltage with an interruption of 3 seconds if there is a failure in the mains, and a continuous anode voltage of 212 volts without interruption. The power is distributed to the various repeaters through a power supply rack, a fuse panel and a power pack.

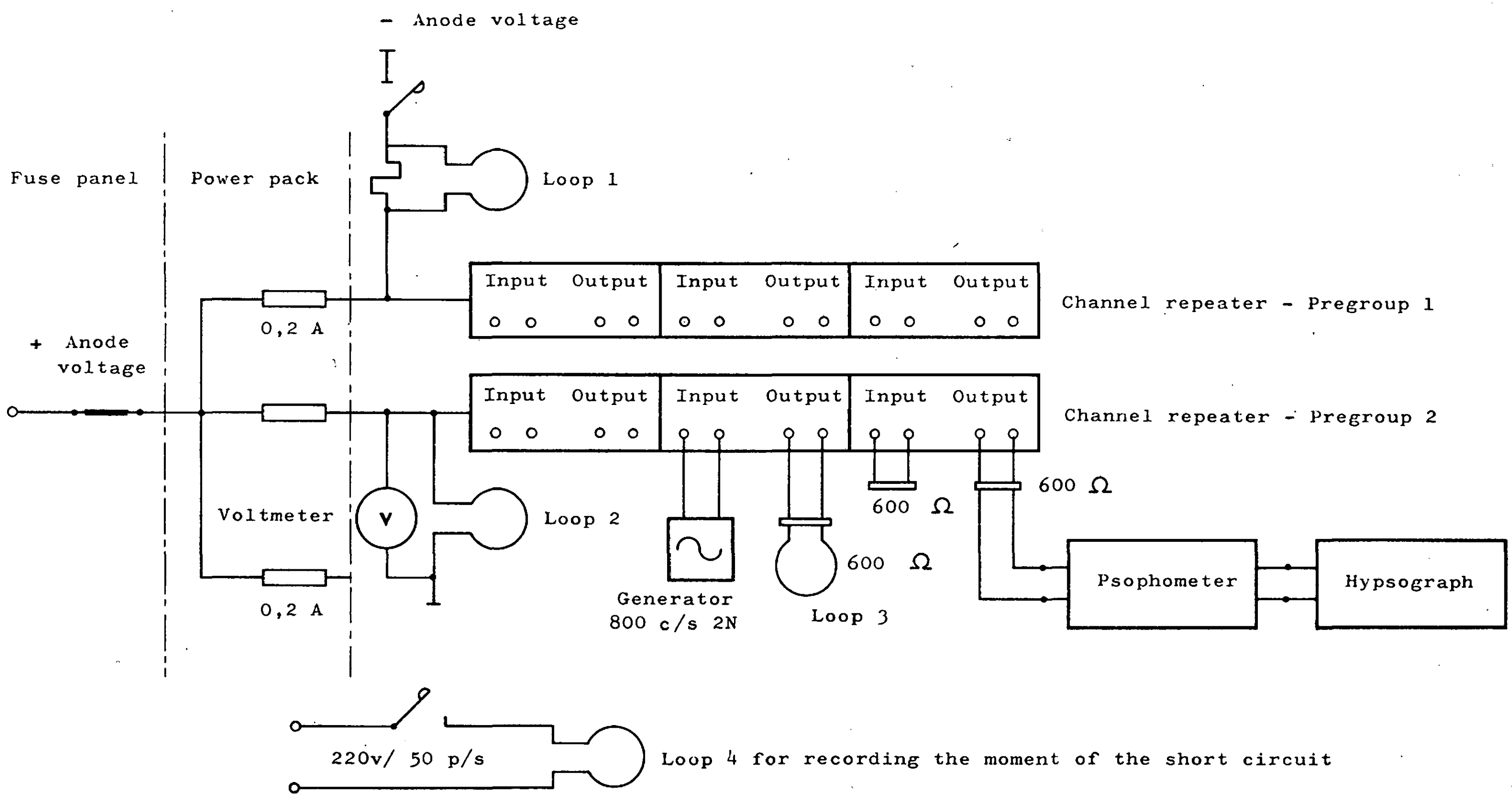


FIGURE 30

Block schematic of arrangement for recording the short-circuit current, the voltage drop, the variation in level and psophometric voltage occurring in units close to the rack or on neighbouring racks.

Figure 30 shows the lay-out of the measuring apparatus. The measurements were taken with the aid of an oscillograph having four measuring loops and a recording psophometer. Simultaneous recordings could be taken of

— the short-circuit current,
— the voltage drop on the neighbouring unit or the neighbouring rack and
— the level variation in the unit near the rack or the neighbouring rack.

A fourth measuring loop served to determine the moment when the short-circuit occurred. The purpose of the psophometer was to record the psophometric voltage on the units near the rack or the neighbouring racks.

In all the measurements, the short-circuit was produced in the anode lead immediately before the repeater. These tests showed that the short-circuit current is determined by the resistance of the fuse in series.

If the fuse nearest to the point where the short-circuit occurs has a resistance of 8 ohms, the short-circuit current is about 11 amperes, but if the fuse has a resistance of only 1 ohm the short-circuit current increases to 44 amperes. The anode voltage drop in the nearby unit if an 8-ohm fuse is used is about 8 % (25 volts) and the level varies by less than 0.1 neper (Fig. 31). In the neighbouring rack, the anode voltage drop is, on the other hand, only 3 % (6 volts). No variation in level was noted (Fig. 32).

In all the short-circuit tests it was noted that the voltage drop was inferior or equal to 1 millisecond. Since this duration and the level variation are both very small, the transmission performance of voice-frequency telegraph circuits is not impaired.

In conclusion, the following comments can be made :

by a suitable choice of fuses, from the viewpoint of resistance and operating time :

1. it is possible to maintain the variation of the anode voltage and the variation in level in the neighbouring unit or the neighbouring rack within limits which are tolerable in operation;
2. if there is a short-circuit, only the apparatus fuse, and no other protection device in series, works.

It should be added that the power of the supply installation in the repeater station where the tests were made was so great that the small internal resistance of the installation and the supply cables did not have any effect on the short-circuit current.

No increase in the psophometric voltage in the channels of the neighbouring repeaters was noted.

* * *

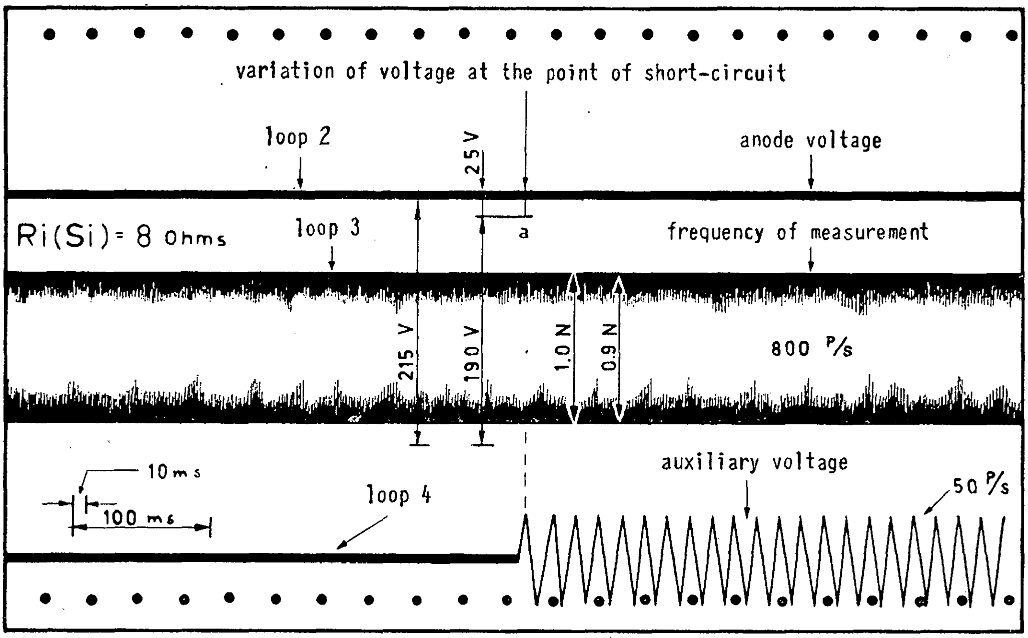


FIGURE 31

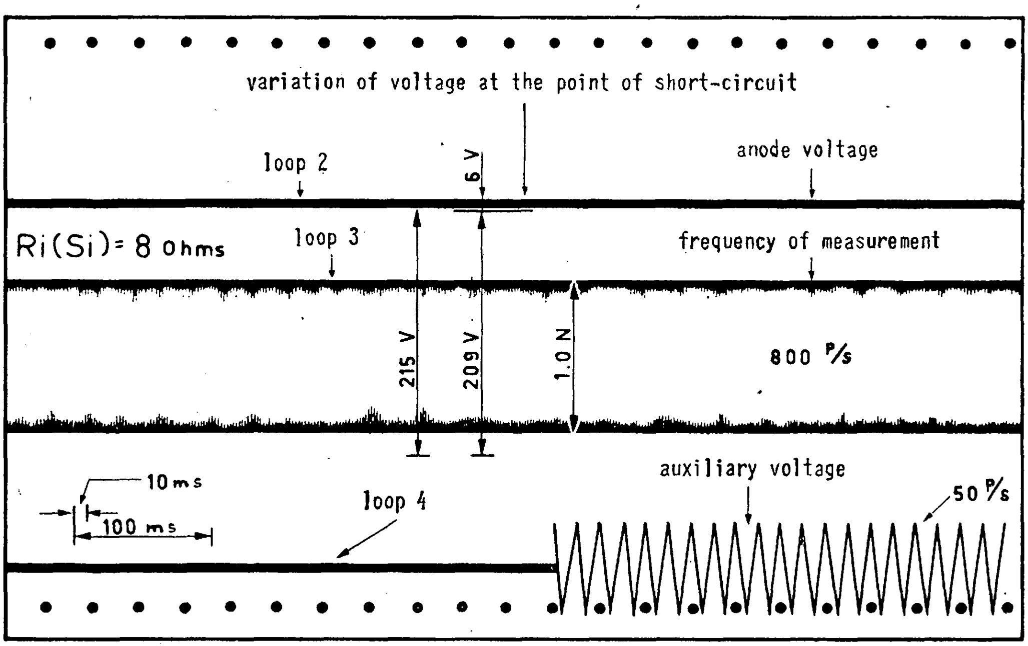


FIGURE 32

SUPPLEMENT No. 15

THE ADVANTAGES OF INSERTING A RECTIFIER ACROSS THE ANODE DECOUPLING RESISTOR

(Study by the Dutch Administration)

Although research is being continued in connection with the protection of power supplies to repeater station equipment, particularly as regards the selectivity of that protection, a provisional method has been developed, pending a final solution to the question, guaranteeing uninterrupted operation of voice-frequency telegraph systems. The observations were made on a 24-channel V.F. telegraph system, all the channels being fitted with their own electronic oscillators. The system was looped at the control station. An oscilloscope displayed :

a) the output voltage of a channel oscillator and

b) the output voltage of the channel filter on the receiving side,

when the 220-volt d.c. power supply was short-circuited by inserting a fuse (4 A DIAZED) between the 220 V terminals of the rack.

The oscillator anode circuits were decoupled by an *RC* circuit ($R = 1000$ ohms, $C = 10^{-6}$ F).

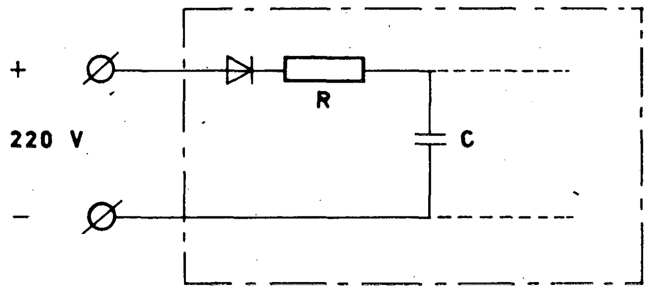


FIGURE 33

It was revealed that a short-circuit on the 220-volt side very quickly caused the decoupling condenser C to discharge, the resistance R being small ($RC = 10^{-3}$ sec.). The oscillograms (two of which are shown in Figures 35 and 36) show that, if a rectifier is inserted in series with the resistance R, the condenser can no longer discharge through the short-circuit; hence, any sudden change in the anode current of the oscillator tube during the short-circuit is avoided.

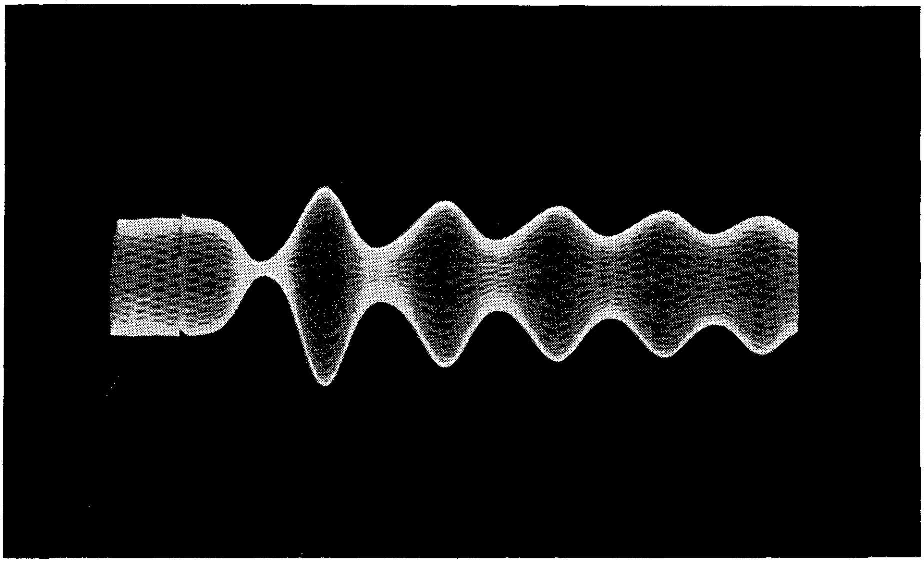


FIGURE 35

Voltage at the output of a 2460 c/s receiving filter when a fuse causes a short-circuit in the 220 V supply (both the oscillator and the transmitting and receiving amplifiers of the system under loop test were connected to this 220 V supply) — (time basis: 220 milliseconds)

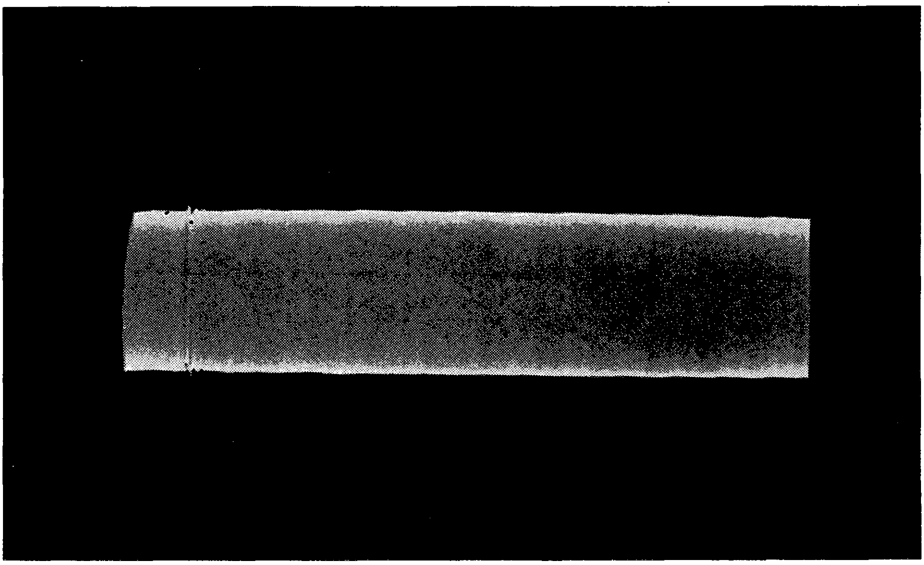


FIGURE 36

Voltage at the output of the 2460 c/s receiving filter after insertion of a rectifier in the decoupling circuit of the 2460 c/s oscillator

It was observed that, without this rectifier, the voltage at the output terminals of a V.F. telegraph channel is interrupted for some time. After the above improvement had been made, the only evidence of a short-circuit was a very short period of 4% additional distortion in the telegraph channel.

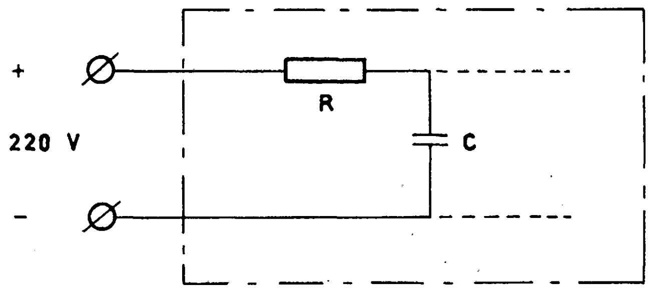


FIGURE 34

SUPPLEMENT No. 16

LETTER SYMBOLS TO BE USED

(including symbols recommended by the International Electrotechnical Commission (I.E.C.) in its Publication No. 27)

1. QUANTITY SYMBOLS

Name	Symbol: chief	Symbol: reserve (alternative)	Remarks
SPACE — TIME			
(Length)			
wavelength	λ		
Propagation coefficient	γ	p	$\gamma = \alpha + j\beta$
phase coefficient	β	b	
attenuation coefficient	α	a	
Time	t		
duration of one cycle	T		
time constant	τ	T	
Frequency	f	ν	
Angular frequency	ω		$\omega = 2\pi f$
TRANSMISSION CHARACTERISTICS			
Gain	k	g, μ	
Equivalent	q		
Level	n		
Psophometric voltage	U_{ps}	U_{ψ}	
Psophometric electromotive force	E_{ps}	E_{ψ}	
Cut-off frequency	f_o ou f_c		
Magnification factor	Q		

2. Electrode symbols

Name	Symbol: chief	Symbol: reserve (alternative)	Remarks
Anode	*a*		
Grid	*g*		
Cathode	*k*		
Filament	*f*		
Metallizing	*m*		
Internal shield	*s*		

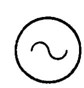
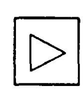
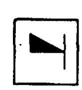
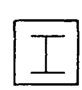
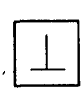
3. Prefixes used in the metric system

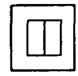
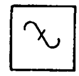
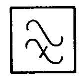
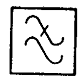
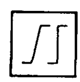
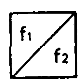
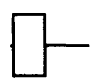
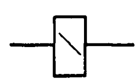
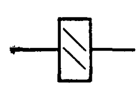
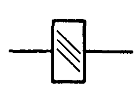
In the metric system the multiples and sub-multiples of the fundamental units are indicated by the following prefixes:

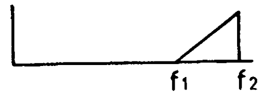
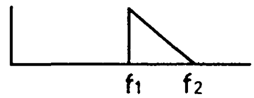
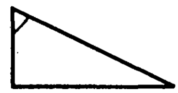
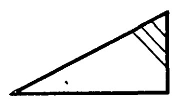
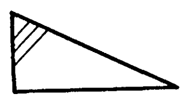
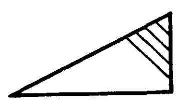
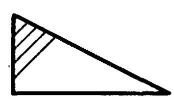
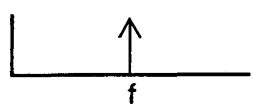
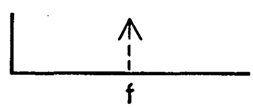
Prefix	Symbol	Meaning	Prefix	Symbol	Meaning
tera	T	10^{12}	déci	d	10^{-1}
giga	G	10^{9}	centi	c	10^{-2}
mega	M	10^{6}	milli	m	10^{-3}
myria	ma	10^{4}	micro	μ	10^{-6}
kilo	k	10^{3}	nano	n	10^{-9}
hecto	h	10^{2}	pico	p	10^{-12}
déca	da	10			

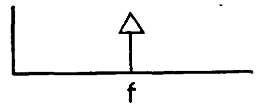
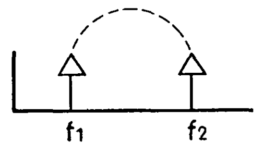
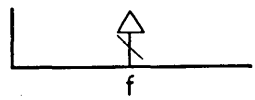
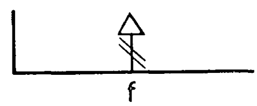
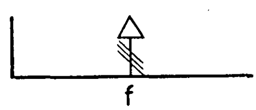
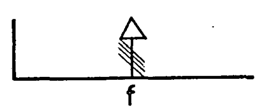
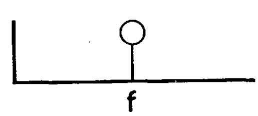
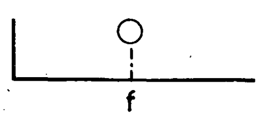
SUPPLEMENT No. 17

MAIN SYMBOLS TO BE USED IN TRANSMISSION DIAGRAMS

No.	Description	Symbol
1	Oscillator	
2	Amplifying equipment	
3	Detector. Modulator-demodulator	
4	Artificial line	
5	Balancing network	

No.	Description	Symbol
6	Recorder	
7	Filter, general symbol	
8	High-pass filter	
9	Low-pass filter	
10	Band-pass filter	
11	Band-stop filter	
12	Attenuation equalizer	
13	Frequency changer	
14	Channel modulating equipment (translation from audio to basic group band, and vice versa)	
15	Group translating equipment (translation from basic group to basic supergroup and vice versa)	
16	Supergroup translating equipment (translation from basic supergroup to basic mastergroup and vice versa)	
17	Mastergroup translating equipment (translation from basic mastergroup to line frequencies and vice versa)	

No.	Description	Symbol
18	Erect sideband	
19	Inverted sideband	
20	Group in which the channel sidebands are erect (group frequency increases with increasing audio-frequency)	
21	Group in which the channel sidebands are inverted (group frequency increases with decreasing audio-frequency)	
22	Supergroup in which the channel sidebands are erect (supergroup frequency increases with increasing audio-frequency)	
23	Supergroup in which the channel sidebands are inverted (supergroup frequency increases with decreasing audio-frequency)	
24	Mastergroup in which the channel sidebands are erect (mastergroup frequency increases with increasing audio-frequency)	
25	Mastergroup in which the channel sidebands are inverted (mastergroup frequency increases with decreasing audio-frequency)	
26	Super-mastergroup in which the channel sidebands are erect (super-mastergroup frequency increases with increasing audio-frequency)	
27	Super-mastergroup in which the channel sidebands are inverted (super-mastergroup frequency increases with decreasing audio-frequency)	
28	Carrier-frequency	
29	Carrier-frequency, suppressed	

No.	Description	Symbol
30	Pilot frequency	
31	Two pilot waves of which one or the other is transmitted	
32	Group pilot	
33	Supergroup pilot	
34	Mastergroup pilot	
35	Super-mastergroup pilot	
36	Additional measuring frequency, general symbol	
37	Additional measuring frequency, which is transmitted or measured on request	

SUPPLEMENT No. 18

RELATIONSHIP BETWEEN TRANSMISSION UNITS (DECIBELS, NEPERS) AND POWER RATIOS

A. CONVERSION TABLES NEPERS-DECIBELS

Strictly speaking, neper-decibel conversion tables may be used only when the quantities to be expressed are the same (power or voltage). There is also a valid equivalence between quantities measured in terms of power (reference 1 milliwatt) and those measured in terms of voltage (reference 0.775 volt) when the impedance of the circuit across which the measurements are made is 600 ohms. (See Figure 5 of Supplement No. 2, page 178.)

Conversion table — decibels to nepers

To convert decibels to nepers, multiply by 0.1151

Decibels	Nepers	Decibels	Nepers	Decibels	Nepers	Decibels	Nepers
1	0.115	26	2.99	51	5.87	76	8.75
2	0.230	27	3.11	52	5.99	77	8.87
3	0.345	28	3.22	53	6.10	78	8.98
4	0.461	29	3.34	54	6.22	79	9.10
5	0.576	30	3.45	55	6.33	80	9.21
6	0.691	31	3.57	56	6.45	81	9.33
7	0.806	32	3.68	57	6.56	82	9.44
8	0.921	33	3.80	58	6.68	83	9.56
9	1.04	34	3.91	59	6.79	84	9.67
10	1.15	35	4.03	60	6.91	85	9.79
11	1.27	36	4.14	61	7.02	86	9.90
12	1.38	37	4.26	62	7.14	87	10.0
13	1.50	38	4.37	63	7.25	88	10.1
14	1.61	39	4.49	64	7.37	89	10.2
15	1.73	40	4.61	65	7.60	90	10.4
16	1.84	41	4.72	66	7.48	91	10.5
17	1.96	42	4.84	67	7.71	92	10.6
18	2.07	43	4.95	68	7.83	93	10.7
19	2.19	44	5.07	69	7.94	94	10.8
20	2.30	45	5.18	70	8.06	95	10.9
21	2.42	46	5.30	71	8.17	96	11.1
22	2.53	47	5.41	72	8.29	97	11.2
23	2.65	48	5.53	73	8.40	98	11.3
24	2.76	49	5.64	74	8.52	99	11.4
25	2.88	50	5.76	75	8.63	100	11.5

Conversion table — nepers to decibels

To convert nepers to decibels, multiply by 8.686

Nepers	Decibels	Nepers	Decibels	Nepers	Decibels	Nepers	Decibels
0.1	0.869	2.6	22.6	5.1	44.3	7.6	66.0
0.2	1.74	2.7	23.5	5.2	45.2	7.7	66.9
0.3	2.61	2.8	24.3	5.3	46.0	7.8	67.8
0.4	3.47	2.9	25.2	5.4	46.9	7.9	68.6
0.5	4.34	3.0	26.1	5.5	47.8	8.0	69.5
0.6	5.21	3.1	26.9	5.6	48.6	8.1	70.4
0.7	6.08	3.2	27.8	5.7	49.5	8.2	71.2
0.8	6.95	3.3	28.7	5.8	50.4	8.3	72.1
0.9	7.81	3.4	29.5	5.9	51.2	8.4	73.0
1.0	8.69	3.5	30.4	6.0	52.1	8.5	73.8
1.1	9.55	3.6	31.3	6.1	53.0	8.6	74.7
1.2	10.4	3.7	32.1	6.2	53.9	8.7	75.6
1.3	11.3	3.8	33.0	6.3	54.7	8.8	76.4
1.4	12.2	3.9	33.9	6.4	55.6	8.9	77.3
1.5	13.0	4.0	34.7	6.5	56.5	9.0	78.2
1.6	13.9	4.1	35.6	6.6	57.3	9.1	79.0
1.7	14.8	4.2	36.5	6.7	58.2	9.2	79.9
1.8	15.6	4.3	37.3	6.8	59.1	9.3	80.8
1.9	16.5	4.4	38.2	6.9	59.9	9.4	81.6
2.0	17.4	4.5	39.1	7.0	60.8	9.5	82.5
2.1	18.2	4.6	40.0	7.1	61.7	9.6	83.4
2.2	19.1	4.7	40.8	7.2	62.5	8.7	84.3
2.3	20.0	4.8	41.7	7.3	63.4	9.8	85.1
2.4	21.0	4.9	42.6	7.4	64.3	9.9	86.0
2.5	21.7	5.0	43.4	7.5	65.1	10.0	86.9

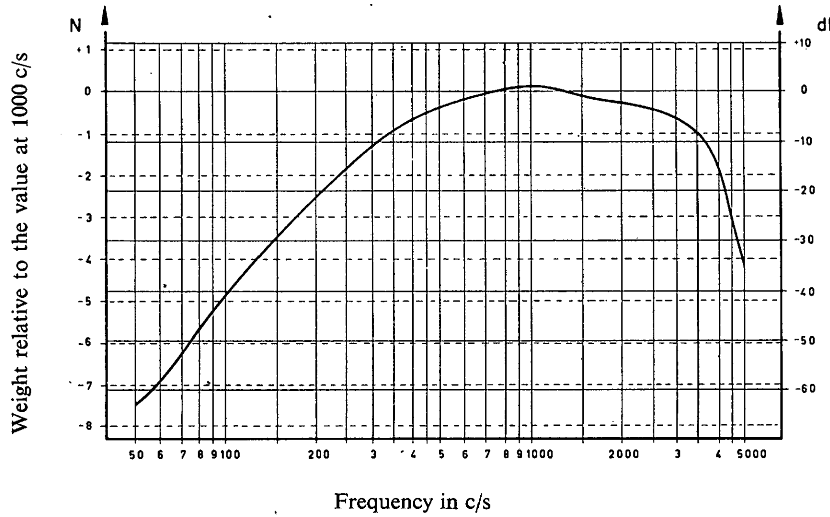
B. TABLE SHOWING CORRESPONDING VALUES OF POWER RATIO AND DECIBELS

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	100.00	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

SUPPLEMENT No. 19

CHARACTERISTIC CURVES OF WEIGHTING NETWORKS FOR:

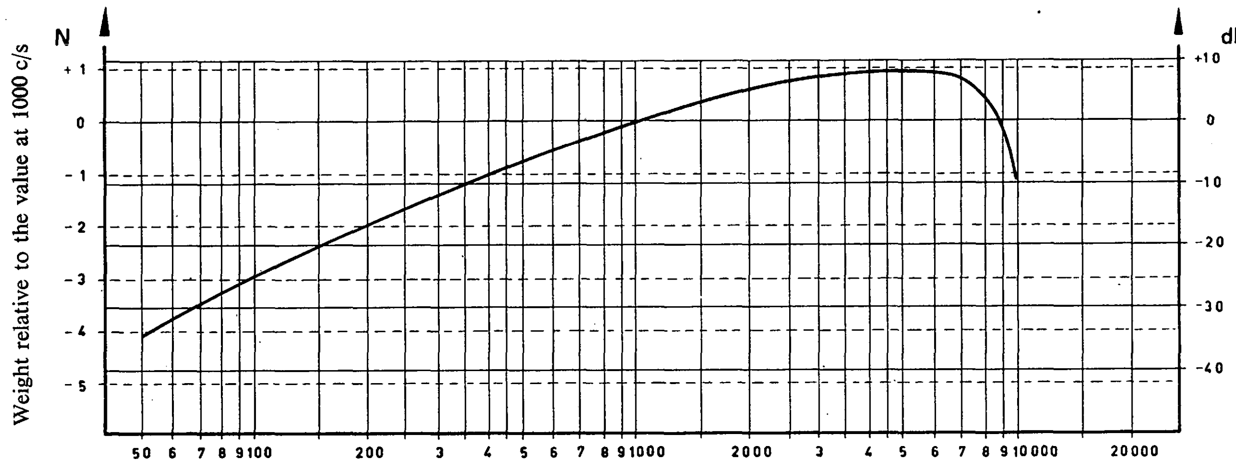
a) **Telephone circuit psophometer**
b) **Programme circuit psophometer**



Characteristic curve of the psophometer filter network used for measurements at the terminals of a telephone circuit

TABLE OF WEIGHTS FOR THE TELEPHONE CIRCUIT PSOPHOMETER

Frequency c/s	Weight		Frequency c/s	Weight	
	Decibels	Nepers		Decibels	Nepers
50	— 63.0	— 7.25	1000	+ 1.0	+ 0.115
100	— 41.0	— 4.72	1200	0.0	0.000
150	— 29.0	— 3.34	1500	— 1.30	— 1.150
200	— 21.0	— 2.42	2000	— 3.00	— 0.345
300	— 10.6	— 1.22	2500	— 4.20	— 0.484
400	— 6.3	— 0.73	3000	— 5.60	— 0.645
500	— 3.6	— 0.41	3500	— 8.5	— 0.979
600	— 2.0	— 0.23	4000	— 15.0	— 1.73
800	0.0	0.000	5000	— 36.0	— 4.14



Characteristic curve of the weighting network for the programme circuit psophometer

TABLE OF WEIGHTS FOR THE PROGRAMME CIRCUIT PSOPHOMETER FOR PROGRAMME CIRCUITS

Frequency c/s	Weight		Frequency c/s	Weight	
	Nepers	Decibels		Nepers	Decibels
60	— 3.70	— 32.2	4000	+ 0.94	+ 8.2
100	— 3.00	— 26.1	5000	+ 0.97	+ 8.4
200	— 2.00	— 17.3	6000	+ 0.94	+ 8.2
400	— 1.01	— 8.8	7000	+ 0.84	+ 7.3
800	— 0.22	— 1.9	8000	+ 0.59	+ 5.1
1000	0	0	9000	— 0.03	— 0.3
2000	+ 0.61	+ 5.3	10000	— 1.12	— 9.7

SUPPLEMENT No. 20

RELATIONSHIP BETWEEN :

a) ELECTROMOTIVE FORCE AND PSOPHOMETRIC VOLTAGE

b) C.C.I.T.T. PSOPHOMETER INDICATIONS

c) AMERICAN CIRCUIT NOISE METER INDICATIONS

The Table on page 265 gives the relationship between :

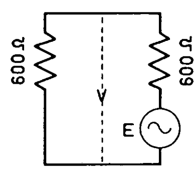
a) e.m.f. and psophometric voltage,

b) C.C.I.T.T. psophometer indications, and

c) American circuit noise meter indications *.

Note that :

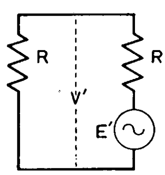
1. care must be taken in the way measurements are expressed, i.e. psophometric e.m.f. or psophometric voltage;
2. the following correction must be made if the measurements are made across an impedance other than 600 ohms.



Psophometric e.m.f. $= E$

$E = 2V$

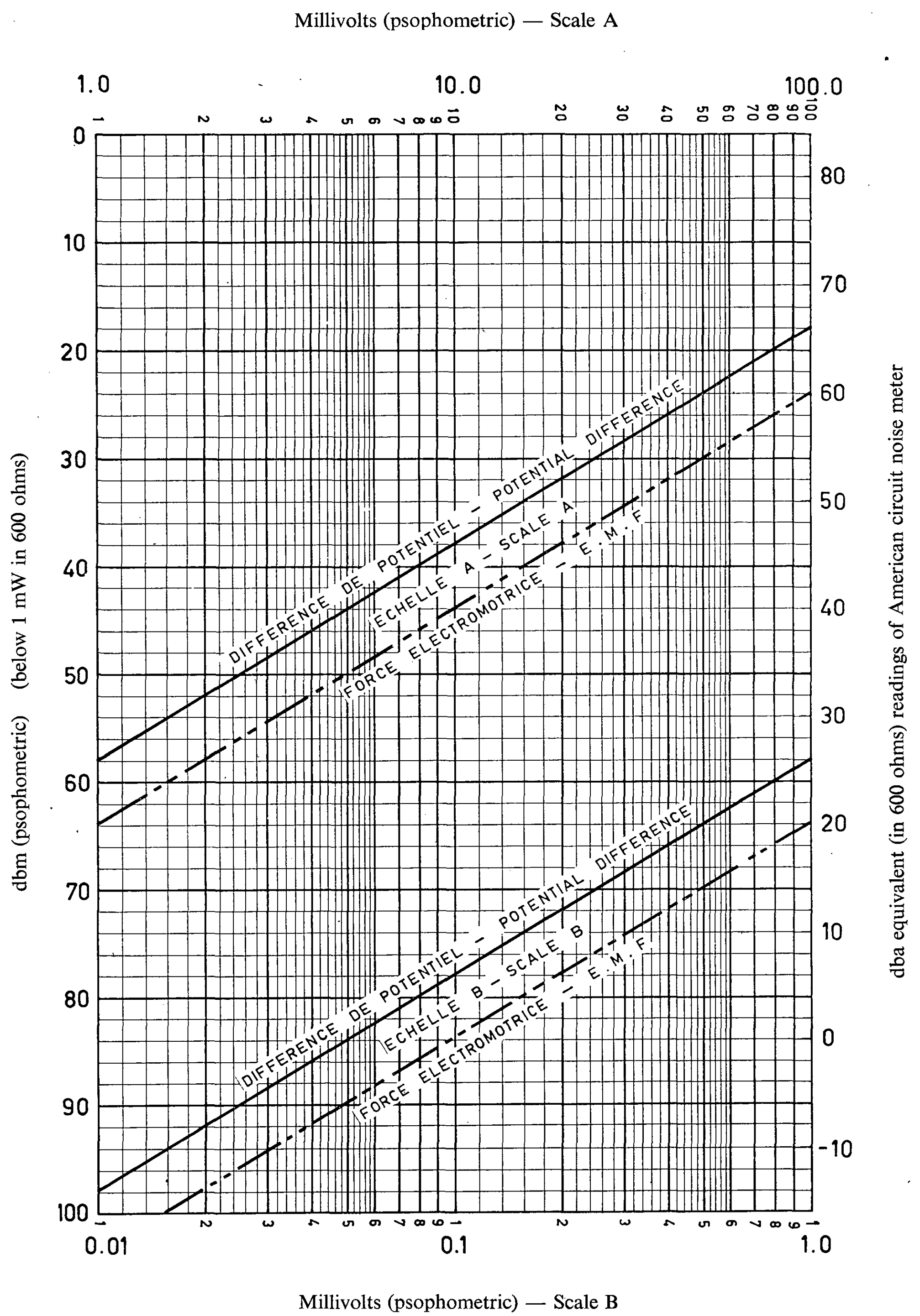
A psophometer measures V not E



$$E = E' \sqrt{\frac{600}{R}}$$

$$= 2V' \sqrt{\frac{600}{R}}$$

* The American circuit noise meter (2 B noise measuring set) with a network for terminal line measurements (F. 1 A line weighting) in graduated in **dba** (decibels adjusted). The reference level (0 dba) of this instrument corresponds to − 85 dbm with a 1000 c/s calibrating signal. (This gives some approximation to the indications of the former instrument, which had a reference level of − 90 dbm and a different weighting network). 0 dba corresponds to − 84 dbm with an 800 c/s calibrating signal, as used in the C.C.I.T.T. psophometer (1949 model).



Note. If noise on a telephone circuit in the 300 to 3400 c/s band has the character of white noise, the unweighted noise voltage which would be measured on this circuit would be 2.5 db above the psophometric voltage.

SUPPLEMENT No. 21

PRINCIPAL CHARACTERISTICS OF VOLUME INDICATORS

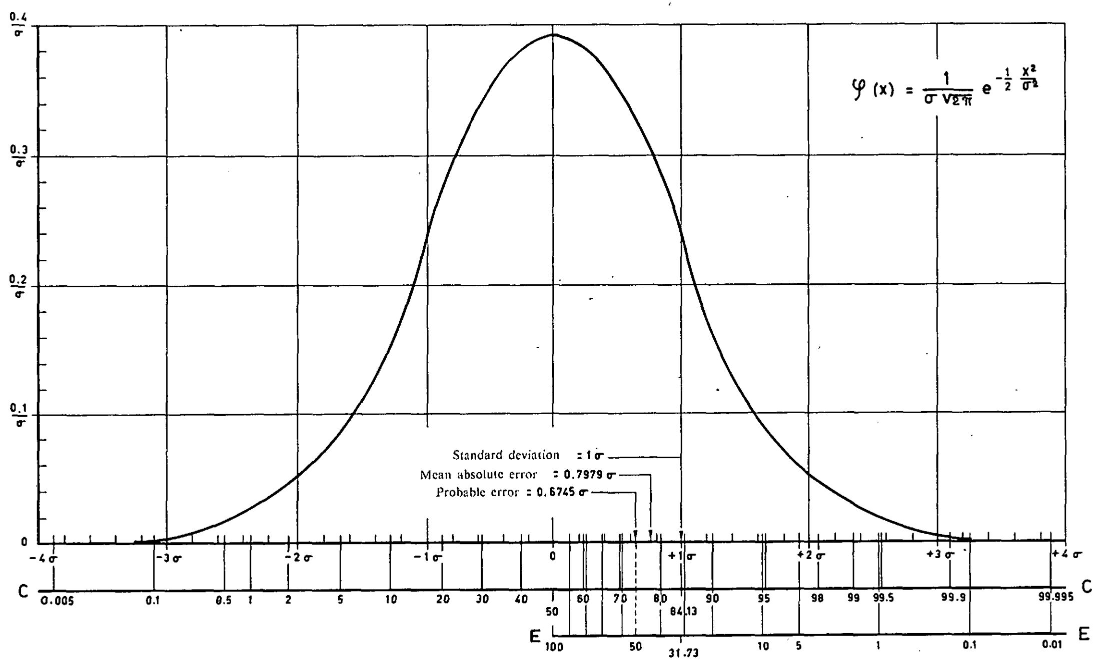
Type of apparatus	Rectifier characteristic *(Note 1)*	99 % rise time (milliseconds)	Integration time (milliseconds) *(Note 2)*	Time to return to zero (value and definition)
British Speech Voltmeter Type 3 identical to the A.R.A.E.N. volume meter	2	230	110 (approx.)	Equal to the integration time
Vu-meter (United States of America)	1.0 to 1.4	300	165 (approx.)	Equal to the integration time
Peak indicator for programme transmissions used by the British Broadcasting Corporation (B.B.C. Peak Programme Meter)	1	about 12	4	3 seconds for the reading to decay 26 db
Maximum amplitude indicator used in the Federal German Republic (Type U21)	1	about 80	5 (approx.)	1 or 2 seconds from 100 % to 10 % of the deflection when continuously applied

Note 1. — The number which appears in this column is the exponent n in the expression $\left[V_{(out)} = V^{n}_{(in)}\right]$ applicable for each half cycle.

Note 2. — The integration time was defined by the C.C.I.F. as the " minimum period during which a sinusoidal alternating voltage must be applied to the terminals of the apparatus for the needle of the indicating instrument to reach within 0.2 neper or about 2 db of the deflection which would be obtained if the same 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 %.

THE NORMAL DISTRIBUTION (GAUSS DISTRIBUTION)

1. σ is the standard deviation.
2. Scale C is the cumulative distribution function in percent. For example the probability of finding x between $-\sigma$ and $+2\sigma$ is $97-16 = 81$ percent.
3. Scale E is the probability that the error (absolute deviation) exceeds the value read on the axis. For example, if the deviation is larger than 2σ in either direction, probability is 4.5 percent.



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ALPHABETICAL INDEX

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