COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE.

Plenary Session,
Paris: November 26—December 6, 1926.

FIRST PART.
Questions of General Organisation.

SECOND PART.
Questions of Transmission, Maintenance and Supervision.

THIRD PART.
Questions of Traffic and Operating.

English Edition,
Issued by
The International Standard Electric Corporation.
London. 1927.

PREFACE TO THE ENGLISH EDITION.

This volume contains an unofficial translation of the official French text of the Proceedings of the COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE (C.C.I.) at its plenary sessions in Paris, 26th November–6th December, 1926, and Como, 5th–12th September, 1927.

The original French text of the 1926 proceedings has been followed in all respects except as regards the symbol used for the Unit of Transmission in terms of the Naperian logarithm and as regards the symbol and the magnitude of the Unit of Transmission in terms of the decimal or Briggs' logarithm. For the Naperian system the French edition uses the symbol n, whilst the English version uses b to express the same values. In terms of Briggs' logarithm the French edition expresses the fundamental Unit of Transmission on a power basis, as $N = \log_{10} \frac{P_1}{P_2}$, whilst the English version gives the working "Transmission Unit," $TU = 10 \log_{10} \frac{P_1}{P_2}$ on a power basis. In other words, the French text notation N is the same as 10 TU's.

In section A.a.1 (page 62) of the 1927 proceedings the Unit of Transmission is discussed and a proposal made that the unit in terms of the Naperian logarithm shall be the *Néper* and that the unit on the Briggs' logarithm basis shall be known as the Decibel, and these terms have been written in full in the English edition. Thus the TU in the 1926 Edition is equivalent to the Decibel in the 1927 Edition.

The English bibliography, contained in the French text of the 1926 proceedings, has been slightly augmented in this translation.

In the English Edition of the 1927 proceedings that part of the French text (pages 123–150) relating to *Questions concerning the protection of Telephone Cables against corrosion due to Electrolysis or to Chemical action* has been printed as a separate edition, otherwise the official French text has been followed in all respects.

The Indices to the 1926 and 1927 proceedings respectively will be found in front of each Edition.

INTERNATIONAL STANDARD ELECTRIC CORPORATION.

GENERAL SUBJECT INDEX.

1926 (PARIS) PROCEEDINGS.

COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE.

Plenary Session, Paris, November 29–December 6, 1926.

LIST OF DELEGATES FROM ADMINISTRATIONS REPRESENTED.

GERMANY .. .. Professor Dr. Breisig, Ministerial Counsellor.
Mr. Brauns, Ministerial Counsellor.
Mr. Stegman, Ministerial Counsellor.
Mr. Höpfner, Counsellor Higher Grade of Posts.
Mr. Dohmen, Counsellor Higher Grade of Posts.
Dr. Jäger, Counsellor of Posts.
Mr. Wiehl, Counsellor of Posts.

AUSTRIA .. .. Mr. R. Heider, Ministerial Counsellor.
Mr. R. Oestreicher, Ministerial Counsellor.
Mr. H. Pfeuffer, Engineer, Ministerial Secretary.

BELGIUM .. .. Mr. J. Dethioux, Chief Engineer, Director in the Administration.
Mr. Fossion, Head of Department.

DENMARK .. .. Mr. Gredsted, Chief of Division in the Telegraph Administration.
Mr. Madsen, Telegraph and Telephone Engineer.

SPAIN ... . Mr. Nieto, Inspector of Telegraphs, Chief of Telegraph Service.

ESTHONIA .. .. Not represented.

FINLAND .. .. Not represented.

FRANCE .. .. Mr. Milon, Chief Engineer, Director of Telephones, Ministry of Posts and Telegraphs.
Mr. Pomey, Inspector-General, Director of "Ecole Supérieure" and of the Investigation and Technical Research Service for Posts and Telegraphs.
Mr. Drouet, Chief Engineer and Director of Telephone Service, Paris.
Mr. Rochas, Chief Engineer, Director of Technical Services in the Suburban Area of Paris.
Mr. Barillau, Deputy Director of Telephone Service.
Mr. Lange, Chief Engineer, Director of Long-distance Underground Line Service.

GREAT BRITAIN ..	Colonel T. F. Purves, the Engineer-in-Chief of the British Post Office. Mr. H. Townshend, Principal, Secretary's Office, British Post Office. Mr. B. L. Barnett, Assistant Principal, Secretary's Office, British Post Office. Captain B. S. Cohen, Engineer of British Post Office. Mr. A. B. Hart, Engineer of British Post Office. Mr. H. G. Trayfoot, Post Office Inspector of Traffic. Mr. S. C. Bartholomew, Engineer of British Post Office. Mr. B. J. Stevenson, Engineer of British Post Office.
HUNGARY	Mr. F. Kol, Under-Secretary of State, Head of Telegraph and Telephone Division. Mr. I. Tomits, Head of Electrical Section in the Experimental Department.
ITALY	Professor di Pirro, Director General of the "Istituto Superiore" of the Italian Posts, Telegraphs and Telephones. Mr. Otto Cuzzer, Engineer in the Experimental Institute of the Ministry of Communications.
LETTONIA	Not represented.
LITHUANIA	Mr. C. Gaigalis, Electrical Engineer to the Postal and Telegraph Administration.
LUXEMBOURG ..	Mr. Edouard Jaaques, Director of Posts and Telegraphs. Mr. Léon Klein, Engineer, Inspector of Telegraphs.
MOZAMBIQUE ..	Mr. J. E. F. Santa Barbara, Chief Inspector of Posts and Telegraphs to the Portuguese Colonies.
NORWAY	Mr. T. Engset, General Secretary and Chief of Traffic in the Telegraph Administration. Mr. S. Abild, Chief Engineer to the Telegraph Administration.
HOLLAND	Mr. S. J. J. H. Van Embden, Inspector-General of Telephones. Mr. H. J. Claasen, Chief of Telephone Division. Jhr. W. M. de Brauw, Chief Engineer of Telegraphs. Mr. E. F. Petritsch, Telegraph Engineer. Mr. R. Santing, Divisional Chief, Central Administration of Posts and Telegraphs.
POLAND	Mr. S. Zuchmantowitcz, Engineer, Ministerial Counsellor in the Postal and Telegraph Administration. Mr. E. Jachimski, Engineer, Ministerial Counsellor in the Postal and Telegraph Administration.
PORTUGAL	Mr. H. Serrao, Telegraph and Telephone Engineer, Chief of Division. Mr. R. Gonçalves, Telegraph and Telephone Engineer.
ROUMANIA	Mr. M. Rosca, Deputy Director of the P.T.T. Mr. Samoil, Chief of the Technical Service of the P.T.T.
SERBS, CROATS AND SLOVENES.	Mr. V. Popovitch, Head of Telephone Service. Mr. Kodjitch, Engineer in the Ministry of Posts and Telegraphs.

SWEDEN	Mr. P. J. W. Hallgren, Head of Lines Section, Swedish Telegraph Administration. Mr. Anders Lignell, Director of Telephones, Stockholm. Mr. A. V. A. Holmgren, Head of Department, Telegraph Administration.
SWITZERLAND ..	Mr. A. Muri, Head of Technical Section, General Administration of Telegraphs, Switzerland. Dr. J. Forrer, Head of Electrotechnical Experimental Section and of Control of Material. Mr. Moeckli, Head of Telephone Department.
CZECHO-SLOVAKIA ..	Mr. S. Chocholin, Ministerial Counsellor, Engineer. Mr. R. Prochazka, Ministerial Counsellor. Mr. F. Schneider, Technical Adviser, Engineer. Mr. J. Michalek, Engineer.
UNION OF SOVIET SOCIALIST REPUBLICS.	Mr. E. Hirschfeld, Chief of International Communications Department, People's Commissariat, P.T.T. Mr. Chafranovski, Chief of International Communications Department, People's Commissariat, P.T.T. Mr. Botcharov, Head of the Electrical Department in the Department of International Communications.

REPRESENTATIVES OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY.

Dr. H. S. Osborne. Mr. L. J. Sivian.

DELEGATES OF THE INTERNATIONAL CONFERENCE OF LARGE SYSTEMS OF HIGH TENSION ELECTRICAL ENERGY.

Mr. Brylinski, President of the French Electrotechnical Committee, General Delegate of the Syndicate of Producers and Distributors of Electrical Energy.
Mr. Otto Meyer, Electricity Director, Strasbourg.
Mr. René Dubois, Director of the High Frequency Society.
Mr. Tribot Laspière, General Secretary of International Conference of High Tension Electrical Systems.

DELEGATES OF THE INTERNATIONAL UNION OF RAILWAYS.

GERMANY	Mr. Schulze, Chief Counsellor, Member of the Central Administration of the German Railways, Berlin. Mr. Schieb, Counsellor, Member of the Board of Directors of the German Railways, Halle.
BELGIUM	Mr. Jacqmin, Chief Engineer, Director of the Electrical Department in the Ministry of Railways, Marine, Posts and Telegraphs of Belgium, Brussels.
FRANCE	Mr. Bachellery, Chief Engineer, in charge of Material and Traction in the Midi Railway Company, Paris. Mr. Laigle, Assistant to Principal Permanent Way Engineer of the Midi Railway Company, Paris.

ITALY .. .. Mr. Romualdo Regnoni, Inspector, Chief of the Permanent Way Service of the Italian State Railways, Rome.

Mr. Alfredo Micarelli, Inspector (higher grade) in the Permanent Way Service of the Italian State Railways, Rome.

SWITZERLAND .. Mr. Théodore Muller, Assistant to the Principal Permanent Way Engineer of the Swiss Federal Railways.

REPRESENTATIVE OF THE CONSULTATIVE AND TECHNICAL COMMISSION ON COMMUNICATIONS OF THE LEAGUE OF NATIONS.

Mr. Haas, General Secretary.

LIST OF EXPERTS OF INDUSTRY, ENGAGED IN CONSTRUCTION AND MANUFACTURE OF TELEPHONE MATERIAL.

GERMANY .. .. Dr. Lüschen, Director of Messrs. Siemens & Halske.

Dr. Schürer, Director of Messrs. Felten & Guilleaume.

Dr. Jordan, Allgemeine Elektrizitäts-Gesellschaft.

Chief Engineers Küpfmüller and Pohlmann of Messrs. Siemens & Halske.

Dr. U. Meyer, Chief Engineer, Messrs. Felten & Guilleaume.

Dr. Gehrts, Chief Engineer, Allgemeine Elektrizitäts-Gesellschaft.

AUSTRIA .. .. Mr. Gustav Czernicky, Messrs. Siemens & Halske, Vienna.

Dr. Knaur, Messrs. Felten & Guilleaume, Vienna.

BELGIUM .. .. Mr. Gallée, Engineer of the Société Anonyme des Câbleries et Corderies du Hainaut.

FRANCE .. .. Mr. Viard, Chief Engineer of the Lignes Télégraphiques et Téléphoniques.

Mr. Leduc, Chief Transmission Engineer to the Lignes Télégraphiques et Téléphoniques.

Mr. Cahen, Chief Engineer, Director of Investigations to the Société d'Etudes pour Liaisons Téléphoniques et Télégraphiques.

Mr. Carvallo, Engineer of the Société d'Etudes pour Liaisons Téléphoniques et Télégraphiques.

Mr. Ravut, Engineer, General Secretary to the Société Industrielle des Téléphones.

GREAT BRITAIN .. Mr. P. E. Erikson of the International Standard Electric Corporation.

Mr. S. M. Catterson of the International Standard Electric Corporation.

Mr. H. T. Werren of the General Electric Co., Ltd.

Mr. H. C. Hannam-Clark of the General Electric Co., Ltd.

Mr. Cobden Turner of the General Electric Co., Ltd.

Mr. G. C. Marris of the General Electric Co., Ltd.

Captain P. Dunsheath of Henley's Telegraph Works.

Mr. C. F. Street of Messrs. Johnson & Phillips.

HUNGARY .. .. Mr. Joseph Hollos, Consulting Engineer to the United Incandescent Lamp Company, Messrs. Felten & Guilleaume and the Hungarian Siemens-Schuckert Company.

POLAND ... .. Mr. Waclas Niemirowski, Engineer of the Polish Ericsson Electrical Company.

COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE.

Plenary Session,
Paris, November 26—December 6, 1926.

FIRST PART.
Questions of General Organisation.

COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE.

Plenary Session, Paris, November 26—December 6, 1926.

First Part.

Questions of General Organization.

SUB-COMMISSION ON GENERAL ORGANISATION.

President: Mr. Muri.

Germany	Dr. Breisig, Messrs. Stegman and Wiehl.
Austria	Mr. Heider.
Belgium	Messrs. Dethioux and Fossion.
Denmark	Messrs. Gredsted and Madsen.
Spain	Mr. Nieto.
France	Mr. Milon.
Great Britain	Col. Purves and Mr. Townshend.
Hungary	Mr. Kol.
Italy	Professor di Pirro.
Luxembourg	Mr. Klein.
Mozambique	Mr. Santa Barbara.
Norway	Messrs. Engset and Abild.
Holland	Messrs. Van Embden, Claasen and Santing.
Poland	Messrs. Zuchmantowicz and Jachminski.
Portugal	Mr. Serrao.
Roumania	Messrs. Rosca and Samoil.
Serbs, Croats and Slovenes	Messrs. Popovitch and Kodjitch.
Sweden	Mr. Hallgren.
Switzerland	Mr. Muri.
Czecho-Slovakia	Messrs. Chocholin and Prochazka.
Union of Soviet-Socialist Republics	Mr. Hirschfeld.

QUESTIONS OF GENERAL ORGANIZATION.

Extracts from the International Regulations Service (Paris Revision 1925).

Chapter XXIV.—Telephone Service, Article 71, Section S.

INTERNATIONAL CONSULTATIVE COMMITTEE FOR LONG-DISTANCE TELEPHONE COMMUNICATIONS.

(1) An International Consultative Committee for long-distance telephone communications is constituted, charged with the study of standards regulating technical and operating questions for international long-distance telephony. This Committee is formed of experts of the Telephone Administrations which declare their wish to participate. This declaration is addressed to the Administration of the country where the last international telegraphic conference has been held.

(2) This Committee centralises all the information which it needs for the study of long-distance telephony and gives advice on questions concerning international telephony.

(3) The International Consultative Committee for long-distance telephony chooses its organization and establishes its own internal regulations and methods of work.

(4) The expenses of the International Consultative Committee are borne by the participating Administrations according to the method of division fixed by the internal regulations of the said Committee.

(5) The International Consultative Committee corresponds directly with all the Administrations which take part in its work.

(6) It communicates all the advice which it formulates to the International Bureau, which publishes them in the "Journal Télégraphique."

Article 71—Section A.—International Network.

§ 1.—(1) The Administrations concerned provide, if necessary, after agreement with the intermediate Administration or Administrations the means of communication* necessary for the exchange of International telephone traffic.

(2) Each intermediate Administration furnishes the sections of the means of communication which must traverse its territory.

(3) Each section to be constructed on the territory of an intermediate Administration is established as far as possible, taking into account difficulties of all kinds, by the shortest route between the points of entry and exit of the international means of communication.

§ 2.—(1) The means of communication destined for the exchange of international telephone traffic and the technical installations are provided, maintained and worked in a manner to ensure a reliable and rapid service, as also satisfactory audition.

(2) In this connection the Administration conforms as far as possible with the advice issued by the International Consultative Committee on long-distance telephony as regards equipment, apparatus, repeaters, allocation, loading, superposition, equivalents of transmission, testing points, etc. (*see* Section "S").

* Wires, cables, offices, wireless stations.

Advice of the International Consultative Committee concerning Questions of General Organization.

Organization and Working of the International Consultative Committee for Long-Distance Telephone Communications.

The International Consultative Committee comprises three divisions :

(*a*) The Plenary Assembly (AP) ;
(*b*) The General Secretary (SG) ;
(*c*) The Commissions of Assessors (*Rapporteurs*) (CR).

(*a*) The Plenary Assembly.

1. The AP meets normally once a year, so far as possible between the 1st of April and the 15th of June.

Such Administrations, belonging to the International Consultative Committee, as wish to be represented at a certain AP are obliged to advise by telegram or letter addressed to the SG the names of the members of their delegations, and particularly the names of the chiefs of the delegations.

Each delegation thus introduced has one vote.

The resolutions put to the vote are considered as accepted if they obtain a majority of votes. The minutes will indicate the results of the voting without indicating the delegations which have voted for or against. The corresponding resolutions will also refer to these results in the following form :—

" The International Consultative Committee .... passes unanimously, the resolution ...."

" The International Consultative Committee .... passes by .... votes, against .... votes, the resolution ...."

It is not permitted that a delegation shall vote on behalf of an Administration not represented.

2. The first meeting of the AP is opened by the Administration of the country where it is held.

It begins by electing the President and the Vice-Presidents and, on the proposal of the General Secretary, nominates the Secretaries.

3. The function of the AP is to approve, reject, or modify the reports presented after having, if necessary, referred them to the competent Commission.

4. The AP decides what further questions shall be specially studied.

5. At the closing meeting the SG gives a summary of the work of the Conference, containing particularly the resolutions approved and the list of questions which have yet to be examined ; the AP appoints until the following meeting the Administrations who will be asked to nominate members of the various Commissions. In addition, it will decide the town where the next meeting will be held.

6. Experts belonging to other groups or organizations dealing with questions likely to have a bearing on international telephony may be invited by the AP to be present at certain meetings.

7. The AP appoints three Auditors of Accounts, entrusted with examining the budget proposals for the ensuing year and the accounts of the past year.

(*b*) The General Secretary.

1. The SG is the Director of the office of the International Consultative Committee. He is elected by the AP for an indefinite period, but with reciprocal powers of terminating his

engagement at the end of each calendar year. As confidant of all the Administrations it is desirable that, for the period of his office, he should not be entrusted with any active service in his Administration.

His salary as General Secretary is payable out of the budget of the International Consultative Committee and is fixed by the AP. His residence is decided by the AP. An office, maintained out of the budget of the C.C.I., shall be at his disposal for his work.

2. The SG conducts the entire correspondence of the International Consultative Committee. When required, the SG will get in touch with the Chief Assessor (*Rapporteur*) of the Commission of Assessors to which a question raised would belong according to its nature.

3. In order that he may always remain in direct contact with the progress of engineering questions, the SG is authorised to attend the special meetings of the Commission of Assessors. The Administrations will allow the SG to visit their installations and will procure for him all the necessary information. The expense incurred on this account will be chargeable to the International Consultative Committee.

4. The SG makes arrangements for the next conference of the AP. He prepares the agenda for this meeting in accord with the reports submitted by the Commissions. In agreement with the Administration of the country where the next plenary meeting will be held, he fixes the date of the meeting, and takes all necessary steps in this connection.

5. The SG will report to the AP on the activities of the Committee since the last AP. During the first quarter of each year he prepares an account of the preceding year, drawn up as of 31st December, and approximate budget proposals for the following year, which he submits for the previous approval of the auditors before submitting them to the next AP. The expenses of the current year are met by means of contribution levies requested during the previous year. An emergency fund enables the period between two budgetary periods to be covered and to meet any unforeseen expenditure or expenditures in excess of the forecast of the budget.

(*c*) **The Commissions of Assessors (*Rapporteurs*) (CR).**

1. The AP appoints each year the Commissions of Assessors (*Rapporteurs*) necessary to deal with the questions which it has submitted for study.

2. The function of the CR is to make a detailed study of new questions and present to the following AP a detailed report on each question complete, by proposed recommendations.

3. During the meeting of the AP, the CR holds itself at the disposal of the AP.

4. Membership of a CR is conferred for one year by the AP on certain Administrations. The latter appoint the persons who will represent them and advise the SG of their names. The choice of any Administration represented on a CR can be renewed without restriction.

5. Each CR elects a Chief Assessor (*Rapporteur*) who assumes the direction of the work of the CR. A CR meets at a convenient place in order to discuss the questions of which the study has been entrusted to it, if the Chief Assessor considers this to be necessary. In such cases the travelling expenses of the representatives of an Administration are borne by that Administration. The CR are authorised to invite experts to participate in their deliberations.

6. The report drawn up by a CR, as well as all the documents which have been used to prepare this report, are sent to the Administration as early as possible, and always at least one month before the date of the AP. The Administrations will be asked to communicate this information to all the experts whom it considers it useful to consult.

7. Questions which have not formed the subject of a report, prepared under the conditions indicated above, cannot be placed on the agenda of the AP.

Distribution of the Expenses incurred in the Operations of the Permanent Secretariat.

The expenses incurred by the work of the Secretariat will be divided between the participating countries in accordance with the following table, in conformity with that adopted by the Universal Telegraph Union in 1925 :—

First Class.—Germany, France, Great Britain, Italy and Union of Soviet-Socialist Republics.

Second Class.—Spain and Poland.

Third Class.—Belgium, Finland, Norway, Holland, Roumania, Kingdom of Serbs, Croats and Slovenes, Sweden and Czecho-Slovakia.

Fourth Class.—Austria, Denmark, Hungary and Switzerland.

Fifth Class.—Esthonia, Latvia, Lithuania and Portugal.

Sixth Class.—Luxembourg and Mozambique.

The nations in the first class shall each pay 25 units; those of the second class 20 units; those of the third class 15 units; those of the fourth class 10 units; those of the fifth class 5 units; and those of the sixth class 3 units.

The contributing shares will be paid in advance on the first of January of each year, by cheque or warrant (*virement de compte*) in gold francs.

The total annual expenditure shall not exceed 60,000 gold francs.

Representation of Private Telephone Organizations on the International Consultative Committee.

The International Consultative Committee

Considering :—

The first paragraph of Article 91 of the International Service Regulations (Paris Revision 1925)

Unanimously passes the following resolution :—

1. That the private telephone enterprises operating within the boundaries of one or more Administrations belonging to the International Consultative Committee, and which participate in the International Service, are regarded (from the point of view of this service) as forming an integral part of the telephone system of those Administrations with which lies the decision whether it is desirable that these private telephone enterprises shall be represented at the meetings of the International Consultative Committee;

2. That at the meetings of the International Consultative Committee a single country can only have one delegation, representing at the same time both the State and the private telephone enterprises operating within the confines of that State; the members of this delegation being all nominated by the State Administration of that country.

Technical Collaboration between the C.C.I. and Technical Organizations dealing with Questions likely to have a bearing on International Telephony.

The International Consultative Committee passes the following resolution :—

1. That it is desirable to establish technical collaboration between the C.C.I. and all the technical organizations which deal with questions likely to have a bearing on international telephony :—

International Union of Railways.
International Electro-technical Commission.
International Conference of the chief power systems.
International Union of Producers and Distributors of Electric Power.

Committee on International Telephony of the International Chamber of Commerce.
Advisory and Technical Commission on Communications and Transit of the League of Nations Union, etc.

2. That it is desirable forthwith to send to all these organizations the reports of the work of the C.C.I. which may interest them.

Official Language to be employed at the Meetings.

The International Consultative Committee

Considering :—

That the selection of the official language should be guided by that which is spoken by the majority of the delegates,

Unanimously resolves :—

That the language generally employed at the Plenary Conferences should be the French language.

Considering, nevertheless :—

That the French language is not spoken and understood with equal facility by all delegates,

Unanimously resolves :—

That during Conferences of the International Consultative Committee each delegate addressing the meeting should be requested to speak slowly and distinctly, while standing, and make frequent stops in such a way as to allow all his colleagues to gather his meaning and, if needs be, to translate his remarks. (Moreover, recourse may be had to the service of interpreters when the deliberations render their presence desirable.)

Nomenclature of the International Circuits and Plan of the International Cables.

The International Consultative Committee

Unanimously resolves :—

That it is useful that the General Secretariat of the International Consultative Committee should keep up to date a nomenclature of the international circuits and a map showing existing and projected international telephone cables.

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COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE.

Plenary Session,
Paris, November 26–December 6, 1926.

SECOND PART.

Questions of Transmission, Maintenance, and Supervision.

Sub-Commission on Transmission.

President: Colonel **T. F. Purves.**

GERMANY	Dr. Breisig, Messrs. Stegman, Höpfner and Dohmen.
AUSTRIA	Messrs. Heider and Pfeuffer.
BELGIUM	Mr. Dethioux.
DENMARK	Messrs. Gredsted and Madsen.
SPAIN	Mr. Nieto.
FRANCE	Messrs. Pomey and Lange.
GREAT BRITAIN ..	Colonel Purves, Captain Cohen, Messrs. Hart, Robinson and Stevenson.
HUNGARY	Mr. Tomits.
ITALY	Professor di Pirro.
LITHUANIA	Mr. Gaigalis.
LUXEMBOURG ..	Mr. Klein.
NORWAY	Messrs. Engset and Abild.
HOLLAND	Messrs. de Brauw and Petritsch
POLAND	Mr. Jachminski.
PORTUGAL	Messrs. Serrao and Gonçalves.
ROUMANIA	Messrs. Samoil and Rosca.
SERBS, CROATS AND SLOVENES.	Messrs. Popovitch and Kodjitch.
SWEDEN	Messrs. Hallgren and Holmgren.
SWITZERLAND ..	Dr. Forrer.
CZECHO-SLOVAKIA ..	Messrs. Chocholin and Schneider.
UNION OF SOVIET-SOCIALIST REPUBLICS.	Messrs. Chafranowski and Botcharov

COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE.

Plenary Session, Paris, November 26–December 6, 1926.

SECOND PART.

Transmission, Maintenance and Supervision.

A. Advice of the International Consultative Committee.

(*a*) General.

1. Transmission Standards and Definitions.
2. Recommendations of principle.

(*b*) General rules concerning

1. Ordinary telephony.
2. Carrier current telephony.
3. Radio-telephonic transmission.

(*c*) Apparatus.

1. Subscriber's sets.
2. Central Offices.
3. Long-distance Central Offices.
4. Telephone Repeater Stations.

(*d*) Lines.

1. Aerial lines.
2. Cables.
    - (α) General.
    - (β) Aerial cables.
    - (γ) Underground cables.
    - (δ) Submarine cables.
3. Mixed lines.

(*e*) Maintenance and supervision of lines and installations.

(*f*) Simultaneous telegraphy and telephony.

B. Essential clauses for typical specifications.

C. Appendices.

D. Bibliography.

A. ADVICE OF THE INTERNATIONAL CONSULTATIVE COMMITTEE ON LONG DISTANCE TELEPHONE COMMUNICATIONS.

(A.a.) GENERAL.

(A.a.1.) Transmission Standards and Definitions.

Transmission Unit.

The International Consultative Committee—

Considering that there is a general agreement regarding the nature and object of the transmission unit, that is to say, that it serves to express the ratios of apparent or real powers, voltages or currents in transmission systems and that in practice the logarithms of these ratios shall be used.

Considering that, as regards the use of Naperian or decimal logarithms, the various Administrations reserve their opinions in favour of the one for which they have, for some time, presented numerous arguments.

Considering, on the other hand, that a majority vote should not compel any Administration, belonging to the C.C.I., to adopt a unit of which it does not approve.

Considering, finally, that converting test results from one system to another present no difficulties, because of the agreement reached in regard to the reference system.

Unanimously advises :—

1. That, though in principle it is desirable, it does not appear to be possible, for the present, to adopt a common transmission unit. The Naperian or the decimal system of logarithms may therefore provisionally be used, as desired, by the Administrations, it being understood that, in international traffic, the two units shall be used indiscriminately, and no Administration shall claim the exclusive use of the unit it adopts.

2. That in the technical literature and particularly in the C.C.I. documents the transmission equivalents, losses or gains, etc., shall be expressed in both units.

Method of expressing Frequency.

The International Consultative Committee—

Considering :—

That it is desirable to adopt a uniform method of expressing frequency, and of making selection between the expression of frequency in periods per second and the expression of the angular velocity in radians per second, and that the first method has the advantage of giving a physical representation more precise than the second,

Unanimously advises :—

That, all things considered, it is preferable to express frequency in periods per second in accordance with common practice.

DEFINITIONS OF SOME EXPRESSIONS USED IN THE QUESTIONS ON TELEPHONE TRANSMISSION.

The International Consultative Committee proposes the following definitions :—

(*a*) **General Definition.**

The **unit of transmission** serves to express the ratios of apparent or real powers, voltages or currents in transmission systems.

I. In practice the number of transmission units in a given case is determined by a logarithmic expression :—

(1) If two powers P_1 and P_2 are concerned the number of units are :—

In the Naperian system.	In the decimal system.
$b \times \frac{1}{2} \log_{nat} = \frac{P_1}{P_2}$	$TU = 10 \log_{10} \frac{P_1}{P_2}$

(2) If two voltages V_1 and V_2 or two currents I_1 and I_2 are concerned this becomes :—

In the Naperian system.	In the decimal system.
$b = \log_{nat} \frac{V_1}{V_2}$ or	$TU = 20 \log_{10} \frac{V_1}{V_2}$ or
$b = \log_{nat} \frac{I_1}{I_2}$	$TU = 20 \log_{10} \frac{I_1}{I_2}$

II. A decimal sub-multiple of the fundamental units above defined may be used; it is permissible to give special denomination to these sub-multiples.

III. In the following special definitions the term "*determined by*" signifies that the computation should be made as indicated under (1) and (2) above.

(*b*) **Special Definitions (provisional).**

1. The **équivalent de transmission** or **rendement de référence** (French), **transmission equivalent or reference efficiency** (English) **Übertragungsäquivalent** (German) of a transmission system or one of its principal parts (transmitting system, transformer system or receiving system) is the number of units of transmission obtained by the reference system when this reference system is adjusted so as to give the same volume of sound at the receiving end before and after the substitution of either the system under test for the reference system or the principal part of the system under test for a corresponding part of the reference system, the acoustic power supplied being identical in both instances.

2. The difference between two transmission equivalents is called **rendement relatif** (French), **relative efficiency** (English), **Differenz der Übertragungsäquivalent** (German). The relative efficiency of two transmitters may, for example, be evaluated by the difference between the transmission equivalents of a given circuit, associated with each of these transmitters.

3. The **pertes ou gains de transmission** (French), **transmission losses or gains** (English), **Verlust or Gewinn** (German) of a part of a system are the difference between the transmission equivalents of this system before and after the insertion of the part in question.

4. The **rendement énergétique** (French), **transmission efficiency** (English), **Wirkdämpfung** (German) of a part or of the whole of the system is *determined* by the ratio of the real powers at both ends of the part or of the whole of the system in question.

5. The **niveau de transmission** (French), **level** (English), **Pegel** (German) of the power, of the volume of sound, of the current, of the voltage at one point in a system is *determined* by the ratio of the value of one of these quantities to the value of the corresponding quantity, chosen as zero reference.

6. The **diaphonie** (French), **crosstalk** (English), **Nebensprechen** (German) between two systems—disturbing and disturbed—is *determined* by the ratio between the powers obtained at given points on the disturbing and disturbed systems under specified terminal conditions (for example, by means of image impedances).

7. **Affaiblissement Image** (French), **image transfer ratio** (English), **Dämpfung** (German). This particular expression of the general term for transfer ratio applies to a quadripole electric system, terminated by its image impedances; it is *determined* by the ratio of the apparent powers at the ends of the system so terminated.

8. **Affaiblissement Itératif** (French), **iterative transfer ratio** (English), **Kettendämpfung** (German). This applies to a quadripole electric system, terminated by its iterative impedances; it is *determined* by the ratio of the real or apparent powers at the ends of the system so terminated.

9. **Affaiblissement Conjugué** (French), **conjugate transfer ratio** (English), **Minimaldämpfung** (German). This applies to a quadripole electric system, terminated by its conjugate impedances; it is *determined* by the ratio of the real powers at the ends of a system so terminated.

10. **Affaiblissement** (French), **attenuation** (English), **Dämpfung** (German). This is a general term, indicating the decrease in a certain quantity (current density, voltage or power) as a function of distance.

11. **Amortissement** (French), **damping** (English), **Zeitliche Dämpfung** (German). A general term indicating a decrease in a certain quantity (current density, voltage or power) as a function of time.

12. **Netteté pour les sons vocaux isolés ou combinés** (French), **articulation** (English), **Verständlichkeit** (German).

French.	*English.*	*German.*
La netteté pour les lettres.	**Articulation of letters.**	**Laut-verstandlichkeit.**
,, ,, **syllabes.**	,, **syllables.**	**Silben-** ,,
,, ,, **mots.**	,, **words.**	**Wort-** ,,
,, ,, **phrases.**	,, **sentences.**	**Satz-** ,,

is characterized by the percentage of the different vocal sounds, correctly received in terms of the total number of words, read from a standard list.

Note.—(*a*) It is also necessary to define the equivalents for the English expressions: **audibility** and **intelligibility.**

(*b*) Similarly the German engineers employ the expression "**Betriebsdämpfung,**" the definition of which is as follows:

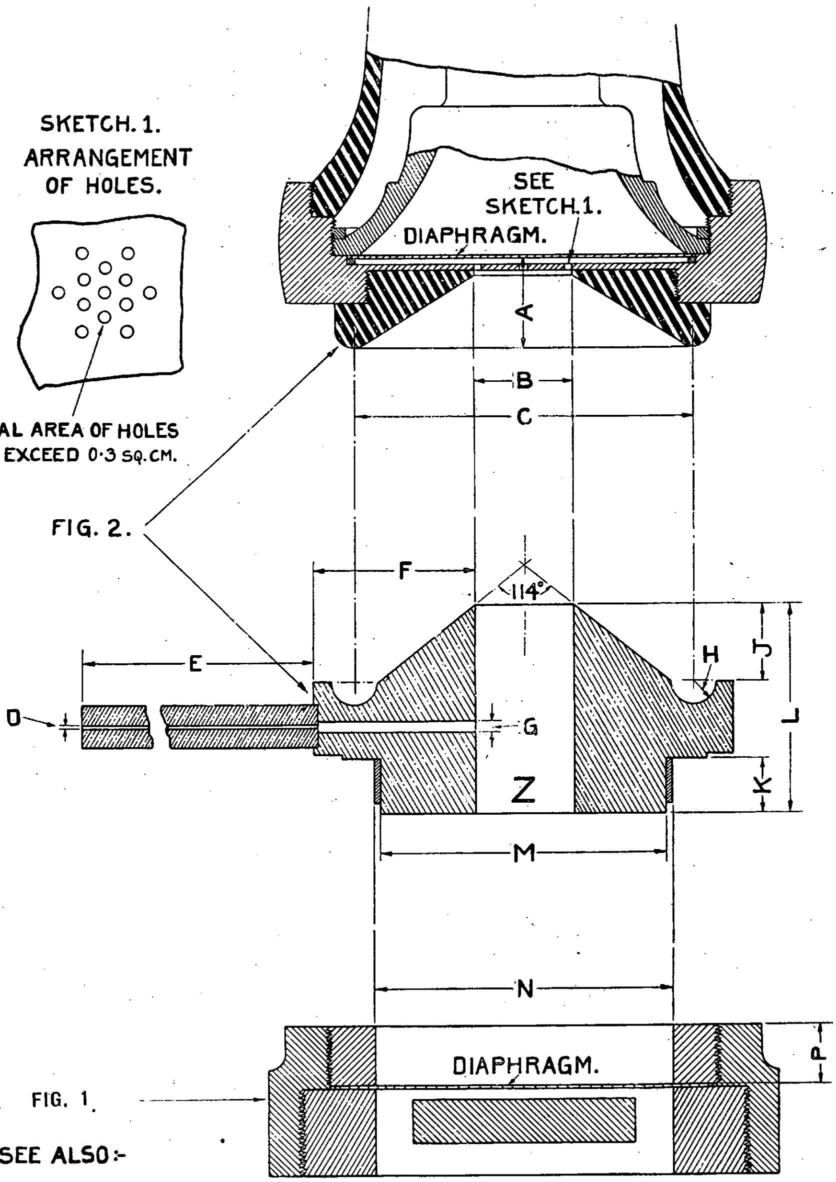
Die Betriebsdämpfung of a system containing the impedances Z_1 and Z_2 is *determined* by the ratio of the apparent power of a generator of the impedance Z_1 applied to a receiving element having an impedance of Z_1 to the apparent power which the same generator would produce through the intermediary of a part of the system having a receiving impedance Z_2.

If the value determined by this ratio is negative, it is called **Betriebsverstärkung.**

The International Consultative Committee has decided that questions (*a*) and (*b*) shall be studied and invites the various Administrations to inform the Committee of the results of their studies of these questions.

SKETCH. 1.
ARRANGEMENT
OF HOLES.

TOTAL AREA OF HOLES
MUST EXCEED 0·3 SQ.CM.



A	1·271 CM.
B	1·43 "
C	4·76 "
D	0·015 "
E	9·52 "
F	2·30 "
G	0·033 "
H	0·357 "
J	0·92 "
K	0·751±0·005 "
L	2·94 CM.
M	4·216 "
N	4·286 "
P	0·851 "

SEE ALSO:-

FIG. 1 B.
FIG. 1 C.

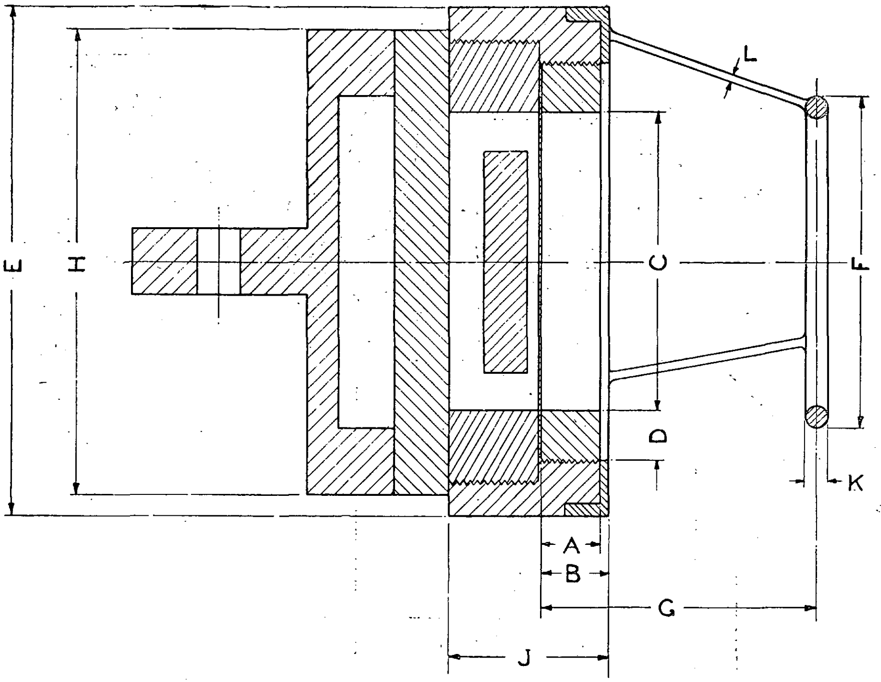


FIG. 1B.

A	0·851	CM.
B	0·950	"
C	4·286	"
D	0·7	"
E	7·3	"
F	4·7	"
G	4·1	"
H	< 7·2	"
I	< 3·5	"
J	2·3	"
K	0·3	"
L	0·18	"

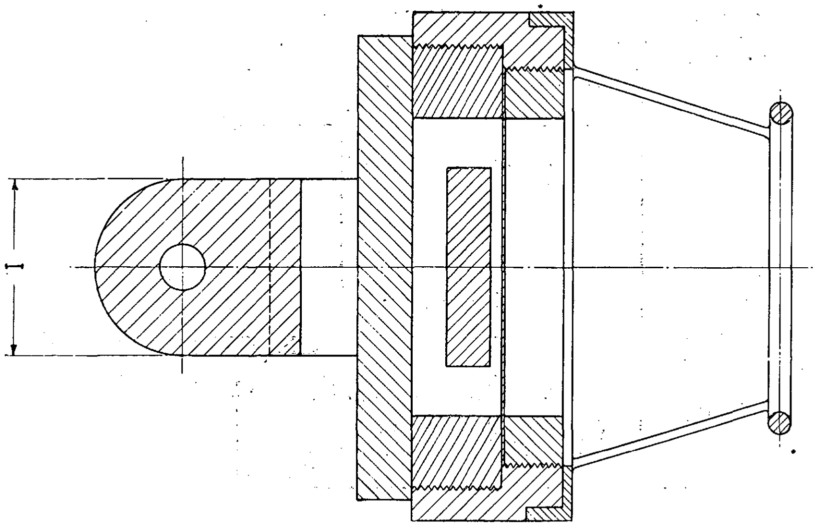


FIG. 1C.

Telephone Transmission Reference System.

A. OBJECT OF THE TELEPHONE TRANSMISSION REFERENCE SYSTEM.

The International Consultative Committee advises :—

That a reference system which can be rigorously defined and exactly reproduced is essential to form a constant basis for transmission measurements and to co-ordinate the transmission data, obtained in telephone systems used in the various countries.

The reference system shall serve to determine :—

(1) Transmission equivalents or reference efficiency.
(2) Relative efficiency.
(3) Transmission losses and gains.
(4) Calibration of working standards.
(5) Articulation.
(6) The practice coefficient of a testing crew, who makes the tests.

B. CONDITIONS WHICH THE TRANSMISSION REFERENCE SYSTEM SHOULD FULFIL.

(I) Transmitting system.

QUESTION 1.

(1) *How should the acoustic input to the transmitter be defined ?*

ANSWER.—In order to simplify the definition of the Reference System, it is useful to start with the sound pressure rather than with the acoustic power. For the transmitter the ratio of the voltage delivered to the input of the reference artificial line to the uniform sound pressure on the diaphragm of the reference transmitter is chosen as the measure of efficiency. Hence it is necessary to fix the essential external mechanical dimensions of the reference transmitter and the manner in which it is to be used—see Question 9, below.

QUESTION 2.

What is the best method of measuring this input ?

ANSWER.—For the measurement of the sound pressure, any reliable method may be used (*e.g.*, Thermophone, Rayleigh Disc, or Compensation methods).

QUESTION 3.

What is the maximum permissible acoustic input for which the transmitter is to be constructed ?

ANSWER.—The maximum acoustic pressure depends upon the permissible non-linear distortion. It has been found that when the types of transmitters and receivers mentioned below, together with suitable amplifiers, are used, no disturbing non-linear distortion is produced over the range of sound pressures normally occurring.

QUESTION 4.

What should be the output impedance of the transmitting system ?

ANSWER.—In order to have all required corrections in a positive direction it is convenient to select 600 ohms. A tolerance of $\pm$ 5 per cent., and an angle not greater than $\pm 10^\circ$ as the output impedance of the transmitting system over the frequency range 100 to 5,000 p.p.s. may be permitted.

QUESTION 5.

Within what limits and by what steps should the efficiency of the transmitting system be adjustable ?

ANSWER.—The transmitting system should be adjustable in steps of $b = 0.1$ (or 1 TU) within the limits $b = -1$ (or -10 TU) and $b = +1$ (or $+10$ TU).

QUESTION 6

What ratio between the acoustic and electric power (taken respectively as the input and output of the transmitting system) should be chosen to define the normal setting or zero point of the transmitting system?

ANSWER.—The zero point of the transmitting system should approximate to that of the standards for commercial transmitting systems in general use and is therefore defined provisionally by the value 0·05 volts per dyne per cm^2, taken as the arithmetical mean of this ratio over the frequency range from 500 to 2,500 p.p.s.

QUESTION 7.

(a) *Over what frequency range should this ratio remain constant?*

(b) *What difference of ratio within this frequency range should be regarded as tolerable?*

ANSWER.—The ratio defined under (1) should not vary by more than $b = \pm 0.2$ (or ± 2 TU) within the frequency range between 100 and 5,000 p.p.s.

QUESTION 8.

What is the non-linear distortion which should not be exceeded in the transmitting system (a) *for the maximum acoustic load,* (b) *for a given fraction of this load?*

ANSWER.—*See* I (3).

QUESTION 9.

What transmitting system and what type of construction are proposed in order to satisfy the required conditions? What are the variations in respect of time of the ratios defined in (5) *and how are they to be compensated?*

ANSWER.—A transmitting system composed of a condenser transmitter with stretched metallic diaphragm connected to a suitable amplifier is recommended. The essential dimensions of the condenser transmitter are indicated in Fig. 1. To compensate the variations which may occur a regulating device should be included in the transmitting system.

(II) Reference Artificial Line.

QUESTION 1.

What should be the characteristic impedance of the artificial line?

ANSWER.—The reference artificial line should have a characteristic impedance of 600 ohms. A tolerance of $\pm$ 1 per cent. and an angle not greater than $\pm 2°$ over the frequency range 100 to 5,000 p.p.s. may be permitted.

QUESTION 2.

By what steps and within what range should the attenuation of the artificial line be adjustable?

ANSWER.—The artificial line should be adjustable in steps of $b = 0.02$ (or 0.2 TU) within the limits $b = 0$ and $b = 12$ (or 100 TU).

(III) Reference Receiving System.

QUESTION 1.

How should the acoustic output of the receiver be defined?

ANSWER.—The sound pressure delivered at the end marked Z in Fig. 2 of a metallic acoustic coupler (artificial ear passage) should be regarded as the measure of acoustic output. The essential dimensions of the coupler are shown in Fig. 2.

It is also necessary to specify the essential dimensions of the receiver; these also are shown in Fig. 2.

QUESTION 2.

What is the best method of measuring this output?

ANSWER.—The measurement of the sound pressure, as in the case of the transmitter, may be carried out by means of any practicable method (calibration by means of a condenser transmitter and the sound pressure compensation method are in practical use).

QUESTION 3.

What should be the electric impedance at the input end of the receiver system?

ANSWER.—The input impedance should be 600 ohms. A tolerance of $\pm$ 5 per cent. and an angle not greater than $\pm$ 10° over the frequency range 100 to 5,000 p.p.s. may be permitted.

QUESTION 4.

By what steps and within what range should the efficiency of the receiving system be adjustable?

ANSWER.—The reference receiver should be adjustable by steps of $b = 0 \cdot 1$ (or 1 TU) within the limits $b = -1$ (or $-$ 10 TU) and $b = +1$ (or $+$ 10 TU).

QUESTION 5.

What ratio between electric and acoustic power taken at the input and output ends of the receiving system, respectively, should define the normal setting or zero point of the receiving system?

ANSWER.—The efficiency of the reference receiving system is determined by the ratio of the sound pressure at the end marked Z in Fig. 2 of the acoustic coupler (artificial ear passage) to the input voltage across the receiving system. The zero point of the receiving system should approximate to that of the standard commercial receiving systems in general use and is defined provisionally by the value of 50 dynes per cm^2 per volt, taken as the arithmetical mean of this ratio over the frequency range 500 to 2,500 p.p.s.

QUESTION 6.

(a) *Over what frequency range should this ratio remain constant?*

(b) *What difference of ratio within this frequency range should be regarded as tolerable?*

ANSWER.—This ratio should not vary by more than $b = \pm 0 \cdot 4$ or ($\pm$ 4 TU) over the frequency range 300 to 3,000 p.p.s. and by more than $b = \pm 1 \cdot 0$ (or $\pm$ 10 TU) over the frequency range 100 to 5,000 p.p.s.

QUESTION 7.

What is the greatest non-linear distortion which may be permitted in the receiving system (a) *for the maximum electric load,* (b) *for a given fraction of this load?*

ANSWER.—*See* I (3).

QUESTION 8.

What receiving system and what type of construction are proposed in order to satisfy the required conditions?

ANSWER.—A receiving system composed of a receiver of the Bell Receiver type, with a diaphragm additionally damped connected to a suitable amplifier, is recommended.

The essential dimensions of the ear cap of this receiver are shown in Fig. 2.

Receivers of the moving coil type have also been found satisfactory in performance and may prove to be preferable if their constancy is found to be adequate.

To compensate the variations which may occur a regulating device should be included in the receiving system.

C. GENERAL RECOMMENDATIONS CONCERNING THE REFERENCE SYSTEM.

The International Consultative Committee—

Considering :—

That any system, which meets the conditions prescribed in the foregoing advice (B) will be adequate for most practical telephone problems.

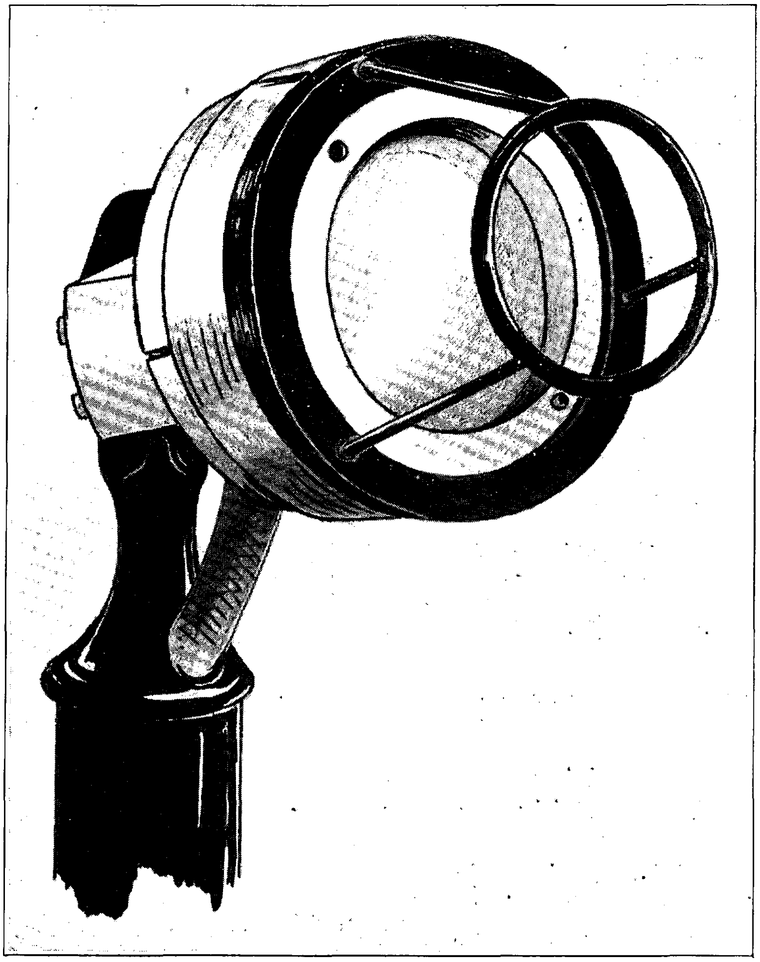
That in any case the physical data given in the foregoing advice cannot by themselves define with sufficient accuracy the characteristics of the Reference System. In other words, two systems, both built to comply with the advice, as far as physical calibration is concerned, may give somewhat different performances for actual speech transmission.

Considering further the very complex character of a description covering all factors entering into the performance of a transmission system under actual speech conditions unanimously decides :—

That, in order to secure uniformity of various standards, one particular physical embodiment shall be chosen as the **Master Transmission Reference System.**

For the present, it is recommended that an exact replica of the American form of Transmission Reference System be designated as the European Master Transmission Reference System and to be held by the C.C.I.

This apparatus includes a condenser transmitter with stretched diaphragm (Fig. 3) coupled to four stages of amplification and a permanent magnet Bell type receiver with a diaphragm,



Condenser Transmitter.
FIG. 3.

mechanically damped by a series of paper discs, and coupled to three stages of amplification. The apparatus is approximately distortionless and transmits speech of very high quality. In addition, it is provided with means for simulating commercial telephone apparatus when desired, by the insertion of distorting electrical networks. The system is provided with complete acoustical and electrical calibrating devices. The condenser transmitter is calibrated when necessary by means of a thermophone in atmosphere of hydrogen. The constants of the thermophone have been found by the Bell System to be accurately computable. The receiver is calibrated by connecting it acoustically to the condenser transmitter by means of a special coupler. The whole of the apparatus, including the calibrating instruments, is mounted on five floor racks. A photograph of this apparatus is shown in Fig. 4.

In the future the Master Transmission Reference System may, subject to approval by the C.C.I., be modified in such respects as will have been proved desirable. Any other system complying with the foregoing advice (B) may, if approved by the C.C.I., be designated as a Primary Transmission Reference System.

These Primary Reference Systems should be of such physical construction that they will be capable of being calibrated by the means provided for calibrating the Master Transmission Reference System.

One important use of these Master or Primary Standards would be the calibration of Secondary and Working Standards. In view of the complexity and cost of the Master Standards, it is not thought that a considerable number of replicas thereof would be likely to be required, but that many Administrations might consider the advisability of calibrating Secondary and Working Standards by means of the Master Standard, or the most conveniently located Primary Standard.

The Secondary Standards might consist of a simpler and more portable type of apparatus, based on the Master or Primary Standard and incorporating many of their features without the calibrating apparatus.

Secondary Reference Systems should therefore be of such physical construction that they will be capable of being calibrated by the means provided for calibrating the Master Transmission Reference System.

Present types of standard telephone sets of commercial type might be used as working standards until some more stable apparatus for the purpose is available. It is recommended that efforts be made to develop working standards which will be more stable than the present types of working standard which incorporate the ordinary patterns of commercial transmitters and receivers.

The International Consultative Committee strongly and unanimously recommends that every Administration should engage itself to adhere strictly to these recommendations. Modifications of one point or another may be found to be desirable from time to time, but any such modifications should be made by mutual agreement and for universal use, and in no case by any Administration acting apart from others.

D. LIST OF OUTSTANDING POINTS TO BE STUDIED IN CONNECTION WITH STANDARD REFERENCE SYSTEMS AND THEIR APPLICATIONS.

The International Consultative Committee submits the following questions for study :—

1. How shall the primary Standard Reference System be compared with the fundamental system, and at what intervals of time will it be necessary to make such comparative measurements ?
2. What are the different permissible methods of constructing secondary Reference Systems ?

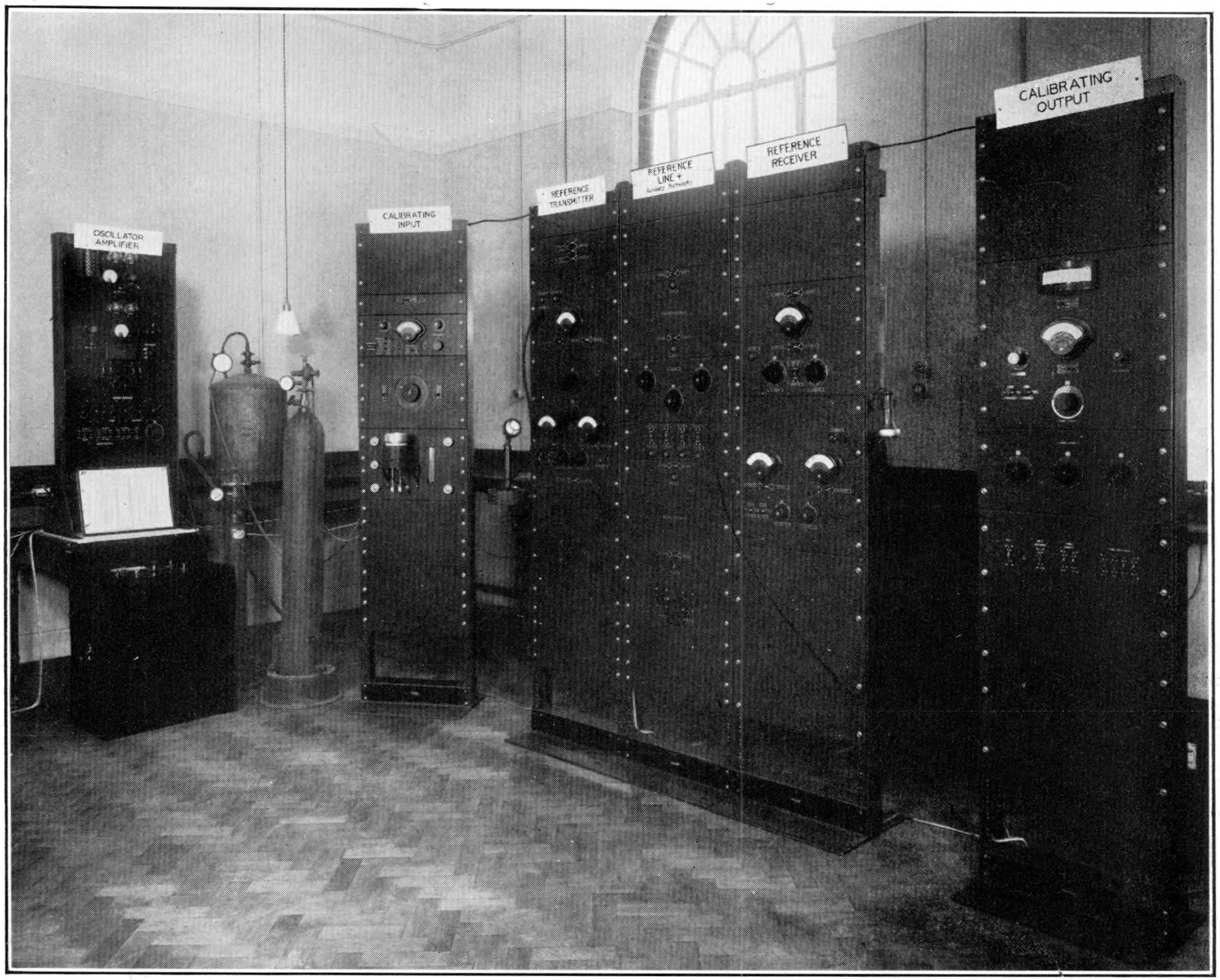


FIG. 4.—Master Transmission Reference System—Assembly.

3. How shall the secondary systems be compared to the primary systems or to the fundamental systems, and at what intervals of time should these comparisons be repeated?

4. How shall the working standards corresponding to the different types of commercial telephone connections existing in the different countries be realised?
How shall these working standards be related to the fundamental, the primary and secondary systems, and at what intervals of time shall these calibrations be repeated?

5. How can the practice coefficient of the different crews of observers making laboratory and voice tests be defined and determined?

6. What tests (physical and physiological) shall be employed in recruiting observers in order to ascertain the state of their hearing and their voice?

7. How can be defined and determined the mean correction factors corresponding to different languages in order that the results of tests of clearness made in different countries may be compared, taking account of the language used?

8. Does the figure 0·05 volts per dyne per centimetre squared specified previously in the proposals of the Conference of London for the zero point of the transmitting system correspond well to the efficiency of the standard transmitting systems of commercial types used by the different Administrations in their working standards for every day measurements?

9. Does the figure 50 dynes per centimetre squared per volt specified for the zero point of the transmitting system correspond well to the efficiency of the standard receiving systems of commercial types used by the different Administrations in their working standards for every day measurements?

10. In measurements of transmission equivalents or transmission efficiency is it desirable to apply corrections to the results because of the difference in impedances between the apparatus measured and the corresponding parts of the reference system?

Note.—Tolerances regarding angle and modulus have been fixed for the impedance of the artificial line of the reference system; also, the attenuation of this line at 800 cycles per second was defined, this attenuation being variable from $b = 0$ to $b = 12$, or 104 TU by steps of $b = 0{\cdot}02$ or 0·174 TU.

It is recommended that, immediately an attenuator permitting an attenuation variable over such a range has been established, the different tolerances permissible for attenuators of this kind shall be decided.

E. SUPPLY, LOCATION, INSTALLATION AND MAINTENANCE OF THE EUROPEAN MASTER TRANSMISSION REFERENCE SYSTEM.

The International Consultative Committee considering that, in addition to the foregoing questions, it is henceforth necessary to examine the questions relating to the supply, location, installation and maintenance of the European Master Transmission Reference system, decides that a special permanent Sub-Commission shall be charged with the study of these questions, and that this Sub-Commission shall be competent to deal with the problems relating to the European Master Reference system and its application.

The members of this Sub-Commission are:—

Dr. Breisig (Germany).
Captain Cohen (Great Britain).
M. Chavasse (France).

Mr. Sivian, of the American Telephone and Telegraph Company, has kindly volunteered to collaborate with this Commission.

The Commission has already examined the following points :—

(a) **Constitution of the European Master Reference system.**

The Commission has adopted the following component parts: 4 thermophones, 4 condenser transmitters, 4 standard receivers, one set of spare vacuum tubes for each position.

(b) **Housing of European Master Reference system.**

The Commission is of the opinion that the premises offered to the C.C.I. by Le Laboratoire du Conservatoire National des Arts et Métiers should be accepted. It approves of these premises with the following reservations :—.

(1) The furniture in Room 1 (intended for the reference system) shall be supplemented by an additional cupboard, provided with lock and key, to house standards belonging to the various Administrations,

(2) There shall be special entrance stairs, permitting the easy ingress of the apparatus,

(3) The walls of the listening operator's cabinet shall be of ordinary brick construction about 25 cm. thick. It shall be lined with felt (or an equivalent sound absorbing material). The floor of the cabinet shall be covered by a carpet of sound absorbing material. There shall be double doors to the cabinet, allowing it to be hermetically closed.

(c) **Accessories.**

I. **Accumulators.**—These are to be provided by the C.C.I. and shall be as hereinafter specified :—

(1)	One battery,	310–325	Volts,	capable of	delivering	80 ma.
(2)	,,	24	,,	,,	,,	5·5 a.
(3)	,,	130	,,	,,	,,	85 ma.
(4)	,,	24	,,	,,	,,	3 a.
(5)	,,	130	,,	,,	,,	10 ma.
(6)	,,	6	,,	,,	,,	1 a.
(7)	,,	6	,,	,,	,,	0·5 a.

The low-tension batteries shall be of the portative type. Each high-tension battery shall be mounted on a small wagon for easy transport and shall be provided with the necessary instruments to test the charge and discharge conditions.

II. **Charging facilities.**—The charging installation of the Laboratoire du Conservatoire des Arts et Métiers shall be augmented to a capacity of about 10 ampères. Furthermore, the possibility of continuous charging (day and night) should be investigated. It is also necessary to arrange for suitable apparatus and measuring instruments, required in order to complete the equipment on the power board and to ensure satisfactory battery maintenance.

III. **Supply of hydrogen and compressed air.**—The hydrogen apparatus shall be of the ordinary transportable reservoir type, equipped with a valve, permitting the desired flow of gas (of a pressure 5 cm. of mercury above atmospheric pressure). Since the consumption of compressed air will be considerably greater, it will be necessary to employ a producer of greater capacity (pressure about 15 cm. of mercury above atmospheric pressure).

IV. **Oscillator and Volume Indicator to adjust the energy of speech emitted.**—This apparatus will be furnished by the American Telephone and Telegraph Company.

V. **Frequency Meter.**—It is necessary to provide a frequency meter with a range of from 30 to 10,000 p.p.s.

(d) **Personnel.**

The engineer and assistant engineer, placed at the disposal of the C.C.I. by the French Administration shall (as from about the month of May 1927) follow the installation and calibration of the Master System and shall familiarize themselves with its operation. Two extra helpers, which will complete the operating staff, shall be assigned when the actual calibrating of working standards begins.

The International Consultative Committee has decided that the expenses in connection with the installation and maintenance of the Master Reference Transmission System shall be covered by means of contributions from the various Administrations, belonging to the C.C.I., these contributions to be in proportion to those which are now made for the maintenance of the secretariat of the International Consultative Committee.

(A.a.2.) Recommendations of Principle.

Uniform value to be given to the Impedance of International Circuits.

The International Consultative Committee—

Considering :—

That, for various general reasons, it is desirable to maintain a uniform value of impedance for all international circuits measured from a repeater station, or from one of the terminal exchanges, by the suitable adaptation of intermediate transformers.

That this impedance should be chosen in such a manner as to avoid, as far as possible, reflection losses at the ends of the long-distance circuits—*i.e.*, that its value should be as near as possible to that of the local circuits to which these long-distance circuits are generally connected.

That it has been found from tests carried out in various countries that the values of the impedance of local circuits varies appreciably with the frequency of the measuring current, with the length of the circuits and with the nature of the subscriber's apparatus.

That, in spite of the lack of precise information, it is, however, possible to give, provisionally, to this typical impedance an average value sufficiently approximate for practical needs, and that, in many cases, satisfactory results have already been obtained.

That this choice (which, however, is subject to revision) will itself constitute an experimental basis for the future.

Unanimously advises :—

That the value to be given to the apparent impedance of international circuits (measured across the terminal transformers, and measured or calculated at a frequency of 800 periods per second) shall be provisionally fixed at 800 ohms; it may, however, fall within the limits of 600 and 950 ohms.

Combinations of International Circuits.

The International Consultative Committee—

Unanimously advises :—

That for reasons of stability in transmission the combining of international telephone circuits shall never be made except between complete repeater sections (*i.e.*, at repeater stations).

Practical Limits of Transmission Equivalents.

The International Consultative Committee—

Unanimously advises :—

1. That the transmission equivalent (measured at 800 p.p.s.) of the combined sections, comprising international lines and repeaters, shall not exceed b = 1·3 or 11·3 TU; that, however, for cable circuits, which are not extended beyond the terminals of the cable, the transmission equivalent, measured between the offices, may be increased to b = 2 or 17·4 TU in certain special cases.

2. That the losses which occur in the entire circuit which connects a subscriber to the international office of his own country—that is to say, the office which gives him international service—should not exceed b = 1 or 8·7 TU in order that the total loss of an international connection shall not exceed b = 3·3 or 29 TU.

> **Note.**—" The losses, occurring in the entire circuit, which connects a subscriber to the international office of his own country " do not include the losses due to battery supply decrease to the transmitter.
>
> When the standard reference system is available, it will be necessary to define the transmission equivalent of the entire connection between a subscriber and the international office of his own country.

Allowable limits of variation in the transmission equivalent with frequency for long 2-wire and 4-wire International Circuits.

The International Consultative Committee unanimously gives the following two advices :—

2-wire circuits.*

The quality of transmission in a repeatered 2-wire circuit is characterized :—

(1) by the loudness of speech, which is defined by the figure of over-all loss at a mean frequency (800 p.p.s.);

(2) by the distortion, which is defined by the deviation of the attenuation figure at the lowest and the highest frequency to be transmitted (300 p.p.s. and 2,000 p.p.s.) from the attenuation figure at 800 p.p.s.;

(3) by the deviations of the over-all loss-frequency curve from the mean curve or the stability of the circuit (singing point). In order to simplify the measurements, the loudness and the distortion are measured after suppressing the amplification in the reverse direction.

According to this the variation of attenuation with frequency on international 2-wire circuits may be defined as follows: having suppressed the amplification in the reverse direction, the over-all loss is measured at the frequencies : 300, 800 and 2,000 p.p.s.

The attenuation at 800 p.p.s. ought to be equal to b = 1·3 or 11·3 TU; the attenuation at 300 p.p.s. should not differ from that at 800 p.p.s. by more than b = 0·5 or 4·3 TU and the attenuation at 2,000 p.p.s. should not differ more than b = 1·5 or 13 TU from that at 800 p.p.s.

Having reduced the over-all loss by b = 0·4 or 3·5 TU, the singing point of the transmission system should not be reached.

4-wire circuits.

The limits laid down in the Typical Specification for a complete telephone cable between terminal offices should remain.

Adoption of Arrangements in regard to Type of Loading and Gauge of Conductors, other than those prescribed by the C.C.I.

The International Consultative Committee—

Unanimously advises :—

That the types of loading and gauges of conductors, adopted as standards by the C.C.I., provide sufficient flexibility to meet all practical requirements in regard to the spacing of repeater stations.

However, cases may occur where standard types of lines cannot be used. Care must then be taken that the performance clauses of the specifications issued by the C.C.I. are observed; particularly those relating to cut-off frequency, characteristic impedance and attenuation frequency curves and, if possible, adopt the type of loading called for in the C.C.I. specifications.

In case it is proposed to increase the diameter of the conductors the International Consultative Committee would point out that it is more difficult to obtain a uniform distribution of the electrical constants of the line with large diameter conductors. Consequently, when it is essential to increase the diameter of the conductors in order to reduce the attenuation of a particularly long repeater section, it may be necessary to select so large a diameter that the attenuation of the repeater sections falls below the normal value. In this manner it is possible to operate the circuit with reduced repeater gains and thus obtain the same degree of stability as that of a standard type of circuit.

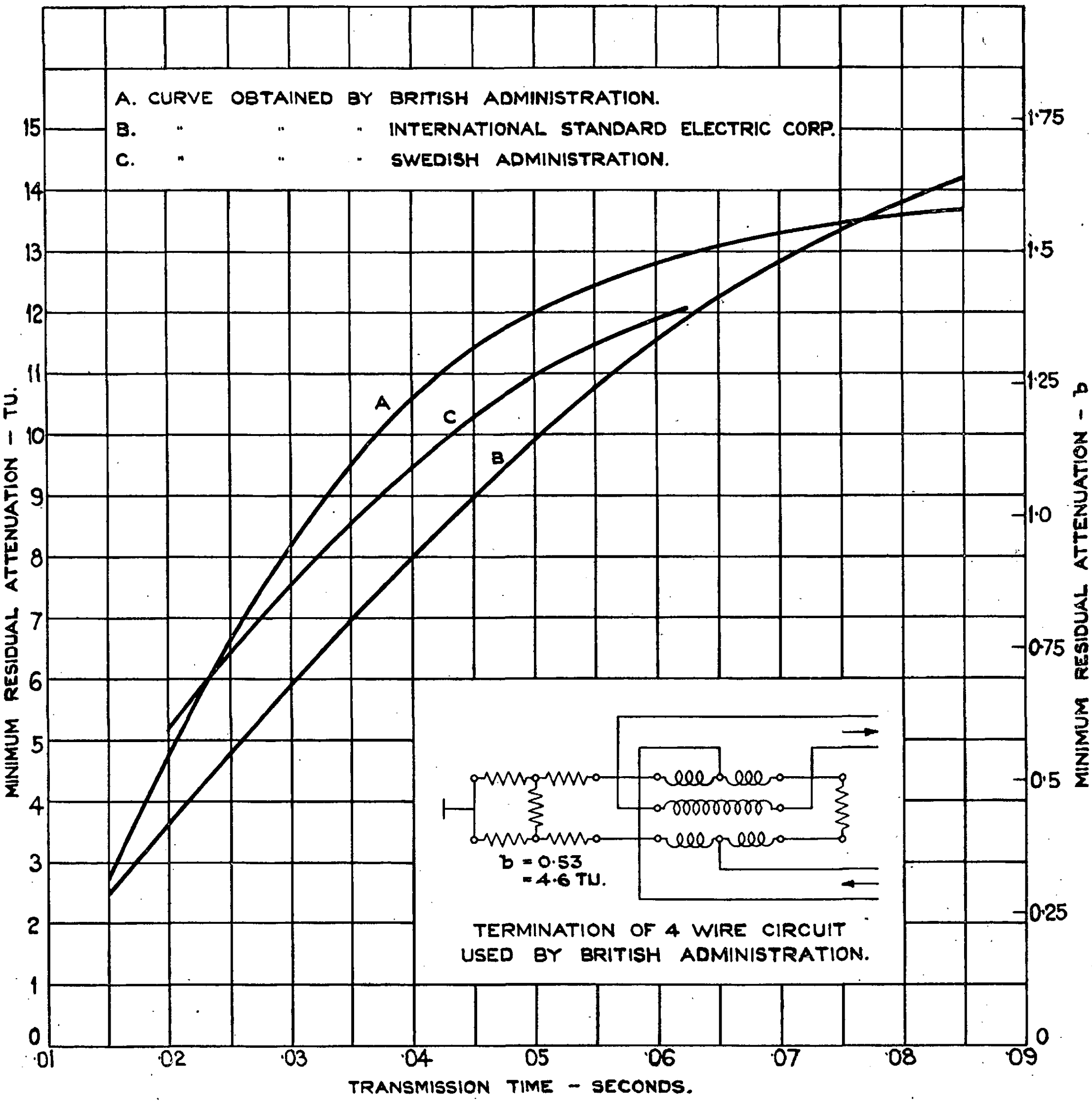
* On this subject, *see* Appendix B.d.2, No. 4, entitled "Essential clauses of a typical specification for the supply of a complete telephone cable."

Echo Effects.

The International Consultative Committee—

Considering :—

That, as a result of practical tests, the maximum distances over which it is possible to transmit commercial speech without the use of echo suppressors are as shown on the curve chart (Fig. 1),



Limitation of the Transmission Efficiency of 4-Wire Circuits due to Echo Effects.

FIG. 1.

Unanimously advises :—

1. That, for the present, all international circuits which exceed the limits indicated by these curves should be specially tested for the presence of echo effects and special means provided for their reduction, if necessary. Devices for this purpose are described in Appendices C.c.4, No. 1, No. 2 and No. 3.

2. That, in any case, considering the simplicity and reliable operation of echo suppressors, together with the fact that 4-wire circuits are often connected repeater-operated to 2-wire circuits, it is recommended that all 4-wire international circuits which may be extended beyond 500 km. ("medium-heavy") or 1,000 km. ("extra-light") should be equipped with echo suppressors.

3. That, in general, long circuits can be considerably improved by the use of echo suppressors, and that, when such provision is made, echo effects will not influence the range of speech.

Transient Phenomena.

The International Consultative Committee—

Unanimously advises :—

1. That further investigation is necessary before definite recommendations can be made on this subject.

2. That the various Administrations should be invited to study transient phenomena particularly on circuits equal to or longer than 800 km.

3. That, in any case, where speech transmission appears to be affected by these phenomena, it may be advantageous to restrict the frequency band transmitted. Proposals by the German Administration give some indications in this respect (*see* Appendix C.d.2, Report of the German Administration with reference to long-distance communications on Extra Light-Loaded Toll Cables. Precautions to be taken when transient phenomena become troublesome).

Star-quad Cable for Long Distance International Circuits.

The International Consultative Committee—

Unanimously advises :—

1. That from a technical point of view star-quad cables are suitable for international telephone circuits in so far as these cables meet the general conditions laid down in the specification for factory lengths and for repeater sections.

2. That whether star-quad cables in any given case should be preferred is purely a question of economics.

Considering, on the other hand—

That the simultaneous use of phantom cables and star-quad cables without phantoms, as portions of a telephone circuit, presents difficulties in so far that star-quad cables render it necessary to change over at junction points from phantom working to physical circuits,

Unanimously advises :—

That, in order to preserve homogeneity of 2-wire repeater circuits in the repeater sections, it must be arranged that star-quad cables, in every case, be used only throughout complete repeater sections.

Uniformity.*

The International Consultative Committee—

Considering :—

That it is desirable, in order to insure a satisfactory performance of the repeaters as well as to avoid reflection losses, to obtain a uniform distribution of the electrical constants throughout a repeater section,

* *See* Appendix C.b.1, entitled : "Different ways in which two Telephone Administrations can co-operate in the construction of a repeater section, which crosses a frontier."

Unanimously advises :—

That cable sections between repeater stations in one and the same country should be absolutely uniform throughout; that it should be prescribed that the construction of the cables shall be such that the circuits shall be perfectly balanced and the electrical constants uniformly distributed.

Considering, however :—

That, for the design of cable sections, extending over the frontiers of two contiguous countries, it may, in certain cases, be necessary to join two sections of cable which do not fulfil the requirements of the same specification, and that certain connections of this kind have given good results, but that no deterioration in quality should be permitted as a result of any departure from the principle of uniformity,

Unanimously advises :—

That uniformity in the make-up of international cable sections between repeater stations, located on either side of a frontier, is very desirable, but that, in exceptional cases, a direct connection may be sanctioned between sections of cable made to different specifications, provided that the conditions relating to impedance balance laid down in the paragraph on "Impedance balance" in the "Essential clauses of a typical specification for repeater sections of loaded international telephone cable" are fulfilled (Appendix B.d.2, No. 3).

> **Note.**—Uniformity of repeater sections is particularly important for circuits, made up of 1·3 and 1·4 mm. conductors; but in view of the fact that these circuits have almost the same total capacity per loading section in Methods 1 and 2, a sufficient degree of uniformity is obtainable if, in a complete repeater section, one or the other of the two loading coils are used, keeping the characteristics of Methods 1 and 2 respectively as regards the equipment of the cable proper in the sections to be joined.

Frequency of Ringing Currents.

The International Consultative Committee—

Considering :—

That, for convenience of international relations, it is desirable to adopt a single frequency for ringing; that this frequency should be sufficiently high for ringing currents to be transmitted by repeaters under normal conditions; that experiments made in various countries with currents of 500 periods per second frequency have given satisfactory results; that the disturbing effect of cross-talk due to currents of frequency of 500 periods per second is generally less than the cross-talk due to currents of a higher frequency; that in view of facilitating the adjustment of apparatus used for receiving calls, it is moreover desirable that in the present state of telephone engineering development to modulate or interrupt at low frequency the currents of musical frequency,

Unanimously advises :—

That for circuits used for international communications, and, for the time being, there shall be employed a ringing current of a frequency of 500 periods per second $\pm$ 2 per cent. interrupted with a frequency between 20 and 25 periods per second and an effective EMF of from 0·5 to 1·5 volts at zero transmission level, and that it is desirable that an agreement should be reached in regard to one frequency.

Choice of a Single Frequency for Routine Measurements.

The International Consultative Committee—

Considering :—

That it is desirable to have, for routine measurement, a current of definite frequency—and a frequency which is always the same—that this frequency should be as near as possible to that of the average frequency of spoken sounds; that it has been provisionally admitted, up to the present, that this frequency should be 800 periods per second and that the experience hitherto acquired with currents of different frequency appears to be still inadequate to enable one to consider a change in the present practice,

Unanimously advises :—

That, provisionally, currents of a frequency of 800 periods per second should still be employed for routine measurement; that the various Administrations should be invited to continue investigations, which they have already undertaken on this question, and to state later their opinion.

Single Frequency Method, suitable to replace Voice Test.

The International Consultative Committee—

Considering :—

That the choice of the frequency for currents used in routine maintenance tests should be of such a nature as to facilitate the investigation of faults in the various types of circuits commonly used;

That in modern telephony, it is becoming increasingly important to consider not only the volume of the sound transmitted, but also the articulation of the speech transmitted;

Considering, on the other hand :—

That testing methods, using single frequency, have been proposed, and that these give results comparable with voice tests, namely :—

(*a*) A method using a conjugate rhythmic frequency with an integrating receiving device. (*See* information furnished by the British delegation, Appendix C.a.1, No. 1.)

(*b*) A method, based on cross-talk measurements at a few frequencies only, the results obtained being interpreted according to a method determined by each country, taking into account the phonetic characteristics of the language of the country. (*See* information furnished by the German delegation, Appendix C.a.1, No. 2, as well as the Note on Cross-talk, submitted by the French delegation, Appendix C.a.1, No. 4);

Considering further :—

That these methods are not yet sufficiently confirmed by experience and that it is necessary to continue the study of their mode of application,

Unanimously advises :—

That the voice tests, prescribed in the paragraphs on "Cross-talk" in the typical specifications for international telephone cables shall provisionally be maintained, but that it is necessary to study, as soon as possible, a testing method for cross-talk, which shall be independent of the tester. The various Administrations are therefore invited to examine the two methods under consideration and give their views on this point.

Use of International Circuits for the relaying of Radio-broadcast Transmissions.

The International Consultative Committee—

Considering :—

That broadcasting has become an important element in the social life,

That experience has shown that the exchange of broadcast programmes over considerable distances can best be done by the use of long-distance telephone lines, capable of reproducing correctly all musical frequencies and protected against atmospheric disturbances, which frequently affect radio transmissions, That the relaying of broadcasting transmissions by means of international circuits, from an economical standpoint, has the double advantage of utilizing the circuits during the slack hours and of obtaining from several broadcasting stations excellent programmes of high artistic standard, which otherwise would entail a considerable expense, lectures or speeches of general interest,

Unanimously advises :—

That it is desirable that radio-broadcast transmissions should be effected on international circuits.

Frequency Band to be transmitted for different Quality of Broadcast Transmissions.

The International Consultative Committee—

Considering :—

That, as regards the frequency band to be transmitted for the reproduction of speech and music, it is necessary to discriminate in each case in practice between what is desirable as an ideal and what can be accomplished, having due regard to the various economical factors involved,

Unanimously advises :—

That an ideal reproduction of speech and music necessitates a distortionless transmission of the currents comprising the entire range of frequency between 30 and 10,000 periods per second; that the transmission of very low frequencies (30 to 100 p.p.s.) is more important from this standpoint than that of the higher frequencies, and that an extension beyond 10,000 periods per second of the band of frequency correctly transmitted would not be of any particular advantage,

That the transmission of a frequency range from 100 to 5,000 periods per second is adequate for the reproduction of good quality music and elocutionary speech,

That for the transmission of lectures and speeches the range of frequencies employed may be restricted to 200—3,000 periods per second.

Co-ordination of Radio Telephony and Wire Telephony in the Exploitation of International Circuits.

Although long distance radio telephony can only be regarded as intimately associated with wire telephony, from a technical and commercial standpoint, the International Consultative Committee has not as yet dealt with long distance radio telephony, which is still in the experimental stage; however, since very rapid technical progress is taking place, which bids fair to introduce radio telephony in the international telephone network, the International Consultative Committee will study means for co-ordinating radio telephony with wire telephony for international traffic.

(A.b.) General Rules concerning the Make-up of Transmission Systems.

(A.b.1.) Ordinary Telephony.

Inter-connection of 4-wire Circuits.

The International Consultative Committee—

Considering :—

That it is desirable that circuits already ear-marked for transit traffic or capable of eventually being inter-connected should be established in such a manner as to operate with full efficiency when they ultimately form part of the projected long distance network, although their provisional use for traffic between terminal stations may not be economical;

That for making connections between long 4-wire circuits, it is desirable to adopt preferably methods of connection which do not introduce prejudicial echo effects, and

That it is desirable to point out, in regard to this matter, that cord circuits have been designed with a view to permitting the extension of a long 4-wire circuit by means of another 4-wire circuit (with or without the introduction of additional telephone repeaters) without its being necessary for the operator to make any adjustment (on this point *see* Appendices C.c. 3, No. 1 and No. 2, describing the methods of inter-connection used by the International Standard Electric Corporation and Siemens and Halske A.G.),

Unanimously advises :—

That, where two 4-wire circuits have to be joined together, it is desirable to make this connection by switching arrangements designed in such a manner as to prevent additional echo effects, and in such a manner that adjustments of the intermediate repeaters by the operators is not necessary.

(A.b.2.) Carrier Current Telephony.

. . . .

(A.b.3.) Radio-Broadcast Transmission.

Maximum and Minimum Transmission Levels to be adopted for Radio-Broadcast Transmissions.

The International Consultative Committee—

Considering :—

That, as regards the maximum and minimum transmission levels to be adopted for the relaying of broadcast transmission, a distinction must be made between cable circuits and open wire lines,

That, in fixing these values, consideration should be given to the technical qualities of the circuits involved,

Unanimously gives the following two advices :—

(a) **Cable Circuits.**

If it is desired to use ordinary vacuum tubes, the mean value delivered to the long distance line and calculated for any interval of time of 10 milli-seconds must not exceed 1 milli-watt. For the transmission of greater powers, it seems necessary to use special cables, equipped with proper vacuum tubes.

The maximum transmission level at any point on the line must not exceed $b = 1 \cdot 1$ or $9 \cdot 6$ TU.

In ordinary cables the minimum transmission level should not be less than the limit allowed for ordinary telephony. In special cables, where the cross-talk is considerably reduced, this limit may be reduced by an amount corresponding to this reduction. For example, in the case of these special, already existing cables having cross-talk values $b = 12$ or 104 TU, the transmission level may be fixed at $b = -5 \cdot 5$ or $-47 \cdot 8$ TU.

(b) **Open Wire lines.**

A limit of 4 milli-watts seems to be permissible for the maximum mean power, calculated for any interval of time of 10 milli-seconds. No definite maximum level for the instantaneous power appears to be necessary, but the minimum value of this power must not be less than 1·6 milli-watts.

Conditions which Open Wire Lines must fulfil in order to be used for Radio Broadcasting.

The International Consultative Committee—

Unanimously advises :—

(a) That in all cases where parasitic noise or interference, due to mutual induction between the open wire lines used for broadcasting and other circuits do not enter into consideration, these open wire telephone lines are in every respect suitable for broadcasting purposes.

(b) That one should not forget that the necessary freedom from inductive interference can only be obtained on circuits which are very carefully balanced and maintained.

(c) That no serious distortion would be caused by the introduction of short, non-loaded cable lengths on open wire lines, such as are used for railway and river crossings, etc. If long, loaded cables are inserted, the effects may be more serious. In the case of long cable lengths, the cut-off frequency must meet the conditions, laid down on page 32, relating to the range of frequency to be transmitted for the various qualities of broadcast transmission.

(d) That when amplification is necessary on open wire lines used for broadcasting, it is desirable that the transmission equivalent of the line between two repeater stations should not exceed $b = 1$ or $8 \cdot 7$ TU.

(e) That with respect to the value of the input power applied to the repeaters, vacuum tubes should be employed which are capable of dealing with 100 milli-watts without undue non-linear distortion. The repeaters to be used must have a very flat frequency characteristic curve over a range of 30 to 10,000 periods per second.

Alterations made in Cable Circuits in order that they may be suitable for Broadcast Transmission.

The International Consultative Committee having regard to the considerations laid down in the advice on page 32 "Frequency band to be transmitted for different quality of broadcast transmissions"—

Unanimously advises :—

(1) That cable circuits for radio broadcasting require a different value of cut-off frequency. In medium-heavy loaded quads, the phantom circuits of which have a cut-off frequency of approximately 3,800 periods per second, these circuits can only be used for transmissions over which a range of 3,000 periods per second is sufficient. For broadcast transmissions of a higher standard, extra-light loaded side and phantom-circuits are usable, with a preference for the phantom circuits.

(2) In long-distance cables of the types specified by the C.C.I. (Systems 1 and 2 of the Typical Specification of Loading, contained in Appendix B.d.2, No. 3), when specially loaded circuits have been reserved for the relaying of broadcasting transmission, it would be possible, both economically and technically, to prescribe for these circuits a cut-off frequency of approximately 10,000 periods per second. It must be remembered that, in this case, the inductance of the line is no longer negligible as compared with the inductance of the loading coils.

(3) That, with respect to the repeaters, it is necessary that the frequency curve of amplification and the frequency curve of the circuit coincide. This coincidence should take place with a maximum allowable deviation of $b = \pm 0{\cdot}05$ or $\pm 0{\cdot}43$ TU within the frequency ranges required for the different types of broadcast transmission. On the basis of the advice already given vacuum tubes may have to be used which are capable of dealing with a power of the order of 100 milli-watts in order to avoid non-linear distortion.

(A.c.) APPARATUS.

(A.c.1.) Subscriber's Instruments.

The International Consultative Committee—

Considering :—

That, in order to obtain satisfactory transmission on international communications, it is essential to have well-defined testing methods for subscriber's instruments;

Considering also :—

That although several methods exist which have been used by various Administrations (*see* Appendices C.c.1. No. 2, No. 3 and No. 4), it is impossible for the present to select one of these methods as standard,

Unanimously advises :—

That it is desirable that each subscriber's station which is used in conjunction with international circuits shall be tested once a year and the Administrations should continue their studies and make proposals to the C.C.I. in order that one method may be adopted.

(A.c.2.) Local Central Offices.

....

(A.c.3.) Long-distance Central Offices.

....

(A.c.4.) Telephone Repeater Stations.

Position of Repeater Stations.

The International Consultative Committee—

Unanimously advises :—

That the position of repeater stations shall be determined by technical rather than on political considerations.

Choice of Repeaters.

The International Consultative Committee—

Considering :—

That, as a result of actual experience, it has been found impossible to ensure, for satisfactory commercial use, a stable operating condition with two or more telephone repeaters in tandem without having artificial lines inserted in the line.

Advises :—

That on two-wire circuits, open wire or cable, there shall be used only two-way repeaters equipped with balancing artificial lines in each direction of the line.

Amplification Characteristics of Repeaters.

The International Consultative Committee—

Unanimously advises :—

That repeaters should ensure a faithful reproduction of the human voice, *i.e.*, transmit telephone currents of such a type that the resulting over-all attenuation of telephonic communication between terminal exchanges should not differ by more than

$b = 1$ or $8 \cdot 7$ TU for any two frequencies between the intervals of frequency indicated below :

Two-wire telephone circuits—300 to 2,000 periods per second.

Four-wire telephone circuits (medium heavy loaded)—300 to 2,200 periods per second.

Four-wire telephone circuits (extra light loaded)—300 to 2,500 periods per second.

In order to obtain these results repeaters may be used, which give uniform amplification over the entire frequency ranges indicated, these repeaters to be associated with correcting devices if required, or, alternatively, repeaters may be used which in themselves supply the desired correction.

Transmission Level—Adjustment of Repeaters.

The International Consultative Committee—

Unanimously advises :—

That, in order to ensure satisfactory transmission on international circuits, it is essential that the rules regarding transmission levels and adjustment of repeaters, laid down in the paragraph entitled " Maintaining satisfactory transmission " (A.e.) be observed.

Compensation of the Effects, due to Rapid Temperature Variations.

The International Consultative Committee—

Considering :—

That in certain cases cables are subjected to temperature variations, which may sensibly affect the electrical characteristics of the circuits,

Unanimously advises :—

That it is recommended to provide regulating devices, permanently associated with the repeaters in cases where appreciable temperature variations frequently affect the transmission on cables, which contain long sections of aerial cable. In this case the control station, from the point of view of adjusting and distributing the amplification of the various repeaters shall be the stations, where such regulating devices are installed.

Adjustment of the Amplification of Telephone Repeaters.

The International Consultative Committee—

Considering :—

That for various reasons—for example, on account of variations in batteries or valves, etc.—the gains actually furnished by telephone repeaters in commercial service inevitably differ appreciably from the nominal value of these gains for each definite adjustment.

Unanimously advises :—

(1) That it is desirable that the attendants responsible for the maintenance of the repeaters need only be requested to inform the supervisor at the Control Station of the effective gains measured in the form of a definite number of units of transmission, and not in the form of the number of the stud, on which the pointer of the regulating device has been placed;

(2) That it would be desirable to make it clear that the gain so communicated should be the effective gain given by the repeaters, and should not include apparatus losses which have to be included in the line losses and indicated on the transmission level diagrams.

(A.d.) LINES.

(A.d.1.) Open Wire Lines.

Loading of Open Wire Lines.

The International Consultative Committee—

Considering :—

That the loading of open wire lines—

(1) renders difficult the operation of these lines because of variations in the insulation resistance and magnetization of the coils, due to atmospheric discharges;

(2) renders difficult the operation of these lines with repeaters;

(3) is incompatible with carrier telephone operation on these lines;

(4) varies excessively the transmission of the different speech frequencies, introduces distortion and consequently decreases the articulation of the conversation,

Unanimously advises :—

That open wire telephone lines, operated with repeaters and used for long distance international traffic, should not be loaded.

Use of Open Wire Lines.

The International Consultative Committee—

Considering :—

That the employment of long distance international communication necessitates the use of open wire lines.

That the maximum efficiency of these lines will be obtained by their phantom circuits, by the use of repeaters and also the introduction of carrier frequency telephony,

That in order to ensure satisfactory working of these devices, as well as to prevent reflection losses, it is essential to have well-balanced circuits and also a uniform distribution of the electrical constants throughout the entire length of the line between successive repeaters.

Unanimously advises :—

That it is desirable, that long open wire lines, used for international communication, should be well balanced and, furthermore, should not have any electrical discontinuity between two successive repeaters; that is to say, the electrical constants should be uniformly distributed throughout such sections.

Crosstalk on Open Wire Lines.

The International Consultative Committee—

Unanimously advises :—

That it should be understood, that the crosstalk between any two circuits, side or phantom, in an open wire line, used for long distance international telephony should always be less than $b = 6 \cdot 9$ or 60 TU, the test to be made from any repeater station or central office of the line.

(A.d.2.) Cables.

α. General.

General Recommendations for Cables allocated to International Service.

The International Consultative Committee—

Considering :—

That the establishing of long international lines in cables is facilitated, if local cable networks of the various countries have characteristics approaching those specified for international cables; that these characteristics are, moreover, those of the usual types of cable now in existence in the various countries.

Unanimously advises :—

That the telephone administrations in the various countries are recommended to apply, for preference the advice given in the essential clauses of the typical specifications to their local cables for national service, particularly the clauses relating to diameters of conductors, loading coil spacing and distances between repeater stations.

β. Aerial Cables.

. . . .

γ. Underground Cables.

. . . .

δ. Submarine Cables.

. . . .

(A.d.3.) Mixed Lines.

General Recommendations concerning Mixed Lines.

The International Consultative Committee—

Considering :—

That on mixed lines—that is to say those comprising both aerial line and cable sections—it is difficult to obtain stable and efficient operation of the repeaters;

That there are always reflection losses at the junction of lines having different characteristics which reduce the total efficiency of the circuit; that the insertion of heterogeneous sections, even of very short length (at tunnels in passing through large towns, etc.) in telephone lines is, according to experience gained by certain countries represented on the International Consultative Committee, of such a nature as seriously to interfere with the development of long-distance telephony owing to disturbances affecting the operation of the repeaters and high-frequency telephony systems; that it is, therefore, advisable to avoid this procedure except where it is impossible to do otherwise.

That, nevertheless, certain cases of this kind may involve the necessity for such practices, but that it would then be best to take special precautions,

Unanimously advises :—

(1) That, as far as possible, it is advisable to avoid the use of mixed lines for international long-distance telephony.

(2) That if it is impossible to avoid mixed lines, efforts should be made to reduce reflection losses as much as possible by the use of continuously loaded or " light-loaded " cables.

Transmission Equivalents and Distortion of Mixed Lines.

The International Consultative Committee—

Unanimously advises :—

That for a mixed line of any length the transmission equivalent and the distortion should be as nearly as possible the same as for a uniform line.

A.e.—Maintenance and Supervision of Lines and Installations.

Extracts from the International Service Regulations.

(Revised in Paris, 1925.)

Section A.

§ 6. The Administrations concerned shall inform each other regarding the make-up of the lines of communication in their respective territories and acquaint each other about all important changes.

In case there is a breakdown in an important line of communication used for international long-distance traffic, every defective section of the line shall, so far as possible, be speedily replaced by a line (or a portion of a line) of communication allocated to the internal service or by a less important channel (or portion thereof) of the same international system. The channels of communication (or portions thereof) which are to be used for replacement purposes shall, if possible, be designated in advance.

§ 7. Daily, at a mutually agreed time, the central offices having direct connection—that is to say, those which form the outlets for international traffic—shall ascertain by means of ringing and talking tests the condition of the channels of communication. Record of any trouble shall be made.

Tests shall be made, as required, by the terminal exchanges or by repeater stations nearest to the frontier. The terminal exchanges or the stations concerned shall agree as to the day and hour when these tests shall be made. The results of the tests shall be exchanged between the services concerned.

Proper means for remedying breakdowns and faults shall be taken immediately.

Advice of the International Consultative Committee regarding Maintenance and Supervision of the Lines and Installations.

Rapid Re-establishment of International Communications.

The International Consultative Committee—

Considering :—

That it is of general interest to re-establish international communications as rapidly as possible in cases of breakdown, lasting some time :

Unanimously advises :—

(1) That the country in whose territory an international line is out of order should endeavour, as far as possible, to substitute for the defective section a circuit from the internal network.

(2) That in order to ensure, in this case, good transmission on the international line, a preliminary study should be made in each country in order to determine the circuits of the internal network, suitable for use in the case under consideration.

Testing Points on the International Circuits.

The International Consultative Committee—

Considering :—

That the localisation of faults should be made, above all, by means of precision methods, avoiding as far as possible sectionalisation of the line :

That, further, the leading-in of circuits in the numerous exchanges increases the attenuation and destroys the homogeneity of the line :

Unanimously advises :—

(1) That the number of leading-in points—a frequent source of fault—be reduced to a minimum compatible with local requirements.

(2) That testing points enabling precision tests to be effected should be installed in the exchange on the route, approximately 200 km. apart. That such exchanges be called " main testing points " and the length of circuit included between two main testing points be called " main section." In a main section the position of a fault will be determined by tests carried out simultaneously at the testing points situated on either side of the fault. The results of these tests will be exchanged between the exchanges concerned.

(3) That tests for conductivity and insulation of the conductors shall be made frequently and at least once a month, by the terminal exchanges or the repeater stations nearest to the frontier and the results of these tests shall be exchanged between the services concerned.

If the circuit is provided with repeaters, the repeater stations will be " main testing points."

It is recommended that the permanent introduction of a long length of cable on an aerial circuit for carrying this circuit to a main testing point be avoided, and a separate testing arrangement at a distance be adopted.

Restriction of the Number of Test Points on International Cable Lines.

The International Consultative Committee—

Unanimously advises :—

That on international cable lines it is advisable to provide leading-in facilities for test purpose only at repeater stations.

That exception may be made for the frontier crossing points after agreement between the services concerned.

Supervision of the Lines by means of Patrol Service.

The International Consultative Committee—

Considering :—

That it is advisable to assure the continued supervision of the lines with the object of preventing faults as far as possible and of ensuring their rapid clearing.

Unanimously advises :—

That it would be advisable, where the importance of the line warrants it, to organise a patrol service for supervision along the lines as is already done in certain countries.

Maintaining Satisfactory Transmission.

In order to ensure satisfactory co-operation between Administrations interested in the maintenance of one and the same circuit, the International Consultative Committee gives, under this heading, a list of the tests which should be made on international circuits and a description of the appropriate apparatus and operating methods. Localisation of faults and the restoration of lines are not dealt with in this report. The apparatus described for maintenance purposes is sufficient to determine the position of faults, but it will, in addition, be necessary to draw up detailed instructions, with a view to ensuring that the tests shall be satisfactorily carried out in practice.

A list of periodic tests forms the subject of the first chapter; a second chapter is devoted to methods and apparatus used in periodic tests; a third chapter indicates the function of the control station (*station directrice*) and contains instructions for that station and specimen report forms for the recording of the supervision and maintenance data of the international telephone lines.

List of Periodical Tests.

I. **At Terminal Stations : Tests to be made on the circuits.**

(1)	Insulation resistance	Monthly
(2)	Conductor resistance	,,
(3)	Over-all transmission test	,,
(4)	Over-all signalling test	Daily
(5)	Over-all speech test	,,

II. **At Repeater Stations : Tests to be made on the circuits.**

(1)	Insulation resistance	Monthly
(2)	Conductor resistance	,,
(3)	Line impedance measurement	Yearly
(4)	Singing point test	Monthly
(5)	End-to-end transmission test between successive repeater stations and between terminal stations and adjacent stations	Yearly
(6)	Transmission level test	,,

III. **At Repeater Stations : Tests upon repeaters.**

(1)	Check of battery voltage and current	Daily
(2)	Repeater gain test at single frequency	Weekly
(3)	Repeater gain test over range of frequencies ..	Half-yearly
(4)	Valve rejection test	As required
(5)	Test of signalling apparatus	Monthly
(6)	Singing point test of repeaters	Quarterly
(7)	Calibration of repeaters	Half-yearly

IV. **Miscellaneous Tests** (made as required).

(1) Crosstalk tests.
(2) Noise measurements.

Apparatus for Making Routine Tests.

I (1) and II (1). Insulation Resistance.

The C.C.I. does not desire to specify the type of apparatus to be used for this test. Whatever instrument is used, it should fulfil the following conditions :—

(1) It should be dead-beat so as to permit of rapid readings.

(2) It should indicate the insulation resistance correct to $\pm$ 10 per cent.

(3) It should require a voltage of not more than 600 volts.

(4) It should give a steady reading with a capacity load, even if a current is produced by manual operation (megger).

(5) Means should be provided to prevent a sudden discharge of the line after test so as not to damage the loading coils.

I (2) and II (2). Conductor Resistance.

The C.C.I. does not desire to specify the type of apparatus to be used in this case. It should be accurate to $\pm$ 0·1 per cent. and lend itself to quick manipulation.

I (3). Over-all Transmission Test.

This test is made with the object of ensuring that the transmission efficiency of the circuit under test is up to its nominal value. A routine test of this type should be made monthly. It is also employed when speech on a circuit is reported "faint." If the result of the measurement indicates that the circuit is below its nominal efficiency, a transmission level test (No. II(6)) will generally be made in order to localise the trouble.

The principle of the measurement is to apply a known alternating voltage or current to the sending end of the circuit and to measure the corresponding voltage or current at the receiving end of the circuit. The apparatus necessary consists essentially of a generator capable of producing alternating current of audible frequencies, and a means of comparing the sent and received voltages.

The apparatus should comply with the following requirements :—

Generator.

The generator, which is preferably of the valve oscillator type, shall be capable of giving an output of not less than 0·2 watts. The wave-form shall be practically sinusoidal. For purposes of test II (3) and III (3) the power output at all frequencies throughout the audible range shall be approximately constant. For the purposes of tests I (3), II (5), III (2) and III (7) the frequency should be constant at 800 p.p.s.

The frequency should not vary appreciably with the output power within the range required or with the variations of battery voltages occurring in practice.

Measuring Apparatus.

(1) The impedance of the apparatus at the sending end and at the receiving end shall be adapted to that of the circuit under test.

(2) The results of the tests shall be expressed in transmission units and the apparatus employed shall be calibrated so that the measurement can be read directly in these units.

(3) The artificial cables and other apparatus, indicating the transmission equivalent of the line under test, should read to $b = 0{\cdot}05$ or 0·43 TU. The measuring instrument shall indicate, with sufficient accuracy, a difference of $b = 0{\cdot}05$ or 0·43 TU.

(4) The instruments for indicating the received voltage should give a visual reading.

(5) Within the range of frequency 700 p.p.s. to 1,100 p.p.s. the apparatus should be capable of reading transmission equivalents with an accuracy of $b = \pm 0{\cdot}05$ or $\pm 0{\cdot}43$ TU (see also test II (6) on this subject).

Within the ranges of frequency 300 to 700 p.p.s. and 1,100 to 2,400 p.p.s. the apparatus should be capable of reading transmission equivalents with an accuracy of $b = \pm 0{\cdot}2$ or $1{\cdot}7$ TU.

(6) The apparatus should be capable of measuring transmission equivalents over a range $b = 0$ to $b = 5$ or $43{\cdot}4$ TU (see also test No. II (6) in this connection).

(7) For international circuits which contain not more than two telephone repeaters and which are not intended to be connected to other circuits which contain repeaters, measuring apparatus may be used, employing listening devices for comparative measurements, the accuracy of which may be in the order of $b = 0{\cdot}1$ or $0{\cdot}87$ TU.

II (5). End-to-end Transmission Test between successive Repeater Stations and between Terminal Stations and adjacent Stations.

The object of this test is to check the transmission efficiency of the circuit between adjacent repeater stations and between the terminal stations and adjacent repeater stations.

A routine test should be made on each circuit yearly in order to check any change in the transmission efficiency of the circuit, due, for example, to changes in the inductance of loading coils. The test may also be made in cases of faint speech, which may be due to faults on the circuit.

The test is made in the same way and with the same apparatus as in the case of test No. 1 (3).

III (2). Repeater Gain Test at Single Frequency.

The object of this test is to check the performance of the telephone repeaters with the gain-regulating adjustment in its working position. If the gain indicated is below the specified value, the valve rejection test (No. III (4)) should be applied.

The test is ordinarily applied weekly and also in localising faults which may be due to failure of a repeater.

The apparatus used for this test is similar in principle to that in the two previous tests, Nos. I (3) and II (5), with the exception that the circuit under test consists of two sections of artificial cable with the repeater connected between them. The characteristic impedance of the artificial cable should be equal to the impedance of the telephone repeater and equal to that of the balancing networks connected to the repeater. Since both ends of the circuit are available, a direct comparison between the sent and received voltages can be made.

III (3). Repeater Gain Test over a Range of Frequencies.

The object of this test is to determine the frequency-amplification characteristic of the repeater.

The test is made by measuring the improvement given by the repeater with the normal adjustment of the amplification-regulating device at frequencies throughout and slightly beyond the efficient range of the repeater. Measurements should be made at frequencies differing by not more than 200 periods per second.

The method of making each measurement is the same as in the case of test No. III (2).

The input should be kept constant at all frequencies.

Test III (7). Repeater Calibration Test.

The object of this test is to ascertain the improvement given by the repeater at a definite frequency in each position of the amplification-regulating device.

In addition to ensuring that the repeater is in an efficient state, the results obtained in this test are used in interpreting the " singing point " tests.

The method of making each measurement is the same as in the case of test No. III (2), the input being kept constant as regards amplitude and frequency for all measurements.

No. II (6). Transmission Level Test.

The object of this test is to ensure that all repeaters in circuit are functioning correctly and that the attenuation due to the circuit or to apparatus connected in circuit is normal. The test also ensures that the transmission levels throughout the circuit fall within the specified maximum and minimum limits.

The results of the routine tests are recorded and form a record showing what transmission levels should be obtained when the circuit is in normal working order.

In addition to the routine measurements, test No. II (6) is also used to localise the position of the fault when the overall transmission measurement (No. I (3)) has indicated that the transmission efficiency of a circuit is below normal.

The apparatus should conform to the requirements given above and, in addition, the impedance of the instrument bridged across the line should not be less than 100,000 ohms at 800 periods per second.

I (4). Over-all Signalling Test.

This test should be made daily by the operators to ascertain whether calling signals in both directions are received correctly.

The test is made by operating the cord-circuit ringing key in the normal way.

I (5). Over-all Speech Test.

This test should be made daily by the operators immediately following the ringing test. The operators should ascertain by exchanging a few words over the circuit whether it is in good condition for commercial work, especially as regards volume of speech and freedom from noise.

II (3). Line Impedance Measurements.

This test consists in measuring the impedance of the line at frequencies throughout the efficient range of the repeaters. The object of the test is to ascertain whether any change has taken place in the impedance of the circuit which would affect the accuracy of the duplex balance or produce reflections.

The impedances may be measured by means of any of the recognised alternating current methods.

The distant end of the circuit should be closed by an impedance approximately equal to the characteristic impedance of the circuit. The measurements should be made both with and without the line transformers actually in use on the circuit. Measurements should be made at intervals of approximately 40 periods per second. The voltage across the sending end of the circuit should be approximately 2 volts.

The results of the tests should be expressed as the resistance and reactance (+ or —) components of the impedance at each frequency. Each component should be expressed in ohms.

II (4). Singing Point of a Circuit.

The object of this test is to ascertain that no appreciable variation has taken place between the circuit and its balance.

The test may be carried out either with the repeater normally working in the circuit, or by means of a specially adapted repeater unit. The latter method is the more accurate and should be adopted whenever the importance of the equipment warrants its use.

To make the test a request should be first made to the stations in both the East and West directions to close the circuit to be tested by an impedance approximately that of the circuit. At terminal stations this should be done by means of a rheostat of the required value, unless a special impedance is provided. Where the termination is made at a repeater station a repeater unit, in normal operating condition but with the gain regulating device set at zero gain, shall be used.

Should it be desired to test the singing point on the direction East, a short-circuiting plug should be inserted in the West repeater balance jack. This converts the differential transformer in the direction West to an intervalve transformer, and the unit gives the improvement of a two-way 2-valve repeater. The two potentiometers should be raised together until "singing" is heard when listening on the monitoring circuit, and then reduced alternately step by step until singing ceases. The test should be then repeated with the positions of the short circuiting and open circuit plugs interchanged.

The singing point should be then taken as the sum of the gains represented by the positions of the potentiometers in whichever of the two tests gives the lower value. An allowance of $b = 0 \cdot 7$ or 6 TU should be added, due to the increased efficiency of the West transformer, acting as an intervalve instead of a differential one.

The gains, represented by the sum of the potentiometer readings, should be taken from the records of test III (7), giving the calibration of the repeaters.

In those cases where a specially prepared repeater unit is provided, a key is substituted for the plugs, but otherwise the method of test is exactly similar.

A second method, hereinafter described, may be used to determine the maximum gain which a repeater may give without "singing."

The circuit in one direction and its balancing network are connected to the repeater in the normal way. The circuit in the opposite direction and its balancing network are replaced by two resistances, one of a fixed value (1,000 ohms) and the other by a variable resistance R. The gain of the two repeater elements are raised to their maximum value. The value of the resistance R is then decreased until "singing" occurs. The limiting value of the relation $R/1{,}000$, obtained in this manner, is a definite function of the maximum permissible gain. For this reason it is possible to calibrate the variable resistance R directly in terms of b or TU.

A record should be made of the result of these tests when the circuit is first formed and the variation from these figures on subsequent tests should not exceed $b = 0 \cdot 2$ or $1 \cdot 7$ TU.

In the event of this figure being exceeded an impedance test should be made of the circuit and the balancing network.

III (1). Check of Battery Voltages and Currents.

The object of these tests is to ensure that the battery voltages are maintained within such limits that the repeater gains do not vary beyond the allowable limits.

III (4). Valve Rejection Test.

The object of this test is to ascertain whether a fault in a telephone repeater, indicated by the measurement of repeater gain, is due to a change in the characteristics of the valve.

A suitable voltage is applied to the incoming terminals of the repeater—the voltage being determined in each case in accordance with the type of repeater and valve employed. The battery potentials on the plates and filament are then given their maximum permissible values and verification is made as to whether the degree of gain corresponding to the desired value (also specified in advance for each type of apparatus) and as to whether any apparent variation of the continuous current of the plate circuit occurs, *i.e.*, whether any such variation is detected. When these conditions are not fulfilled the valve should be rejected.

III (7). Determination of the Singing Point of Telephone Repeaters.

This test is to ensure that the balance of the repeater unit is maintained.

The test is made in a similar manner to test II (4), except that balanced non-reactive resistances are substituted for the circuit and for the balancing network respectively. The repeater should not "sing" when the gain-adjusting device on each half of the repeater is set at full gain.

IV. Miscellaneous Tests (made as required).

(1) **Definition and Measurements of Crosstalk.**

The crosstalk between two circuits is defined by comparing the impedance network and the connections which join the incoming terminals of the disturbing circuit to the outgoing terminals of the disturbed circuit with an heterogeneous transmission line having the same output of energy and characteristic terminal impedances Z1 Z2, equal respectively to the real impedance of the disturbing circuit, regarded from the side of its incoming terminals and to that of the disturbing circuit, regarded from the side of its outgoing terminals.

The intensity of crosstalk corresponding to a given frequency is measured by the co-efficient of attenuation b or the corresponding exponent, e^{-b}, of this equivalent line.

In the particular case where the two terminal impedances Z_1 and Z_2 are equal to one another as well as the impedance R, to which the disturbed circuit is looped, the fractional number e^{-b} is equal to the ratio of the intensity coming from the disturbed circuit to the intensity given to the disturbing circuit.

The measurement of the crosstalk is then reduced to a direct measure of this ratio.

When these conditions have not been satisfied, the true value of the cross-talk is deduced from the direct measure $\frac{i}{I}$, or of that of the ratio of i to the applied voltage U, by one or other of the formulæ :—

$$e^{-b} = \frac{i}{I} \cdot \frac{R + Z_2}{2} \cdot \frac{1}{\sqrt{Z_1 Z_2}} = \frac{i}{U} \cdot \frac{R + Z_2}{2} \sqrt{\frac{Z_1}{Z_2}}$$

When the measurement, properly so called, is being carried out, the ends of the disturbing and disturbed circuits, other than those used for supplying current and for listening, will be closed with the corresponding characteristic impedance. Current will be supplied by the same generator to the disturbing circuit, and a potentiometer, artificial line or any other apparatus which enables us to attenuate the alternating energy within known proportions. (The latter may be joined up in series or in parallel with the line or substituted for the latter.)

The same telephone receiver will be successively shunted across the end of the disturbed circuit and that of the apparatus in question, which will be adjusted to give equality of sound, and consequently of current, in the two listening positions. The value of the ratio $\frac{i}{I}$ in the series arrangement, or of the ratio $\frac{i}{U}$ in the parallel arrangement, will be obtained from the adjustment of the attenuating apparatus and in all cases will permit e^{-b} to be calculated.

It may be convenient, finally, to adapt the impedances Z_1, Z_2, and R to one another by means of suitable transformers, so long as the latter have a sufficiently high output and are sufficiently well balanced so as not to modify the results of the measurement.

When voice tests are made, the same operating methods and correcting formulæ as those indicated above may be allowed; the value of the crosstalk will be deduced from the readings shown by the apparatus in the same manner as if equality of sound had been obtained by unaffected (pure) sound. The elements which enter into the measurement and which are adapted to this purpose will then be adjusted to values corresponding to a frequency of 800 periods per second.

(2) **Noise Measurement on Telephone Circuits.**

The object of this test is to obtain a measurement in some definite units of the amount of disturbance on a telephone circuit. The C.C.I. considers it desirable to postpone the choice of the method of making these measurements until further experimental work has yielded more definite results.

Three methods have been considered :—

(*a*) Comparison of the sound produced by the disturbance with a standard source of sound attenuated by a known amount.

(*b*) Measurement of the voltage produced by that portion of the disturbance falling within the audible frequency range.

(*c*) Measurement of the reduction in intelligibility due to the disturbance.

Note.—The International Consultative Committee recommends that the periodic measurements of transmission losses and transmission levels should be carried out in accordance with the following rules :—

I. Transmission Losses or Gains.

(*a*) For reasons of practical convenience, and to give in general the same sense to the corrections which it will be necessary to apply to measured results for an accurate theoretical interpretation, the measurements shall be made with the two ends of the line terminated with a fixed impedance of 600 ohms.

(*b*) The measurements will comprise in all cases the line repeating coils.

(*c*) The measurements should be made in such a manner that the sending apparatus connected to the line terminals shall be equivalent to the generator having an internal impedance equal to 600 ohms and developing a power of 1 milliwatt into an external resistance of 600 ohms.

(*d*) The apparatus shall be arranged in such a manner that the result of the measurement shall be expressed in terms of the exact theoretical attenuation in the case in which the line under test is homogeneous and has a characteristic impedance equal to 600 ohms.

If the measuring apparatus complies with the conditions indicated above, it shall indicate directly transmission losses or gains.

(*e*) The maintenance data will be expressed directly in transmission losses or gains.

2. Transmission Levels.

The object of these measurements is the determination of transmission power levels. These levels are fixed on the establishment of the circuits, the zero level corresponding to the power of 1 milliwatt.

For practical measurements the voltage transmission levels which correspond to the power transmission levels are determined beforehand, account being taken for each repeater station of the impedances in the two directions.

The voltage transmission level is determined by the ratio of the voltage measured to the voltage at the terminals of a resistance of 600 ohms, absorbing a power of 1 milliwatt.

The measuring instruments should be constructed in such a manner that they indicate directly the voltage level expressed in attenuation units.

To deduce the power level from the voltage level, it is necessary to add to the latter one-half of the logarithm of $\frac{Zn}{600}$ if Zn indicates the impedance at the point considered regarded in the direction of the transmission.

The values of voltage level corresponding with normal measured conditions at both sides of each repeater are indicated once for all at each repeater station. The reports normally supplied to the headquarters station will comprise only the measurements made at the outputs of the repeater stations. In case of trouble, each repeater station will measure the two voltage levels and will make them known to the headquarters station.

While measurements are in progress in one direction on a circuit the amplification in the other direction will be suppressed if necessary, without the impedances being altered in the direction in which the measurements are made.

Function and Duties of the Control Station (" *Station directrice* ").

The International Consultative Committee—

Considering :—

That, in so far as the maintenance of international circuits is concerned, it will be necessary to work out a complete system of tests which will permit of the rapid localisation of faults, and for the adjustment of questions of detail relating to each group of circuits.

That, independently of this, general rules may also be recommended to serve as a basis for such systems of tests.

Unanimously advises :—

That one of the terminal stations of each group of circuits, termed the " Control Station " (" *Station directrice* ") for that group of circuits, in accordance with agreements arrived at between the Administrations interested, shall be entrusted with maintenance control. This station will be responsible for the following matters :—

(1) Drafting of a programme of tests in conjunction with all the other stations interested.

(2) Preserving reports of these tests, and ensuring that they will be carried out in accordance with the procedure laid down.

(3) Supervision of the localisation of faults.

The Administration in whose territory lies the section of line in which the fault is found will be responsible for removing the fault. The Control Station will be informed of the cause of the fault, and of the time at which it has been removed. The Control Station will keep a record of all faults.

(4) The giving of instructions with respect to the position on the scale of the apparatus used for adjusting amplification. This adjustment will not be changed without the authority of the Control Station.

(5) The Control Station will be responsible for maintaining the normal transmission efficiency of each of the circuits, as well as the organization of a system of tests, of such a nature that the periods during which the circuit may be out of use in consequence of the tests may be reduced to a minimum.

Considering further :—

That for practical reasons it appears necessary to assign to each country the duty of directing the operations of clearing faults occurring in their territory.

Unanimously advises :—

1. That in each country and for each group of circuits one station belonging to the group of circuits considered, and known as sub-control station (" *Station sous-directrice* ") for this group of circuits, shall have charge of directing the operations of clearing the faults occurring in the country concerned; it being understood that the control station for this group of circuits preserves the duties and the responsibility outlined in the preceding advice.

2. That the various Administrations are invited to utilise standard record forms for collecting the maintenance data and the data pertaining to the supervision of the international circuits (specimens of records are shown on pages 54, 55 and 57) and give their opinion as to the results obtained.

SPECIMEN TYPICAL FORM FOR RECORDING DATA OF MAINTENANCE AND SUPERVISION ON INTERNATIONAL TELEPHONE LINES (FRONT SIDE).

Circuit No.................. A........ B........ Control Station : X...............	Sub-Control { D.... E.... F....	Attenuation at $f = 800$ p.p.s. " total { max. value .... min. value .... " resultant :	In Service since the.............

Serial No.	From.	To.	Length in Km.	Pair No.	Diameter of Wires in mm.		Characteristic Impedance and Cut-off Frequency.		Attenuation at 880 p.p.s. Max. value. Min. value.	Impedance Ratio of Rep. Coil.	Building-out Section in the First Loading Section.	Additional Line Networks.			Kind of Ringing Current. a : 25— b : 500— c : 500/25—	Remarks.
					Cable.	Aerial Line.	Z	f_0				with or without Distortion.	b	Z		
1	2	3	4	5*	6	7	8	8a	9	10	11	12	13	13a	14	15

* *Symbols to be used :* 2-wire side circuit : 21
2-wire phantom circuit : (21/22)
4-wiie side circuit : 31/32
4-wire phantom circuit : (31/32) / (35/36)

SPECIMEN TYPICAL FORM FOR RECORDING DATA OF MAINTENANCE AND SUPERVISION ON INTERNATIONAL TELEPHONE LINES (BACK SIDE).

Serial No.	Repeater Stations.	Type of Repeater (indicating the Frequency Range).	Distortion Compensator.	Repeater Impedance.	Adjusted to.	Direction A—B.						Direction B—A.						Remarks.
						Gain Value at 800 p.p.s.	Value of Transmission Level.	Step on Potentiometer.	Balancing Device.	Quality of Balance.*	Singing Point.	Gain Value at 800 p.p.s.	Value of Transmission Level.	Step on Potentiometer.	Balancing Device.	Quality of Balance.	Singing Point.	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34

* Figure indicating correctness of simulation of the actual line.

Maintenance of Circuits Used for the Relaying of Broadcast Transmission.

Maintenance Tests.

The International Consultative Committee—

Unanimously advises :—

(a) That for the maintenance of lines used for broadcast purposes similar measurements are necessary to those used for long-distance telephone traffic, *i.e.*,

(1) Periodic measurements on the cable lines themselves for verifying the condition of insulation, resistance and the attenuation of the various repeater sections.

(2) Periodic measurements of the repeaters in order to determine whether the frequency curve of amplification is satisfactory. For this purpose it is necessary to test with four frequencies within the transmission range.

(3) Periodic measurements of the line used throughout its whole length in order to determine the total transmission loss and the transmission level at the various repeater stations; for this purpose it is usually sufficient, in accordance with long-distance telephone practice, to make tests with a frequency of about 800 periods per second.

(b) That volume measurements appear to be necessary only at the input end of the line; the various Administrations are invited to ascertain what devices can best be used for these tests as outlined in Appendices C.e., No. 1 and No. 2.

Division of Responsibility between Telephone Administrations and Radio Broadcast Services (State or Private) regarding the Maintenance of Circuits used for the Relaying of Broadcast Transmissions.

The International Consultative Committee—

Unanimously advises :—

(a) That the limit of responsibility of supervision between Telephone Administrations on the one hand, and the Broadcasting Authorities on the other, should be the protectors which are inserted at the broadcasting stations in the leads to the telephone exchanges at both ends of the line.

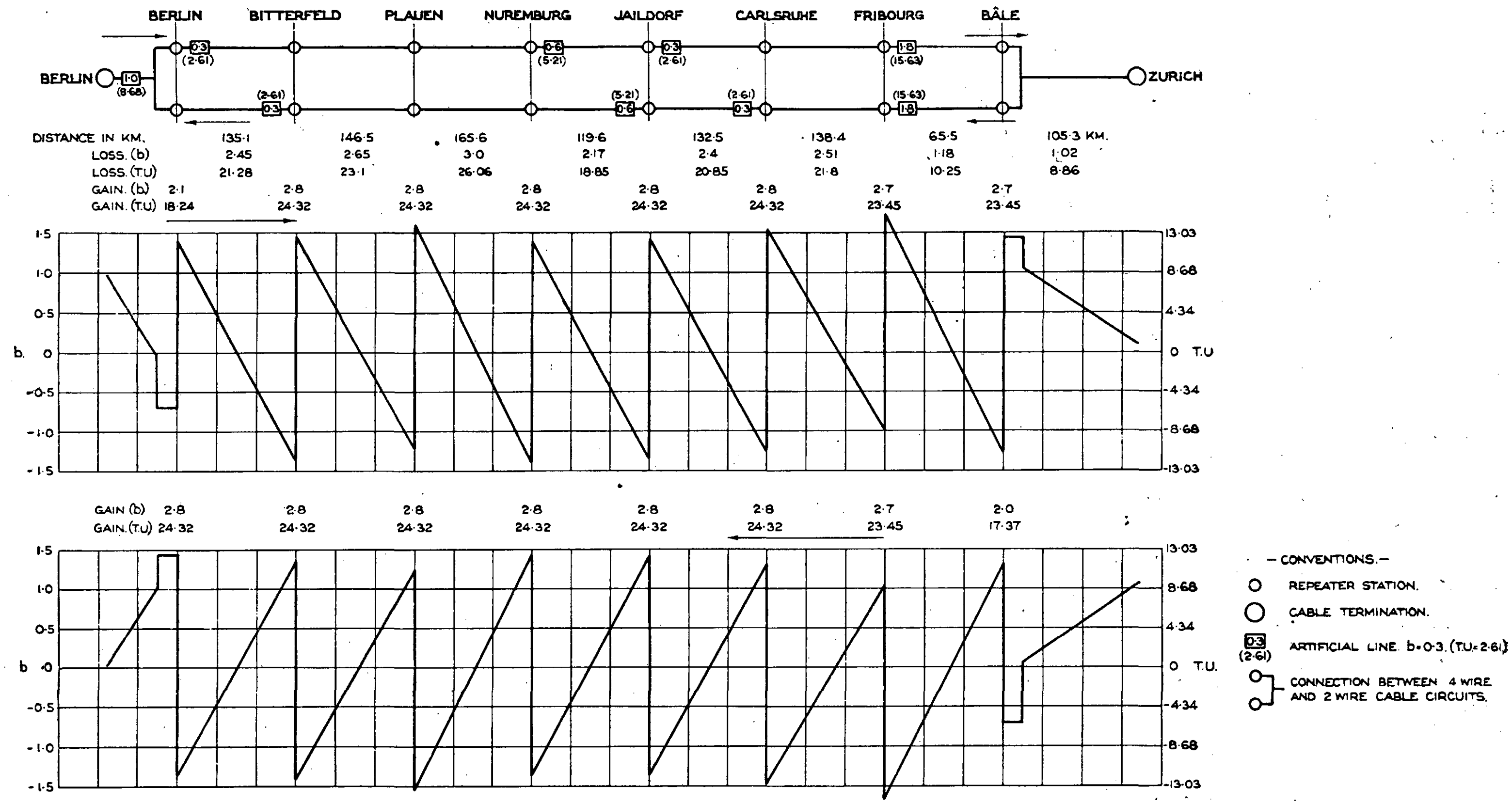
(b) That when there is a broadcasting circuit in a long-distance telephone cable, the *rôle* of the directing station should be the same as it is in ordinary telephone communication.

Technical Responsibility in Connection with the Renting of International Telephone Circuits to Broadcasting Authorities.

The International Consultative Committee—

Unanimously advises :—

That Broadcasting Authorities should be responsible for the supply of broadcasting energy at the requisite level, while the directing station of the Telephone Administration should control the transmission over the telephone circuits as in the case of ordinary telephone connections.



TRANSMISSION LEVEL DIAGRAM.
BERLIN-ZURICH CIRCUIT.
0·9% SIDE CIRCUIT.

APPENDIX TO THE QUESTIONS CONCERNING SUPERVISION AND MAINTENANCE OF INTERNATIONAL TELEPHONE LINES.

Description of Apparatus for making Transmission Measurements.

The descriptions below show a typical device of making the transmission tests referred to in the report. At the end of this description will be found circuit diagrams of special instruments used in different countries to measure the over-all transmission equivalent of a telephone circuit between test boards in the central offices.

Fig. 1 shows the general arrangement of the apparatus. An oscillator G producing currents of audible frequencies is connected through a regulating resistance P, a screened and balanced transformer T and a milliammeter A to a section of artificial Cable C_2. The functions of this cable are: (1) to make the impedance of the sending end approximately equal to that of the line; (2) to reduce the current in some convenient ratio so that the milliammeter A may measure a current larger than that entering the line under test. By this means it is possible to use a robust type of instrument for measuring the current and at the same time obtain more accurate measurements of the current entering the line under test than would be the case if the latter current were measured directly. A convenient ratio of reduction is found to be 5 to 1.

A switch S provides for the connection of the oscillator and measuring instrument to one extremity of an artificial cable C_1, or, alternatively, to one extremity of the circuit under test.

Each circuit is normally closed through a resistance Z_0, approximately equal to the characteristic impedance of the line. The voltmeter should be of the recognised thermionic valve type having an impedance high compared with that of the line. Connection is made to the line under test by means of the jacks shown.

Fig. 2 shows the method of applying this set to "Gain" measurement.

The telephone repeater R is connected between fixed sections of artificial cable. The two ends of circuit thus formed are connected by means of plugs to the "send" and "receive" jacks, respectively.

The current entering the circuit is adjusted to a suitable value. The length of the cable C_1 is adjusted until the deflection on the voltmeter is the same in either position of the switch.

The transmission equivalent of the circuit under test is then equal to the indicated length of the cable C_1.

Fig. 3 shows the application of the apparatus to over-all measurements. At the sending end the switch is left in the position shown and the current adjusted to an agreed value.

At the receiving end the line under test is connected to the "receive" jacks. The current into the artificial cable C_2 is adjusted to the same agreed value as that at the sending end. A balance is then made as before by manipulating the switch and adjusting the length of the cable C_1. The resultant length of C_1 then indicates the transmission equivalent of the circuit under test.

Fig. 4 shows the application of the apparatus to "transmission level" measurements. The sending and receiving ends are similar to Fig. 3 and the measurements are made in the same way.

At intermediate stations the line is connected to the "intermediate" jack as shown. A balance is made in the same way as at the receiving station. The indicated value of the cable C_1 then gives the "transmission level" required.

The voltage corresponding to this "transmission level" may be greater than that at the sending end. To provide for this condition cable C_1 is set at zero and the cable C_2 is made adjustable and is so calibrated that it indicates directly the transmission units (or absolute units) by which the transmission level exceeds that at the sending end of the circuit.

It will be understood from the above description that it is essential that all circuits should be brought to approximately the same impedance in order that this system of measurement should give accurate results.

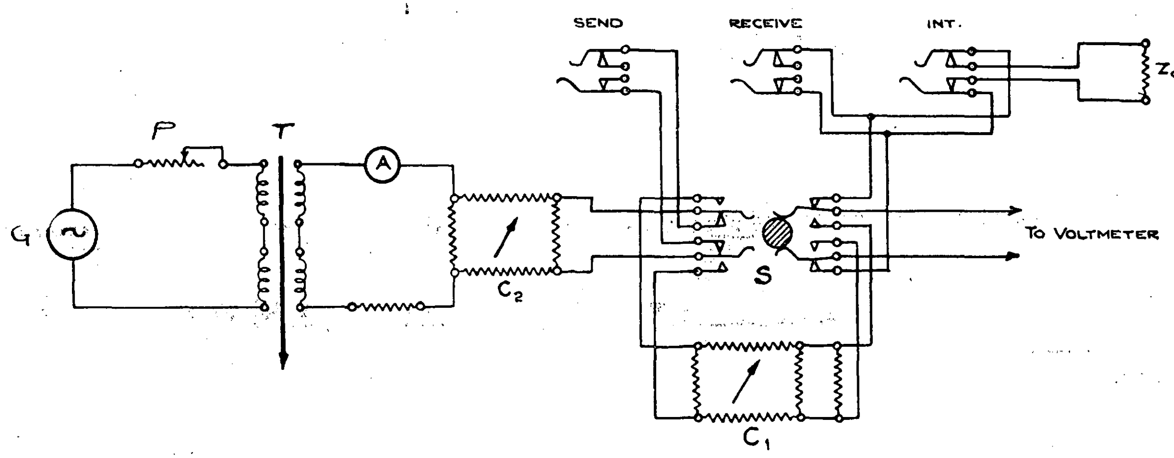


FIG. 1.

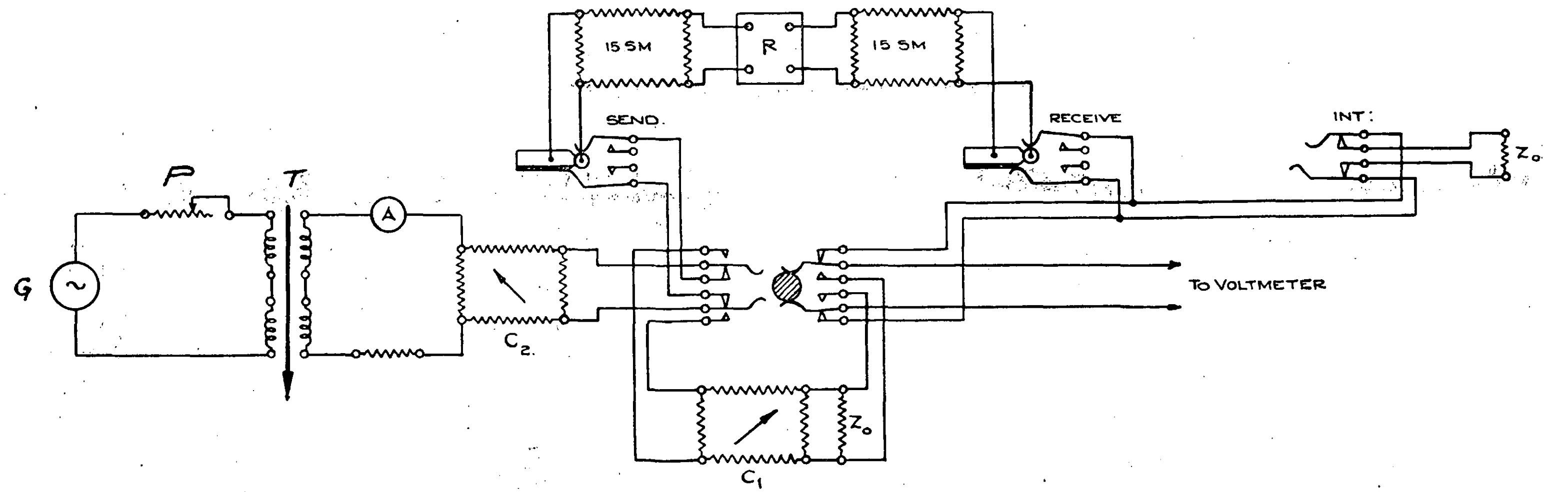


FIG. 2. GAIN MEASUREMENT.

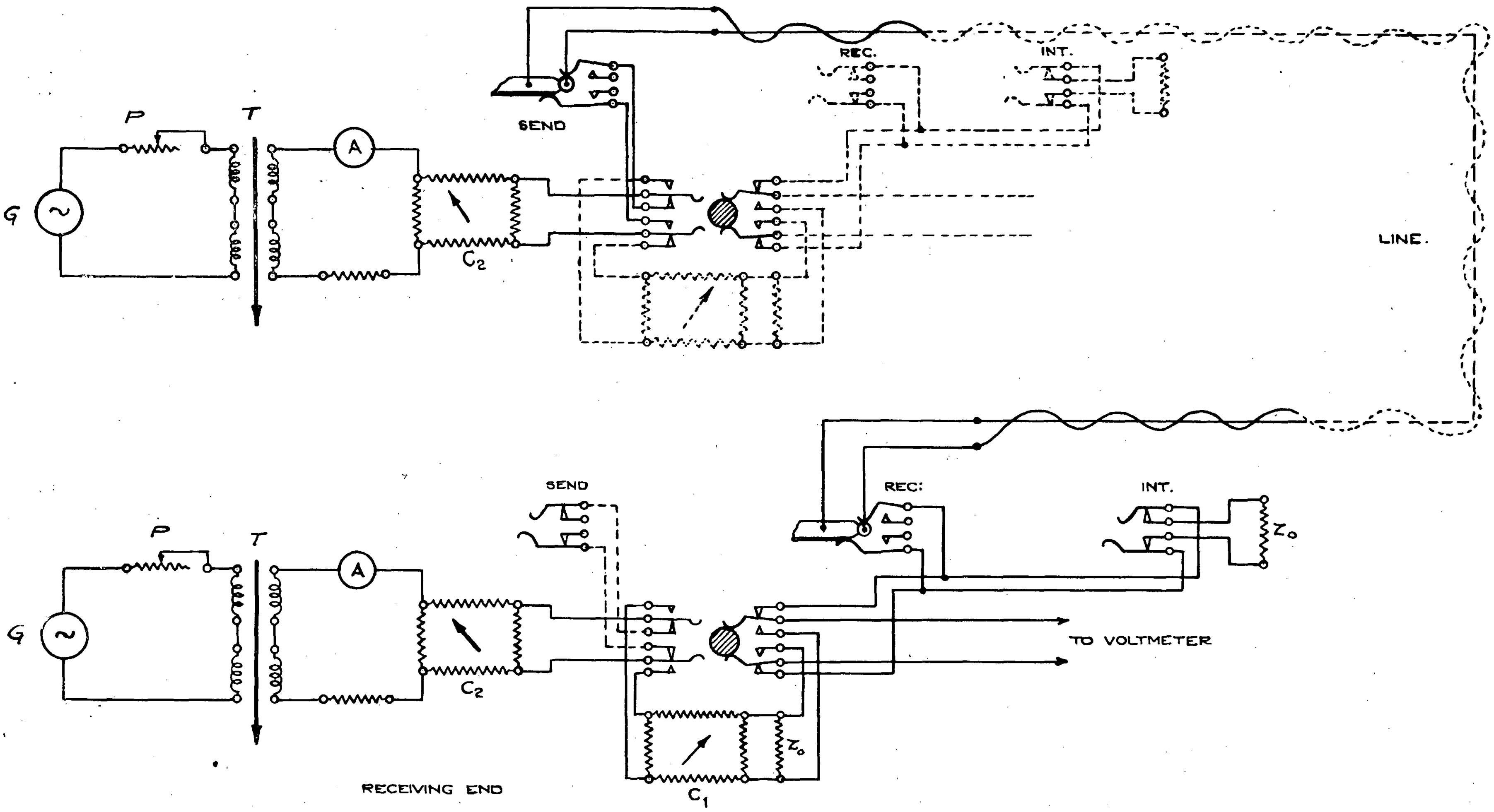


FIG. 3. OVERALL TRANSMISSION MEASUREMENT.

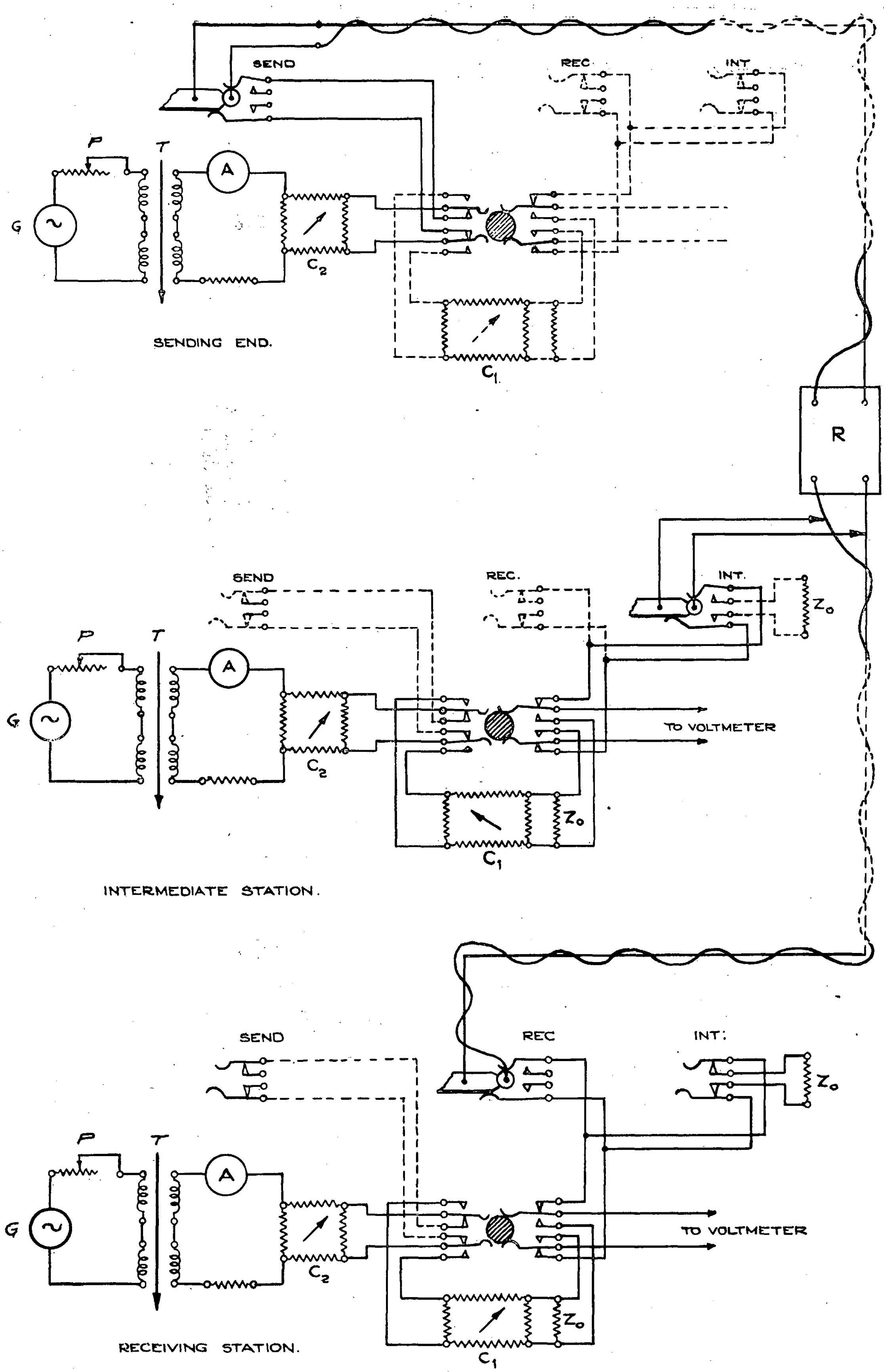
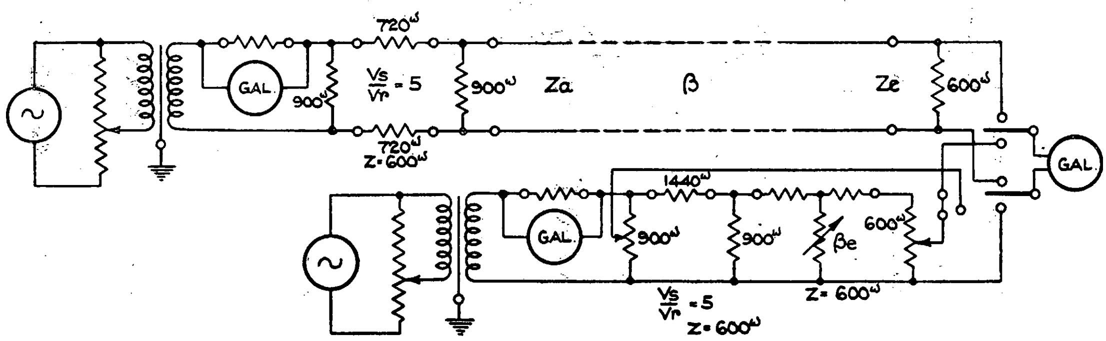


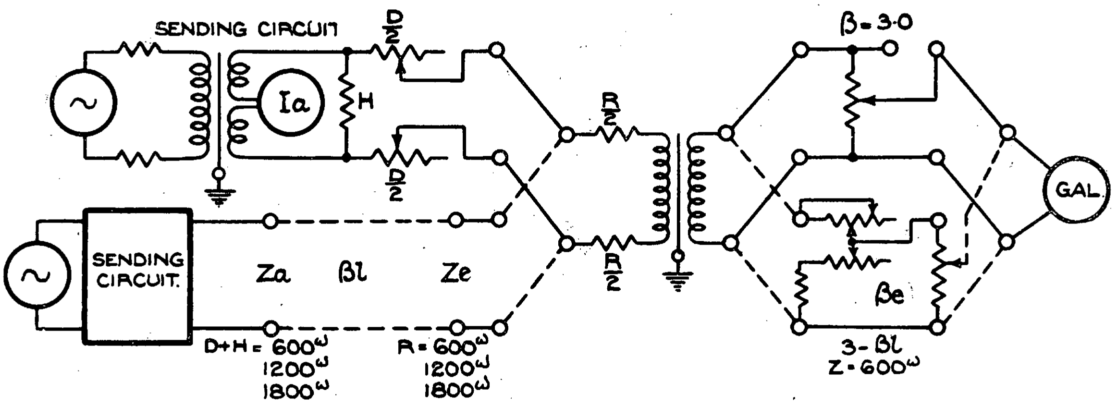
FIG. 4. TRANSMISSION LEVEL MEASUREMENT.

Various Special Instruments used for Measuring Over-all Transmission between two Offices.

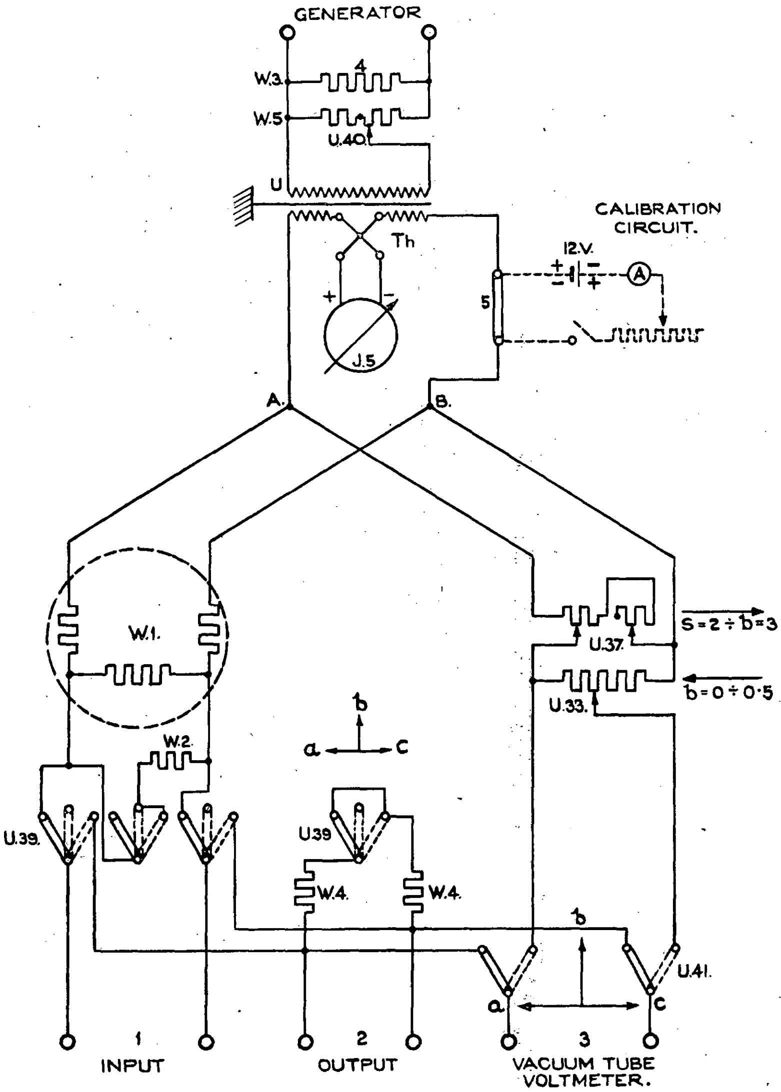
(1) *Method used by the British Post Office.*



(2) *Method used by the International Standard Electric Corporation.*



(3) *Method used by the German Administration and Messrs. Siemens & Halske.*



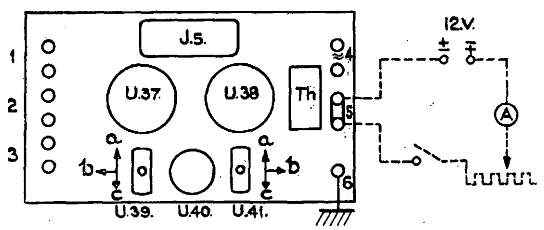


DIAGRAM OF THE LEVEL METER.

(A.f.) Co-existence of Telephone and Telegraph Circuits in the same Cable.

1. Recommendations adopted.

The International Consultative Committee—

Considering :—

That technical arrangements already exist which permit telephone and telegraph service in the same cable, either over separate conductors or even over common conductors; that with these arrangements, and by taking the precautions stated below, the telephone circuits, including phantoms, are practically not influenced by the telegraphs, either from an electrical or from a traffic standpoint.

That even when the cable is subject to influence by power systems (in particular railroads using A.C.) it is possible to obtain a telephone and telegraph service free from interference troubles, by using devices which have already proved satisfactory in practice.

That, furthermore, the simultaneous use of long-distance cables for telephony and telegraphy is recommended for economical reasons.

Unanimously advises—

That the simultaneous exploitation of international telegraph and telephone circuits in the same cables be forthwith accepted in principle, either over separate conductors or common conductors, on condition that all measures be taken to ensure that the telegraph does not interfere with present and future telephone traffic.

The particulars given in the attached Appendix (Appendix No. 1) indicate the conditions which should be satisfactory from a technical standpoint and from the standpoint of the exploitation of different types of telegraph and telephone installations, both simultaneous and co-existent.

The Administrations are invited to undertake experiments to verify the numerical data given in this Appendix, which should not prejudice future developments. These data have been given by certain experts and must necessarily be confirmed.

2. Recommendations Regarding Voice-Frequency Telegraphy.

The International Consultative Committee—

Considering :—

That in cables the use of carrier frequencies (voice frequency carrier telegraphy) instead of separate conductors is strongly to be recommended.

That it will be desirable to employ standardised carrier frequencies for voice-frequency carrier telegraphy.

That a proposition on this subject has been presented to the Committee.

That, nevertheless, it has not been possible to determine the influence of all the considerations involved.

Unanimously advises :—

That the *rapporteurs* who have been nominated to examine the co-existence question, and who have already studied the frequency problem, shall continue the examination of the proposition which has been submitted on this subject (*see* Appendix 2: Proposal for the selection of carrier telegraph frequencies) and report at the next meeting of the C.C.I.

That in order to arrange the frequencies in such a manner as to obtain the greatest traffic-carrying capacity from the circuits, either with existing apparatus or a standard apparatus which may eventually be developed, these *rapporteurs* shall keep in touch with the work of the *rapporteurs* of the C.C.I. dealing with the question of standardisation of apparatus.

APPENDIX 1.

CONDITIONS WHICH SHOULD SATISFY THE PRESENT TECHNIQUE REGARDING SIMULTANEOUS, OR CO-EXISTENT, TELEGRAPH AND TELEPHONE INSTALLATIONS.*

I. Simultaneous Telegraphy and Telephony (over the same Conductors) or Infra-Acoustic Telegraphy.

In order not to prejudice the transmission quality of telephone circuits the following requirements must be met :—

1. The E.M.F. produced in the line circuit by the telegraph transmitter must not exceed 50 volts.

2. When the terminals of the telegraph transmitter are closed through a resistance of 30 ohms substituted for the line, the current through this resistance must not exceed 50 m.a.

3. The increase in the attenuation of the telephone line due to infra-acoustic telegraph installations must not exceed $b = 0{\cdot}06$ or $0{\cdot}5$ TU for a line section having the length of the section between two successive repeaters, and over the frequency range of 300 p.p.s. and the maximum frequency transmitted.

4. Over 4-wire circuits the variation of line impedance produced by infra-acoustic telegraphs must not exceed 10 per cent. in the frequency range indicated. As regards 2-wire circuits, infra-acoustic telegraph installations must not exceed the values prescribed by the Telephone C.C.I. for the exact simulation of the impedance of the line by balancing networks.

5. Interference noise produced in telephone circuits by telegraph apparatus must not exceed a value which corresponds to an interference voltage of $0{\cdot}1$ mv for a transmission level $b = -1{\cdot}0$ or $-8{\cdot}7$ TU and an impedance of 800 ohms.

6. The increase in crosstalk produced by infra-acoustic telegraph installations shall be determined as follows :—

The cable quads are replaced by artificial lines free from crosstalk and reproducing, within the closest possible limits, the impedances of the circuits (terminal apparatus for quads). Under these conditions the attenuation corresponding to the crosstalk measured from the telephone office side must not be inferior to the following values :—

a. For 4-wire circuits : $b = 7{\cdot}5$ or 65 TU for the crosstalk between any two speech circuits in the same quad.

b. For 2-wire circuits : $b = 8{\cdot}5$ or 74 TU for the crosstalk between any two speech circuits in the same quad.

c. For 4-wire and 2-wire circuits : $b = 10{\cdot}0$ or 87 TU for the crosstalk between two speech circuits in different quads.

7. For international telephone communications the total length of circuit sections employed simultaneously for infra-acoustic telegraphy must not exceed 450 km.

8. After infra-acoustic telegraph systems are connected into a circuit the unbalance to earth must not exceed the value prescribed by the C.C.I.

II. Co-existent Telegraphy and Telephony (over separate Conductors).

1. Where the telegraph uses loaded conductors which may later be used for telephony :—

The conditions stated under heading I., Nos. 1, 2 and 5, must be fulfilled.

2. Where the telegraph uses non-loaded conductors :—

Paragraph 5 of heading I. need only be fulfilled.

* Various systems of infra-acoustic telegraphy and voice frequency telegraphy, used by different Administrations, are described in Appendices C.f., Nos. 1, 2, 3, 4 and 5.

III. Voice-Frequency Telegraphy.

The sum of the effective voltages corresponding to the frequencies used simultaneously on the same circuit, should be less than 2 volts, and the sum of the effective currents corresponding to the frequencies used simultaneously on the same circuit, should be less than 2 m.a.

When it is required to use currents or voltages greater than the above values, it is desirable, for preference, to choose the circuits allotted to telegraph purposes in the outer layers of the cable and to balance them in separate groups.

The Committee has received the attached proposal (Appendix 2), which is to be further studied : " Proposal for the selection of Carrier Telegraph Frequencies to be used in Loaded Telephone Cables."

APPENDIX 2.

PROPOSAL FOR THE SELECTION OF CARRIER TELEGRAPH FREQUENCIES TO BE USED IN LOADED TELEPHONE CABLES.

It is desirable that the various countries should agree as to the exact frequency values to be employed in Voice Frequency carrier current telegraphy, particularly for loaded telephone cable circuits. With reference to telegraph apparatus, it is necessary to consider first of all Start-Stop apparatus, Siemens high-speed telegraphs and Multiplex systems.

Taking as a basis an output of 480 letters per minute for Start-Stop apparatus and 1,500 per minute for multiplex apparatus, there results for the two cases a dot frequency of 56 and 125 cycles per second. To transmit this, a filter frequency band of 65 and 150 cycles per second is required. Such a transmission band is also adequate for the operation of the Siemens high-speed telegraph system.

For medium-heavy loaded cables a frequency band is available between 300 and 1,800 cycles per second. When a distance of at least 50 cycles per second between the cut-off frequencies of adjacent filters is prescribed, it is possible to operate 12 Start-Stop systems, or Siemens high-speed telegraph, and six Multiplex systems within this interval.

Regarding the distribution of carrier frequencies it is necessary to take care, on the one hand, that the carrier frequencies should be odd multiples of a single fundamental frequency, so that interference oscillations which may occur should not be included in any of the channel frequency bands, and, on the other hand, that the carrier frequencies for simplex and multiplex apparatus coincide, thus allowing the same source of current to be used for both systems.

These requirements will best be met by starting from the fundamental frequency;

60, for simple transmission apparatus (Start-Stop or Siemens high-speed);

and

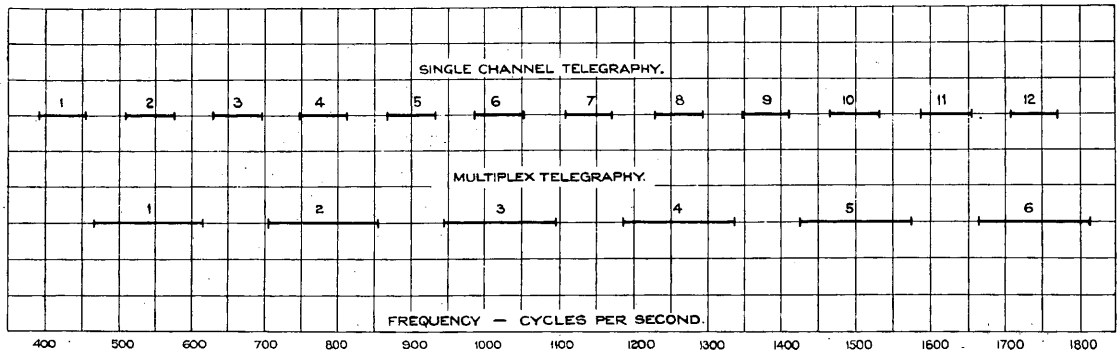
113, for the multiplex apparatus.

Then the following odd multiples are obtained :—

Table 1.

Simplex Apparatus.	Multiplex Apparatus.	Per cent. difference of frequencies.
420 p.p.s. 540	565 p.p.s.	5 per cent.
660 780	791	1·3 ,,
900 1,020	1,017	0·3 ,,
1,140 1,260	1,243	2 ,,
1,380 1,500	1,469	2 ,,
1,620 1,740	1,695	2·6 ,,

Applying in place of the carrier frequencies indicated on the second line those indicated on the first line, we obtain a maximum variation of 5 per cent., the interference oscillations being in this case sufficiently remote from the carrier frequencies of the different filters. It is thus expedient to select the transmission bands indicated in Fig. 1 and in Table 2.



PROPOSED ALLOCATION OF CARRIER FREQUENCIES FOR SINGLE CHANNEL AND MULTIPLEX TELEGRAPHY IN MEDIUM HEAVY LOADED CABLES.

FIG. 1.

Table 2.

Simplex Apparatus.			Multiplex Apparatus.		
Freq. No.	Carrier frequency cycles per second.	Frequency band cycles per second.	Freq. No.	Carrier frequency cycles per second.	Frequency band cycles per second.
1	420	387·5– 452·5			
2	540	507·5– 572·5	1	540	465– 615
3	660	627·5– 692·5			
4	780	747·5– 812·5	2	780	705– 855
5	900	867·5– 932·5			
6	1,020	987·5–1,052·5	3	1,020	945–1,095
7	1,140	1,107·5–1,172·5			
8	1,260	1,227·5–1,292·5	4	1,260	1,185–1,335
9	1,380	1,347·5–1,412·5			
10	1,500	1,467·5–1,532·5	5	1,500	1,425–1,575
11	1,620	1,587·5–1,652·4			
12	1,740	1,707·5–1,772–5	6	1,740	1,665–1,815

Carrier frequency band for the simplex and multiplex apparatus.

The same method could be adopted for circuits with extra-light loading.

For the reason that the duration of propagation of the frequencies appropriated to the transmission is more or less long, the transient period exceeds the duration imposed by the filter frequency band. The differences in duration of propagation of frequencies included in a band are increased in proportion as the carrier frequencies approximate to the cut-off frequencies of the circuits and as the filter bands are widened. The range of the different carrier frequencies is therefore limited. If an extension of 10 per cent. of the transient periods is allowed, the duration of which depends on the width of the filter band, the theoretical ranges indicated in Table 3 result for cables with medium-heavy loading.

Table 3.

Simplex Apparatus. Start-Stop Apparatus.				Multiplex Apparatus.		
Freq. No.	Range Km.	Number of letters/min. for the range indicated.	Siemens High-Speed Telegraph.	Freq. No.	Range Km.	No. of letters per/min.
1–4	10,000	1,920	2,640	1	1,900	1,500
				1–2	1,500	3,000
				1–3	800	4,500
				1–4	500	6,000
1–5	6,500	2,400	2,300	1–5	500	7,500
1–6	5,000	2,880	3,960	1–6	300	9,000
1–7	4,200	3,360	4,620			
1–8	3,500	3,840	5,280			
1–9	3,000	4,320	5,940			
1–10	2,300	4,800	6,600			
1–11	1,900	5,280	7,260			
1–12	1,500	5,760	7,920			

Range for circuits in cables with medium-heavy loading.

For distances exceeding 300 km. the best operation of the circuit is obtained if multiple apparatus and simplex apparatus are used simultaneously. For different distances the most favourable operating conditions will therefore be those indicated below :—

Length of line. Km.	Multiplex Apparatus Frequencies. No.	Simplex Start-Stop Apparatus Frequencies. No.	Total number of letters transmitted per min.	Multiplex Apparatus Frequencies. No.	Siemens High-Speed Telegraphy.	Total number of letters transmitted per min.
200	1–6	—	9,000	1–6	—	9,000
300– 400	1–5	12	7,980	1–5	12	8,160
400– 500	1–4	10–12	7,440	1–4	10–12	7,980
500– 800	1–3	8–12	6,900	—	1–12	7,920
800–1,500	1 and 2	6–12	6,360	—	1–12	7,920
1,500–1,900	1	4–11	5,340	—	1–11	7,260
1,900–2,300	—	1–10	4,800	—	1–10	6,600
2,300–3,000	—	1–9	4,320	—	1–9	5,940
3,000–3,500	—	1–8	3,840	—	1–8	5,280
3,500–4,200	—	1–7	3,360	—	1–7	4,620
4,200–5,000	—	1–6	2,880	—	1–6	3,960
5,000–6,500	—	1–5	2,400	—	1–5	3,300
6,500–10,000	—	1–4	1,920	—	1–4	2,640

For cables with extra-light loading there is available the band included between 300 cycles per second and 2,500 cycles per second. Within this band it is possible to operate with the fundamental frequency of 60 cycles per second :

9 multiplex circuits

or

18 single channel circuits.

Under the same conditions as those outlined above, for the single channel apparatus there will be, generally, theoretical ranges of more than 10,000 km.

For multiplex apparatus, table 4 indicates the range over extra-light loaded circuits:

Table 4.

Frequency No.	Frequency cycles per sec.	Range Km.
1	540	2,200
2	780	5,000
3	1,020	5,900
4	1,260	5,300
5	1,500	4,400
6	1,740	3,400
7	1,980	3,500
8	2,220	2,000
9	2,460	1,800

Range of the multiplex apparatus in cable circuits with extra-light loading.

As is known, it is possible to compensate, to a certain extent, the difference in the duration of propagation of different frequencies.

Using for this object the same networks as those used in telephony, it is possible to obtain the following ranges:

Table 5.

Frequency No.	Simplex Apparatus.	Frequency No.	Multiplex Apparatus.
1	8,000	1	8,000
2–12	10,000	2	8,000
		3	5,000
		4	2,000
		5	3,000
		6	5,000

Range in cable circuits with phase balancing.

The most favourable distribution resulting from this is indicated below:

Length of line. Km.	Simplex Apparatus. Freq. No.	Multiplex Apparatus Freq. No.	Total number of letters transmitted per minute.	
			Start-Stop Apparatus.	Siemens High-Speed Telegraphs and Multiplex Apparatus.
2,000		1–6	9,000	9,000
2,000–3,000	8	1–3, 5, 6	7,980	8,160
3,000–5,000	8–10	1–3 6	6,840	7,980
5,000–8,000	6–12	1 and 2	6,360	7,920
8,000	2–12	—	5,280	7,260

Summary.—It is proposed to employ Voice-frequency carrier operation for international traffic on loaded cables, and a study is being made to determine what output it is possible to obtain from the circuits with Start-Stop apparatus, Siemens high-speed telegraphs, and Multiplex apparatus. The frequencies proposed can be very well adapted to all practical requirements.

B. ESSENTIAL CLAUSES OF TYPICAL SPECIFICATIONS.

The International Consultative Committee considers that the efficiency of a long distance cable (containing several repeaters) depends to a large extent on questions of details of construction and of the general arrangement of the system.

The International Consultative Committee proposes to recommend to an Administration which would prefer to leave the proposal for a complete cable, including several repeaters, in the hands of the Contractor, instead of having a service of specialised engineers and of assuming the responsibility which would result from the acceptance of the various portions of the system, separately, to discuss matters in detail with the Contractor, in order to obtain necessary information with regard to the lay-out, general arrangements, etc., and to demand all the guarantees desired in order that the conditions specified in the partial specifications, appended, shall be duly fulfilled. At the outset, this Administration should give the Contractor information in respect to the circuits which will be necessary and with respect to the probable traffic.

Certain Administrations show, in their proposals respecting specifications for underground cables, details with respect to methods of constructions, laying, etc. These are not included in the typical specifications dealt with in Appendices B., because the C.C.I. is of opinion that it is preferable to give a free hand to the various Administrations in respect to the choice of their methods relating to everything that concerns construction and laying of the cables, subject to the condition that the circuits established will satisfy the conditions imposed by the appropriate specifications.

It is specified in Appendix B.d.2 No. 1 that when the processes of manufacture do not admit of realising, with sufficient approximation, equality of the capacities of the various loading sections included between two successive telephone repeaters, this equality might be obtained as perfectly as possible by suitably distributing factory lengths amongst these loading sections.

Precise rules have been specified in Appendix B.d.2. No. 5 in respect to the spacing of loading coils in cables. If, in consequence of local circumstances, a regular spacing of these loading coils cannot be observed, the special arrangements adopted in this case should be such that the result shall not be detrimental.

Some Administrations prefer, in carrying out tests of dielectric strength of the cables in the factory, to apply the testing voltage for two (2) minutes instead of two (2) seconds specified in Appendix B.d.2 No. 1. The C.C.I. does not see any objection to this method of procedure.

The rules and specifications will be found in the following Appendices: B.c.4 Nos. 1 and 2, B.d.2 Nos. 1, 2, 3, 4 and 5.

APPENDIX B.c.4 No. 1.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR THE SUPPLY OF TWO-WIRE TELEPHONE REPEATERS.

General.

This Specification covers the most important electrical requirements concerning the essential qualities of repeater units as supplied by the factory. It does not cover the requirements for installed repeaters.

Type.

It shall be a two valve vacuum tube repeater, associated with balancing networks. It shall give two-way amplified transmission without introducing appreciable distortion for all frequencies within the efficient speech-range of the cable circuits and for the maximum inputs occurring in practice.

Balance.

The telephone repeater shall not "sing," *i.e.*, it shall not generate oscillations which cause "singing" at maximum gain, when the circuit and network terminals on either side are closed through non-reactive resistances equal to the input impedance specified for the repeater, whilst the circuit and network terminals on the other side are open and short circuited, respectively, or vice versa.

Gain.

Means shall be provided for regulating the gain of the telephone repeater, preferably by steps not exceeding $b = 0{\cdot}2$ or $1{\cdot}7$ TU.

Within the efficient speech range of the cable the repeater gain shall be approximately uniform for all gain settings.

The repeater circuit and apparatus shall be so designed, that the variations of power voltage and current occurring under normal maintenance conditions shall not cause an average variation from the working gain greater than $b = 0{\cdot}05$ or $0{\cdot}43$ TU.

Impedance.

The impedance of the repeater, looking into the line terminals, shall be approximately equal to that of the circuit in connection with which it is intended to operate. Suitable terminal transformers shall be provided, if necessary, to adjust the line impedance to that of the repeater where the latter is required to operate on circuits of impedance other than that for which it is designed.

Monitoring.

Means shall be provided so that it is possible to monitor on the circuits in either or both directions with an operator's telephone set and to talk on the circuit when necessary.

When monitoring on a through connection, the losses caused by the monitoring device shall not exceed $b = 0{\cdot}03$ or $0{\cdot}26$ TU.

Crosstalk.

When repeater units, mounted either side by side or one over the other, are operated by batteries, as in practice, the crosstalk between the units, measured on the output side shall not be less than $b = 8$ or 69 TU; on the understanding that when these measurements are being carried out the repeaters will be joined to impedances having a value equal to that of the uniform impedance fixed for international circuits.

APPENDIX B.c.4 No. 2.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR THE SUPPLY OF FOUR-WIRE TELEPHONE REPEATERS.

General.

This Specification covers the most important electrical requirements concerning the essential questions pertaining to telephone repeater units as supplied by the factory. It does not cover the requirements for installed repeaters.

Type.

It shall be a vacuum tube repeater and shall give one-way amplified transmission without appreciable distortion for all frequencies within the efficient speech range of the cable circuits with which it is associated for the maximum inputs occurring in practice.

Gain.

Means shall be provided for regulating the gain of the repeaters, preferably by steps not exceeding $b = 0 \cdot 1$ or $0 \cdot 87$ TU. In the case of very long circuits it may be necessary to provide for an adjustment by steps not exceeding $b = 0 \cdot 03$ or $0 \cdot 26$ TU.

Within the efficient speech range of the circuit, the repeater gain shall increase with frequency so as to compensate for the distortion of the circuit contained between successive repeaters.

The general shape of the gain frequency characteristic curve shall be maintained for all gain settings of the repeater. Suitable terminal transformers shall be provided at the ends of the circuits, if necessary, to adjust the line impedance to that of the repeater, where the latter is required to operate on lines of impedance other than that for which it is designed.

Monitoring.

Means shall be provided so that it is possible to monitor on the lines in either or both directions with an operator's telephone set and to talk on the circuit when necessary.

When monitoring on a through connection the losses caused by monitoring shall not exceed $b = 0 \cdot 03$ or $0 \cdot 26$ TU.

Crosstalk.

With repeater units mounted either side by side or one over the other and operated by batteries, as in practice, the crosstalk between units, measured between the outgoing terminals, shall not be less than $b = 8$ or 69 TU; on the understanding that, when these measurements are being carried out, the repeaters will be joined to impedances having a value equal to that of the uniform impedance fixed for international circuits.

APPENDIX B.d.2 No. 1.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION GENERALLY APPLYING TO FACTORY LENGTHS OF INTERNATIONAL TELEPHONE CABLES OF THE QUADDED TYPE.

General.

This specification covers the electrical requirements which must be fulfilled by factory lengths of air space paper-insulated lead-covered cables for long distance telephone circuits. These requirements are specified in order to ensure that the cables will be suitable for :—

(1) Phantom working.
(2) Loading of pair and phantom circuits.
(3) Efficient long-distance working in conjunction with repeaters.

These requirements do not apply :—

(1) To cables in which the conductors are smaller than eight-tenths (0·8) of a millimetre (approximately 16 lb. per mile).

(2) To groups of one gauge of conductors of less than ten (10) quads.

(3) When the total number of circuits of each gauge specified is such that the lay-up of the cable is necessarily unsymmetrical, or such that conductors of different gauges are required to be in the same layer.

Some of the more important raw material requirements are also specified.

Raw Materials.

Copper Conductors.

Each conductor shall consist of a wire of pure, annealed copper, smoothly drawn, cylindrical, uniform in quality and resistance, free from scales or other defects and having a conductivity equal to that specified by the International Electro-technical Commission (Berlin, 1913), that is, one fifty-eighth ($\frac{1}{58}$) of an ohm for the resistance of a wire of standard annealed copper one (1) metre in length and of a uniform section of one (1) square millimetre at a temperature of twenty (20) degrees Centigrade.

When correcting for temperature, the temperature coefficient specified by the same Commission will be admitted—that is, at a temperature of twenty (20) degrees Centigrade, the "constant mass" temperature coefficient of resistance of standard annealed copper is 0·00393 per degree Centigrade.

The diameter of the wires used shall not vary by more than one and a half (1·5) per cent. above or below the nominal diameter.

Factory Joints.

When it is necessary to join conductors in the factory, the joint shall be made by a method which meets the following requirements :—

The tensile strength of a section of a conductor which includes the joint shall be at least ninety (90) per cent. of the tensile strength of an adjacent section of the conductor of equal length without joint.

The resistance of a section of the conductor not exceeding fifteen (15) centimetres (approximately 6 inches) in length, which includes the joint, shall not exceed by more than five (5) per cent. the resistance of an adjacent section of the conductor of equal length without joint. No twist joints shall be used. The material used for the joints must not contain acid. The joints shall be brazed with silver solder.

Insulating Paper.

The paper used for insulating the conductors shall be uniform in texture and thickness, long-fibred and free from metallic particles or other deleterious substances.

A sample of paper, taken from the finished cable and subjected to exposure to the atmosphere for one hour, shall have a tensile strength of not less than 4 kilometres (approximately 2·5 miles) length of paper of the same dimensions and the same quality.

Sheathing and Armouring Material.

The requirements for these materials shall be specified separately for each individual cable.

Electrical Characteristics.

Conductor Resistance.

The direct current resistance of any wire in a finished manufacturing length shall not exceed by more than four (4) per cent. the value calculated for a straight wire of the nominal size of the conductor considered.

The average resistance of all the wires in a group of one gauge shall not exceed the nominal value, as defined above, by more than one (1) per cent.

For the maximum and for the average value an additional allowance, for the increase in length, due to the stranding, shall be made in accordance with the table below :—

Overall diameter of outer layer containing the gauge considered (in millimetres).	Allowance for the increase in length due to stranding.
Below 30	1·0 per cent.
30–40	1·6 ,,
40–50	2·5 ,,
50–60	3·7 ,,
60–70	5·0 ,,
70–80	7·0 ,,

In any length of cable the difference between the direct-current resistances of the two conductors of a pair shall not exceed one (1) per cent. of the loop resistance of that pair.

Insulation Resistance.

In a length of cable each conductor, when measured for insulation against all other conductors and the sheath connected to earth, shall have an insulation resistance equivalent to not less than ten thousand (10,000) megohms per kilometre of cable (approximately 6,200 megohms per mile), the potential difference employed being at least 100 volts and not more than six hundred (600) volts. The reading shall be taken after an electrification of one (1) minute, at a temperature of not less than fifteen (15) degrees Centigrade (approximately 60° F.).

Dielectric Strength.

When specially called for, the cables shall be designed so that the insulation on every length of cable shall be capable of withstanding for two (2) seconds without rupture a fifty (50) cycle alternating-current potential of the R.M.S. value specified in each particular case, but not exceeding two thousand (2,000) volts, when applied between all conductors of the cable connected together and the cable sheath earthed.

The maximum value of the testing voltage shall not differ by more than ten (10) per cent. from that of a true sine wave of the same R.M.S. value.

Mutual Capacity (Alternating Current).

The mutual capacity of a pair is the capacity measured between the two conductors of the pair when all the other conductors in the cable are connected to the lead sheath.

The mutual capacity of a phantom circuit is the capacity measured between the two pairs of a quad with each of the pairs short-circuited, and all other conductors in the cable connected to the lead sheath.

The test shall be made with alternating current at room temperature. No correction for temperature shall be applied. In case of dispute, the results obtained with an alternating current of 800 p.p.s. at not less than fifteen (15) degrees Centigrade (approximately 60° F.) will be taken as final.

In each length of cable the average mutual capacity of all the pairs of each gauge, taken separately, shall be as specified by the Administration concerned; a tolerance of plus or minus five (± 5) per cent. on ninety (90) per cent. of all factory lengths, and a tolerance of plus or minus eight (± 8) per cent. on one hundred (100) per cent. of all factory lengths shall be allowed.

In each length of cable the average mutual capacity of phantom circuits of each group of one gauge shall not differ by more than plus or minus five (± 5) per cent. from the value which shall be determined by multiplying the average pair-capacity of that group by the factor 1·62.

The mutual capacity of every pair and every phantom circuit shall be measured on not less than ten (10) per cent. of the total number of factory lengths.

In any length of cable the capacity deviation of the pair or phantom circuits, respectively, of a group of one gauge shall not exceed the following values :—

Average, 4 per cent.
Maximum, $12\frac{1}{2}$ per cent.

By " capacity deviation " is meant the difference of the capacity of any circuit of a group from the average capacity of all similar circuits of that group in the same factory length. This difference shall be expressed as a percentage of this average value.

Measures to be taken with a view to Equalising, as far as possible, the Capacities of the Loading Sections between Successive Repeaters.

For each group of physical circuits of the cable the average capacities of the various loading sections between repeater stations should not differ by more than ± 2 per cent. from the average value of the capacity of the group of circuits in question throughout the whole of the loading sections. Where such regularity could not be obtained directly by manufacturing processes, if there are deviations greater than the limits indicated, it is recommended that the factory lengths be distributed in each loading section in such a manner that the capacities of the various loading sections shall fulfil the condition mentioned above.

Leakance Constant.

The average leakance of the pair and phantom circuits shall be determined on a small percentage of factory lengths with an alternating current of 800 p.p.s.

The average leakance constant for each type of circuit for any length tested shall not exceed twenty-five (25). This constant shall be taken as being equal to the ratio of the average leakance and the average mutual capacity measured with alternating current.

This value may also be expressed as the ratio : $G/w\ C$ = Leakance/Susceptance, which must not exceed 0·005.

Capacity Unbalance.

In a cable two hundred and thirty (230) metres (approximately 750 ft.) in length, the capacity unbalances, measured with alternating current of approximately 800 p.p.s. (5,000 radians per second), shall not exceed the value given in the following table, each gauge being considered separately :—

	Limits for Capacity Unbalance in micro-microfarads per 230-metre lengths.	
	Average.	Maximum.
Side to side	40	150
Phantom to side	150	750
Phantom to phantom between adjacent quads in a layer or between quads in the centre and in the first layer	80	300
Side to earth	150	720

In cables intended for four-wire operation, the average capacity unbalance between circuits in one direction and similar circuits in the other direction shall be measured on one or more factory lengths and the average unbalance for a factory length of 230 metres shall not exceed 3 m.mf.

In every length of cable other than two hundred and thirty (230) metres the capacity unbalances, measured with alternating current for each gauge, shall not exceed the values determined by multiplying the figures, given in the above table, for two hundred and thirty (230) metres, by the square root of the ratio between the length in question and two hundred and thirty (230) metres.

This correction shall not apply to lengths of cable less than one hundred (100) metres (approximately 110 yards). For such lengths the limits for a one hundred (100) metre length shall apply, computed in accordance with the preceding rule.

Note.—For lengths of cable of one-tenth (0·1) of a mile (approximately 161 metres), the limits for the capacity unbalances would, in accordance with the conversion rule given in the preceding paragraph, assume approximately the following values :—

	Approximate limits for capacity unbalances in micro-microfarads per 0·1 mile length.	
	Average.	Maximum.
Side to side	33	125
Phantom to side	125	625
Phantom to phantom	67	250
Side to earth	125	600

The limits here specified are based on the following definitions for the capacity unbalances.

The capacity unbalance between a phantom circuit and either of its side circuits is the capacity unbalance which would be produced or corrected, as the case may be, by the insertion of a capacity between one wire in the side circuit in question and the sheath of the cable.

Some Administrations define this capacity unbalance as the unbalance which would be produced or corrected, as the case may be, by the insertion of a capacity between one wire of a pair and a wire of the other pair. In this case the limits of the unbalance in micro-microfarads are those given above, but divided by two (2).

The capacity unbalance between the side circuits of a quad is the unbalance which would be produced or corrected, as the case may be, by the insertion of a capacity between one wire of one pair and one wire of the other pair of the quad.

The capacity unbalance between two phantom circuits is defined as the unbalance which would be produced or corrected, as the case may be, by the insertion of a capacity between one of the pairs of one quad and one of the pairs of the other quad.

The capacity unbalance to earth of a side circuit is the difference between the direct capacities of the two wires of the pair to the conductors of all other quads in the cable connected together and to the sheath, which shall be earthed.

APPENDIX B.d.2 No. 2.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION GENERALLY APPLYING TO FACTORY LENGTHS OF INTERNATIONAL TELEPHONE CABLES NOT INTENDED FOR PHANTOM WORKING.

General.

This specification covers the electrical requirements which must be fulfilled by factory lengths of air space, paper-insulated, lead-covered cables for long distance telephone circuits where phantom circuits are not required. These requirements are specified in order to ensure that the cables will be suitable for :—

(1) The loading of physical (pair) circuits.
(2) Efficient long distance working in conjunction with repeaters.

These requirements do not apply :—

(1) To cables in which the conductors are smaller than eight-tenths (0·8) of a millimetre (approximately 16 lb. per mile).

(2) To groups of one gauge of conductors of less than 20 pairs.

(3) When the total number of circuits of each gauge specified is such that the lay-up of the cable is necessarily unsymmetrical, or such that conductors of different gauges are required to be in the same layer.

Some of the more important raw material requirements are also specified.

Raw Materials.

Copper Conductors.

Each conductor shall consist of a wire of pure, annealed copper, smoothly drawn, cylindrical, uniform in quality and resistance, free from scales or other defects and having a conductivity equal to that specified by the International Electro-technical Commission (Berlin, 1913); that is, one fifty-eighth ($\frac{1}{58}$) of an ohm for the resistance of a wire of standard annealed copper one (1) metre in length and of a uniform section of one (1) square millimetre at a temperature of twenty (20) degrees Centigrade.

When correcting for temperature, the temperature coefficient specified by the same Commission will be admitted; that is, at a temperature of twenty (20) degrees Centigrade, the "constant mass" temperature coefficient of resistance of standard annealed copper is 0·00393 per degree Centigrade.

The diameter of the wires used shall not vary by more than one and a half (1·5) per cent. above or below the nominal diameter.

Factory Joints.

When it is necessary to join conductors in the factory, the joint shall be made by a method which meets the following requirements :—

The tensile strength of a section of a conductor which includes the joint shall be at least ninety (90) per cent. of the tensile strength of an adjacent section of the conductor of equal length without joint.

The resistance of a section of the conductor not exceeding fifteen (15) centimetres (approximately 6 inches) in length, which includes the joint, shall not exceed by more than five (5) per cent. the resistance of an adjacent section of the conductor of equal length without joint. No twist joints shall be used. The material used for the joints must not contain acid. The joints shall be brazed with silver solder.

Insulating Paper.

The paper used for insulating the conductors shall be uniform in texture and thickness, long fibred and free from metallic particles or other deleterious substances.

A sample of paper, taken from the finished cable and subjected to exposure to the atmosphere for one hour, shall have a tensile strength of not less than 4 kilometres (approximately 2·5 miles) length of paper of the same dimensions and the same quality.

Sheathing and Armouring Material.

The requirements for these materials shall be specified separately for each individual cable.

Electrical Characteristics.

Conductor Resistance.

The direct current resistance of any wire in a finished manufacturing length shall not exceed by more than four (4) per cent. the value calculated for a straight wire of the nominal size of the conductor considered.

The average resistance of all the wires in a group of one gauge shall not exceed the nominal value, as defined above, by more than one (1) per cent.

For the maximum and for the average value an additional allowance for the increase in length, due to the stranding, shall be made in accordance with the table below :—

Over-all diameter of outer layer containing the gauge considered (in millimetres).	Allowance for the increase in length due to stranding.
Below 30	1·0 per cent.
30–40	1·6 ,,
40–50	2·5 ,,
50–60	3·7 ,,
60–70	5·0 ,,
70–80	7·0 ,,

Insulation Resistance.

In a length of cable each conductor, when measured for insulation against all other conductors and the sheath connected to earth, shall have an insulation resistance equivalent to not less than ten thousand (10,000) megohms per kilometre of cable (approximately 6,200 megohms per mile), the potential difference employed being at least 100 volts and not more than six hundred (600) volts. The reading shall be taken after an electrification of one (1) minute, at a temperature of not less than fifteen (15) degrees Centigrade (approximately 60° F.).

Dielectric Strength.

When specially called for, the cable shall be designed so that the insulation on every length of cable shall be capable of withstanding for two (2) seconds without rupture a fifty (50) cycle alternating current potential of the R.M.S. value specified in each particular case, but not exceeding two thousand (2,000) volts, when applied between all conductors of the cable connected together and the cable sheath earthed.

The maximum value of the testing voltage shall not differ by more than ten (10) per cent. from that of a true sine wave of the same R.M.S. value.

Mutual Capacity (Alternating Current).

The mutual capacity of a pair is the capacity measured between the two conductors of the pair when all the other conductors in the cable are connected to the lead sheath.

The test shall be made with alternating current at room temperature. No correction for temperature shall be applied. In case of dispute, the results obtained with an alternating current of 800 p.p.s. at not less than fifteen (15) degrees Centigrade (approximately 60° F.) will be taken as final.

In each length of cable the average mutual capacity of all the pairs of each gauge taken separately, shall be as specified by the Administration concerned; a tolerance of plus or minus five ($\pm$ 5) per cent. on ninety (90) per cent. of all factory lengths, and a tolerance of plus or minus eight ($\pm$ 8) per cent. on one hundred (100) per cent. of all factory lengths shall be allowed.

The mutual capacity of every pair shall be measured on not less than ten (10) per cent. of the total number of factory lengths.

In any length of cable the capacity deviation of the pair circuits of a group of one gauge shall not exceed the following values:

Average 4 per cent.
Maximum $12\frac{1}{2}$ per cent.

By "capacity deviation" is meant the difference of the capacity of any circuit of a group from the average capacity of all similar circuits of that group in the same factory length. This difference shall be expressed as a percentage of this average value.

Measures to be taken with a view to equalising, as far as possible, the Capacities of the Loading Sections between Successive Repeaters.

For each group of pairs of the cable the average capacities of the various loading sections between repeater stations should not differ by more than $\pm$ 2 per cent. from the average value of the capacity of the group of circuits in question throughout the whole of the loading sections. Where such regularity could not be obtained directly by manufacturing processes, if there are deviations greater than the limits indicated, it is recommended that the factory lengths be distributed in each loading section in such a manner that the capacities of the various loading sections shall fulfil the condition mentioned above.

Leakance Constant.

The average leakance of the pair circuits shall be determined on a small percentage of factory lengths with an alternating current of 800 p.p.s.

The average leakance constant for all circuits of one gauge for any length tested shall not exceed twenty-five (25). This constant shall be taken as being equal to the ratio of the average leakance and the average mutual capacity measured with alternating current.

This value may also be expressed as the ratio: Gw/C = Leakance/Susceptance, which must not exceed 0·005.

Capacity Unbalance.

In a cable two hundred and thirty (230) metres (approximately 750 ft.) in length, the capacity unbalances, measured with alternating current of approximately 800 p.p.s., shall not exceed the value given in the following table, each gauge being considered separately:

	Limits for Capacity Unbalance in micro-microfarads per 230-metre lengths.	
	Average.	Maximum.
Pair to pair	40	150
Pair to earth	150	720

In cables intended for four-wire operation, the average capacity unbalance between circuits in one direction and similar circuits in the other direction shall be measured on one or more factory lengths and the average unbalance for a factory length of 230 metres shall not exceed 3 m.mf.

In every length of cable other than two hundred and thirty (230) metres the capacity unbalances, measured with alternating current for each gauge, shall not exceed the values determined by multiplying the figures, given in the above table, for two hundred and thirty (230) metres, by the square root of the ratio between the length in question and two hundred and thirty (230) metres.

This correction shall not apply to lengths of cable less than one hundred (100) metres (approximately 110 yards). For such lengths the limits for a one hundred (100) metre length shall apply, computed in accordance with the preceding rule.

Note.—For lengths of cable of one-tenth (0·1) of a mile (approximately 161 metres), the limits for the capacity unbalances would in accordance with the conversion rule given in the preceding paragraph, assume approximately the following values:—

	Approximate limits for capacity unbalances in micro-microfarads per 0·1 mile lengths.	
	Average.	Maximum.
Pair to pair	33	125
Pair to earth	125	600

The limits here specified are based on the following definitions for the capacity unbalances.

The capacity unbalance between pairs is the unbalance which would be produced, or corrected, as the case may be, by the insertion of a capacity between one wire of a pair and one wire of the other pair.

The capacity unbalance to earth of a pair is the difference between the direct capacities of the two wires of the pair to the conductors of all other pairs in the cable connected together and to the sheath, which shall be earthed.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR REPEATER SECTIONS OF LOADED INTERNATIONAL TELEPHONE CABLE.

General.

This specification covers the chief electrical requirements of installed repeater section lengths of loaded cable, where the factory lengths of cable and the loading coils are in accordance with their corresponding specifications.

The clauses of this specification are drawn up so as to ensure that the cable shall be suitable for phantom working in the cables and for efficient long-distance performance in conjunction with 2-wire or 4-wire repeaters.

The clauses below apply to circuits which may be used for either 2-wire working or 4-wire working, except when otherwise indicated in the test.

Resistance Unbalance.

In any cable section between telephone repeaters, not exceeding 100 km., the difference between the direct current resistance of the two conductors of any pair shall not exceed six (6) ohms for conductors of 1 mm., maximum diameter, nor four (4) ohms for conductors larger than this.

Insulation Resistance.

The insulation resistance, between any wire and all other wires together with the sheath connected to earth, measured from the terminals of the cable, and not including the internal office wiring, shall not be less than five thousand (5,000) megohms per kilometre of cable, this insulation resistance being measured with a difference of potential of at least 100 volts and not more than 600 volts, the readings to be taken after one minute's electrification.

Impedance Balance.

The balance between the impedance Z_{ct} of any side or phantom circuit and the corresponding network impedance Z_{eq}, calculated from the measured average constants of the circuit, shall satisfy the following requirements: after determination, by direct measurement, of the real and imaginary components of the impedance Z_{ct} and Z_{eq}, the difference between the real components and the difference of the imaginary components, will be expressed in percentages; d_e and d_i, of the impedance Z_{eq} of the balancing network, and if d_e and d_i are taken as the Cartesian co-ordinates of a point, this point should be situated within a circle having a radius of $\frac{18}{100}$ for all the circuits and for any frequency between 300 and 2,200 periods per second. Further, for 90 per cent. of the circuits and for all the frequencies indicated above, the corresponding point should fall within a circle having a radius $\frac{15}{100}$.

System of Loading and Cut-off Point.

By way of example, two systems are described below under the titles: **System No. 1** and **System No. 2**. Both systems are equally satisfactory from an International point of view.

In the application of either system to any repeatered section of cable, the whole of the specified requirements for that particular system must be adopted. There is no objection to the two systems being used in adjacent repeatered lengths of cable respectively, provided that, in any circuit, the cable between two adjacent telephone repeaters is of one system.

The requirements of System No. 1 are given in paragraphs (i), (ii), (iii), (iv) and (v).

The requirements of System No. 2 are given in paragraphs (vi), (vii), (viii), (ix) and (x.

System No. 1.

(i) Loading Coil Spacing.

In any cable section between successive telephone repeaters the average loading coil spacing shall be eighteen hundred and thirty (1,830) metres within limits of plus or minus two (± 2) per cent.

The actual length of any loading section, measured along any cable section between two successive repeaters, may vary as a maximum, plus or minus ten (10) metres from the normal spacing.

(ii) Loading Coil Inductances.

For circuits which are planned not to exceed seven hundred (700) kilometres in length the units of loading shall have nominal inductance values of one hundred and seventy-seven (177) millihenrys for side circuits and sixty-three (63) millihenrys for phantom circuits (alternatively, one hundred and seven (107) millihenrys may be used for the phantom circuit inductance). The limit of seven hundred kilometres may be extended to one thousand (1,000) km. for 4-wire circuits, provided that no disturbing echo currents are produced.

For circuits which are planned to exceed seven hundred (700) kilometres in length, with the exception stated in the preceding paragraph, the units of loading shall have nominal inductance values of forty-four (44) millihenrys for side circuits and twenty-five (25) millihenrys for phantom circuits.

(iii) Cut-off Point.

The cut-off point for the various systems of loading for both side and phantom circuits shall be calculated by the formula:

$$w_o = \frac{2}{\sqrt{LC}}$$

where w_o = cut off point, expressed in radians per second.
L = inductance per coil, in henrys.
C = mutual capacity of the cable circuit between loading coils, in farads.

The cut-off point has approximately the nominal values given in the following table:—

	Side.		Phantom.	
	Radians.	Periods per Second.	Radians.	Periods per Second.
Circuits less than 700 km. in length.				
With 177 mh. side, 63 mh. phantom ..	18,000	2,900	23,600	3,600
With 177 mh. side, 107 mh.	18,000	2,900	18,000	2,900
Circuits over 700 km. in length.				
With 44 mh. side, 25 mh. phantom	36,000	5,800	37,400	6,000

(iv) **Impedance.**

The characteristic impedance of side and phantom circuits, loaded in accordance with the foregoing systems of loading and calculated by the formula :

$$Z_o = \sqrt{L/C}$$

(where Z_0 = the characteristic impedance, L and C being the constants referred to in paragraph on " Cut-off Point ") has the values given in the following table :—

	Ohms Impedance.	
	Side.	Phantom.
Circuits less than 700 km. in length.		
With 177 mh. side, 63 mh. phantom ..	1,590	740
With 177 mh. side, 107 mh. phantom ..	1,590	970
Circuits over 700 km. in length.		
With 44 mh. side, 25 mh. phantom ..	790	470

(v) **Attenuation Constant.**

The average attenuation constant for all circuits of one type, in any section between successive repeaters, loaded in accordance with the foregoing systems of loading, shall not exceed the values quoted in the following tables.

The attenuation constants shall be measured on the cable sections between telephone repeaters, including exact half value terminating loading sections. In cases where exact half value terminating loading sections do not exist, these terminating sections shall be built out to half value by artificial cable and suitable corrections made to the measurements taken.

The following table gives the values of the attenuation constants for circuits loaded with 177 mh. side circuit coils and 63 mh. phantom circuit coils on 1,830 m. nominal spacing.

Mean mutual capacity of cable : side circuit 0·0385 m.f. per km., phantom circuit 0·0625 m.f. per km.

MAXIMUM AVERAGE ATTENUATION PER KM. AT 800 PERIODS PER SECOND.

Diameter of Conductors.	Side Circuit.	Phantom Circuit.
	β	β
0·9 mm.	0·0217	0·0228
1·3 mm.	0·0121	0·0125

MAXIMUM AVERAGE ATTENUATION PER KM. AT 1,900 PERIODS PER SECOND.

Diameter of Conductors.	Side Circuit.	Phantom Circuit.
	β	β
0·9 mm.	0·0250	0·0245
1·3 mm.	0·0164	0·0147

The following table gives the values of the attenuation constants for circuits loaded with 177 mh. side circuit coils and 107 mh. phantom circuit coils at 1,830 m. spacing.

Mean mutual capacity of cable: side circuit 0·0385 m.f. per km., phantom circuit 0·0625 m.f. per km.

MAXIMUM AVERAGE ATTENUATION PER KM. AT 800 PERIODS PER SECOND.

Diameter of Conductors.	Side Circuit.	Phantom Circuit.
	β	β
0·9 mm.	0·0214	0·0177
1·3 mm.	0·0119	0·0099

MAXIMUM AVERAGE ATTENUATION PER KM. AT 1,900 PERIODS PER SECOND.

Diameter of Conductors.	Side Circuit.	Phantom Circuit.
	β	β
0·9 mm.	0·0251	0·0202
1·3 mm.	0·0159	0·0127

The following table gives the values of the attenuation for circuits loaded with 44 mh. side circuit coils and 25 mh. phantom circuit coils on 1,830 m. spacing.

Mean mutual capacity of cable: side circuit 0·0385 m.f. per km.; phantom circuit 0·0625 m.f. per km.

MAXIMUM AVERAGE ATTENUATION PER KM. AT 800 PERIODS PER SECOND.

Diameter of Conductor.	Side Circuit.	Phantom Circuit.
	β	β
0·9 mm.	0·0390	0·0328

MAXIMUM AVERAGE ATTENUATION PER KM. AT 1,900 PERIODS PER SECOND.

Diameter of Conductor.	Side Circuit.	Phantom Circuit.
	β	β
0·9 mm.	0·0410	0·0339

System No. 2.

(vi) Loading Coil Spacing.

For cables with wires 0·9 mm. diameter (having a mean mutual capacity of 0·0335 microfarad per kilometre for the side circuit and 0·054 microfarad per kilometre for the phantom circuit) and with wires 1·4 mm. diameter (having a mutual capacity of 0·0355 microfarad per kilometre for the side circuit and 0·057 for the phantom circuit) the nominal loading coil spacing shall be two thousand (2,000) metres ± 2 per cent.

In any cable section between two successive telephone repeaters the actual length of any loading section (measured along the cable) shall not vary from the nominal spacing by more than plus or minus ten (± 10) metres.

(vii) **Loading Coil Inductance.**

For circuits which are planned not to exceed seven hundred (700) kilometres in length, the units of loading shall have nominal inductance values for wires of 0·9 mm. diameter, 200 mh. for side circuits and 70 mh. for phantom circuits; for the wires of 1·4 mm. diameter 190 mh. for side circuits and 70 mh. for phantom circuits. The limit of seven hundred (700) kilometres may be extended to one thousand (1,000) kilometres in case of 4-wire circuits, provided always that this does not give rise to disturbing echo currents.

For circuits which exceed 700 kilometres in length, excepting as provided in the preceding paragraph, the units of loading shall have nominal inductance values of fifty (50) mh. for the side circuits and twenty (20) mh. for the phantom circuits.

(viii) **Cut-off Point.**

The cut-off points, calculated by the previously mentioned formula, will have the approximate values given in the following table :—

	Side.		Phantom.	
	Radians.	Periods.	Radians.	Periods.
Circuits less than 700 km. in length.				
Wires of 0·9 mm. diameter (200 mh. side, 70 mh. phantom)	17,300	2,750	23,000	3,670
Wires of 1·4 mm. diameter (190 mh. side, 70 mh. phantom)	17,200	2,740	22,100	3,520
Circuits over 700 km. in length.				
Wires of 0·9 mm. diameter (50 mh. side, 20 mh. phantom)	33,500	5,340	43,000	6,840

(ix) **Impedance.**

Calculated by the previously mentioned formula, the characteristic impedance shall have the values given in the following table :—

	Ohms Impedance.	
	Side.	Phantom.
Circuits less than 700 km. in length.		
Wires of 0·9 mm. diameter (200 mh. side, 70 mh. phantom)	1,730	805
Wires 1·4 diameter (190 mh. side, 70 mh. phantom)	1,630	775
Circuits over 700 km. in length.		
Wires of 0·9 mm. diameter (50 mh. side, 20 mh. phantom)	855	440

(x) Attenuation.

The table below gives the values of the attenuation for circuit of :—(1) 0·9 mm. diameter (loaded with 200 mh. side circuit coils and 70 mh. phantom circuit coils, with 2,000 metre spacing, and mean mutual capacities of cable :—side circuit 0·0335 microfarad per kilometre, phantom circuit 0·054 microfarad per kilometre); (2) for circuits of 1·4 mm. diameter (loaded with 190 mh. side circuit coils and 70 mh. phantom circuit coils with 2,000 metre spacing, with a mean mutual capacity of cable :—side circuit 0·035 microfarad per kilometre, phantom circuit 0·0585 microfarad per kilometre).

MAXIMUM AVERAGE ATTENUATION PER KM. AT 800 PERIODS PER SECOND.

Diameter of Conductors.	Side Circuit.	Phantom Circuit.
	β	β
0·9 mm.	0·0197	0·0210
1·4 mm.	0·0097	0·0101

MAXIMUM AVERAGE ATTENUATION PER KM. AT 1,900 PERIODS PER SECOND.

Diameter of Conductors.	Side Circuit.	Phantom Circuit.
	β	β
0·9 mm.	0·0236	0·0234
1·4 mm.	0·0133	0·0131

The following table gives the values of the attenuation for circuits of 0·9 mm. diameter, loaded with 50 mh. coils on the side circuits and 20 mh. coils on the phantom circuits, the normal spacing being 2,000 metres and the mean mutual capacity 0·0335 m.f. per km. side circuit, and 0·054 m.f. per km. phantom circuit.

MAXIMUM AVERAGE ATTENUATION PER KM. AT 800 PERIODS PER SECOND.

Diameter of Conductors.	Side Circuit.	Phantom Circuit.
	β	β
0·9 mm.	0·0307	0·0350

MAXIMUM AVERAGE ATTENUATION PER KM. AT 1,900 PERIODS PER SECOND.

Diameter of Conductors.	Side Circuit.	Phantom Circuit.
	β	β
—	0·0308	0·0353

Cross-talk.

The following tables state the maximum cross-talk allowable between any circuits as specified above and measured on any repeater section of cable between two successive repeaters. The values are those which would be measured from the terminals of the cable and include only cross-talk contributed by the cable and loading coils. They do not include cross-talk introduced by arrestors, repeating coils, repeater station cabling and other equipment located in the repeater or terminal buildings.

The cross-talk values shall be determined by means of a talking test or by tone approximating, in energy distribution, to speech (in cases of dispute, speech tests shall be taken as final).

The measuring circuits employed shall be such that both the disturbing and disturbed circuits are closed at both ends through impedances which conform to the impedance of the disturbing and disturbed circuits, respectively.

The limiting value of attenuation corresponding to the cross-talk expressed in *b* or TU shall be at least equal to the values quoted below :—

Near End Cross-talk, 2-wire Circuits.

	b	TU
Side to Side of same quad		
Phantom to Side of same quad		
Phantom to Phantom	7·5	65
Phantom to Pair of different quads..		
Pair to Pair of different quads		

Near End Cross-talk, 4-wire Circuits between Opposite going 4-wire Groups.

	b	TU
Pair to Pair		
Phantom to Phantom	9	78
Phantom to Pair		

Far End Cross-talk, 4-wire Circuits.

	b	TU
Side to Side of same quad		
Phantom to Side of same quad		
Phantom to Phantom	7·5	65
Phantom to Pair of different quads..		

APPENDIX B.d.2 No. 4.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR THE SUPPLY OF A COMPLETE TELEPHONE CABLE BETWEEN TERMINAL EXCHANGES, INCLUDING REPEATER STATIONS, ASSUMING THAT THE CABLE IS ORDERED FROM ONE CONTRACTOR, WHO ASSUMES RESPONSIBILITY FOR OVER-ALL RESULTS.

Introduction.

The International Consultative Committee considers that the information at present at its disposal is not sufficient to enable it to specify all the details which such a specification should cover. It is also of the opinion that certain supplementary specifications are necessary for the supply and installation of repeater stations, for repeating coils, &c. Consequently, the parts of a typical specification for which it has been possible to collect sufficient data have been drafted and completed by means of two Appendices :—

(1) Appendix (*a*), indicating the points which should be taken into consideration in the specification and the corresponding information which it has been possible to obtain.

(2) Appendix (*b*), indicating the points which necessitate further research.

The International Consultative Committee recommends that the following information should be given to the contractors in as much detail as possible :—

(1) Details of the Route.
(2) Detailed information as to the number of circuits necessary and the expected traffic.
(3) Details of telephone and telegraph cables existing on the projected route, if any.
(4) Ducts and manholes available along the route, if any.
(5) Detailed information as to repeater stations, if any.
(6) Location preferred for new repeater stations and reasons justifying this preference.
(7) Power supply available at these points.
(8) Initial and final capacities of the new repeater stations.
(9) Type of Construction preferred; aerial cable, underground cable (armoured and non-armoured).
(10) Detailed information as to available poles in the case of aerial cables.
(11) Information on the power systems liable to produce inductive disturbances or electrolytic damage.

Specification.

1. Component Parts of the Circuits.

The various parts of the circuits should conform with the corresponding specifications published by the C.C.I.

The parts in question and the corresponding specifications are the following :—

Cable : Factory lengths, Appendices B.d.2 No. 1 and No. 2.
Section between 2 Repeaters, Appendix B.d.2 No. 3.
Loading Coils (Pupin Coils), Appendix B.d.2 No. 5.
Telephone Repeaters, Appendices B.c.4 No. 1 and No. 2.

Signalling apparatus	The corresponding specifications have not yet been published.
Installation of repeater stations	
Terminating apparatus and protective devices ..	
Apparatus for testing and measurement	
Balancing networks for 2-wire repeaters	
Line Transformers	Specification proposed in the present report (*see* V. Appendix (*e*) attached).

2. **Attenuation and Distortion.**

(1) The over-all attenuation measured at a frequency of 800 cycles per second between testboards at terminal exchanges should not exceed $b = 1 \cdot 3$ or $11 \cdot 3$ T.U. The International Consultative Committee considers that 5 per cent. of the circuits of each type should be tested with greater accuracy. A method of test is indicated in Appendix (*c*) for consideration by the Administrations interested. During such a test the repeaters amplifying in the opposite direction should be disconnected.

(2) When the circuits are not to be extended beyond their terminal points in the cables in question, the attenuation indicated above may be increased in these special cases to $b = 2 \cdot 0$ or $17 \cdot 4$ T.U.

(3) The attenuation of a circuit, measured at 800 cycles per second, should have the same value in both directions, with a tolerance of not more than $b = 0 \cdot 3$ or $2 \cdot 6$ T.U.

(4) In 4-wire circuits the maximum overall attenuations should not differ by more than $b = 1 \cdot 0$ or $8 \cdot 7$ T.U. within the following frequency intervals :—

Medium-Heavy Loading—300–2,000 cycles per second.
Extra-Light Loading—300–2,500 cycles per second.

Clauses 1 and 4 may be modified when a more accurate method of testing has been laid down.

(5) As regards 2-wire circuits, the permissible variation in the attenuation with frequency shall conform with the following advice of the C.C.I. :—

The attenuation at 800 p.p.s. shall not be less than $b = 1 \cdot 3$ or $11 \cdot 3$ T.U.

The attenuation at 300 p.p.s. shall not differ from the attenuation at 800 p.p.s. by more than $b = 0 \cdot 5$* or $4 \cdot 3$ T.U.* and the attenuation at 2,000 p.p.s. shall not differ from the attenuation at 800 p.p.s. by more than $b = 1 \cdot 5$* or 13 T.U.*.

Reducing the over-all transmission loss by $b = 0 \cdot 4$ or $3 \cdot 4$ T.U. shall not cause singing.

The contractor should give detailed information on the methods of obtaining these results as well as curves showing how the attenuation of the line (repeaters and attenuation equalizers *not included*) varies with frequency as well as curves showing the variations with frequency, between the limits indicated above, of the overall attenuation of the circuit (*including* repeaters and attenuation equalizers).

The variations in attenuation due to normal changes in atmospheric conditions should not exceed $b = \pm 0 \cdot 2$ or $\pm 1 \cdot 7$ T.U. In the case of aerial cables for which these limits may be exceeded, the contractor shall provide suitable apparatus to correct these effects and furnish all desirable information regarding such apparatus.

3. **Transmission Levels.**

The transmission level at any point on the circuit is determined by the ratio, expressed in units of transmission, of the power, voltage or current measured at that point to the power, voltage or current measured at the transmitting end of the circuit. (For such measurements the circuit is connected to the test table at the sending end.)

A correction must be made to take account of the differences in impedance of the line at the two points at which the measurement is carried out. If, at the point considered, the value of the power, voltage or current, as the case may be, is greater than the corresponding value measured at the sending end, the sign of the transmission level in this case is positive ($+ b$); if it is less, the sign is negative ($- b$).

In the case of 4-wire circuits, the transmission level at any point on a circuit contracted for must be within the limits $b = + 1 \cdot 1$ or $+ 9 \cdot 6$ TU and $b = - 3 \cdot 0$ or -26 TU. In the case of 2-wire circuits, it is desirable to maintain the level between the limits $b = + 0 \cdot 6$ or $5 \cdot 2$ TU and $b = - 1 \cdot 6$ or $13 \cdot 9$ TU.

The contractor should give detailed information as to the variation in transmission levels for each of the type of circuits contracted for.

* The figures, marked with an asterisk (*) are provisional and should be verified by the Administrations concerned.

4. **Echo Effects.**

There must be no appreciable echo effect when a conversation is carried out between two terminal exchanges by means of ordinary telephone apparatus, including or not including anti-echo devices.

In order to satisfy this condition and to eliminate the possible echo effects, special means may be employed where this becomes necessary.

The contractor must forward detailed information as to the measures taken to ensure the absence of echo on the terminated circuit.

5. **Transient Phenomena.**

On terminating circuits there should not be any appreciable alteration in the articulation (quality of speech) on account of transient phenomena.*

6. **Stability of Circuits.**

Circuits must remain stable under all ordinary atmospheric conditions and for all the normal conditions of termination for which the circuit has been designed.

From this point of view, the circuit is considered as unstable when the quality of the conversation is appreciably affected by any reaction produced at any point in the circuit, even if this does not consist of actual " singing " (howling).

In order to ensure that a telephone circuit fulfils the conditions indicated above, the amplification of the repeaters on the circuit, assumed to be connected to the usual equipment, should be maintained at a value sufficiently below the singing point (for example lower by an amount $b = 0{\cdot}4$ or 3·5 TU.†

7. **Cross-talk and other Disturbances.**

Cross-talk shall be measured and corrected by the method described on page 50 and 51.

Cross-talk measured in the various component parts of the circuits shall remain within the limits fixed in each of the separate foregoing specifications. It is desirable to choose the various component parts of international circuits in such a way as to obtain on these circuits as low a value of cross-talk as possible.‡

In commercial working, international circuits should be protected from disturbance due to external causes (*e.g.* power lines) or causes arising in the repeater stations themselves.§

8. **Cross-talk between Pairs of 4-Wire Circuits.**

Measures shall be taken to reduce to a minimum the cross-talk between pairs of conductors used for the " go " and " return " of a 4-wire circuit; for example, the conductors in " go " conductors shall be separated from the " return " conductors throughout the whole length of the cable, as well as in the repeater stations. The contractor should indicate the means adopted in this respect.

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* Appendix (*c*) outlines the tests proposed by the German Administration in order to verify that the circuit is satisfactory in this respect, and Appendix (*d*) contains the comments of the International Standard Electric Corporation on the same point.

† For the exact definition of the " singing point " refer to page 45, line 5, of the Blue Book (C.C.I., Paris, 1925).

‡ *See* Appendix (*a*), paragraph headed : " Cross-talk."

§ Investigation is in progress to determine the maximum tolerable limits of noise due to various disturbances.

APPENDIX A.

The points mentioned in this appendix have not been quoted in the typical specification, the International Consultative Committee considering that in the actual state of the art, it is not possible to specify definite figures. The C.C.I. has merely put on record the following considerations accompanied by authoritative information.

(a) Type of Repeaters, Loading, etc.

The contractor should give detailed information on the gauge of the conductor, the type of loading, the spacing and the type of repeaters which he proposes to instal.

The C.C.I. recommend the following numerical limits. The contractor should explain any appreciable deviation from these limits.

Gauge of Conductors.

The C.C.I. recommends that diameters at least equal to 0·9 mm. or 1·3 mm. should be adopted for the conductors of underground cables, on the understanding, however, that there will not be more than two types of conductors in the same cable.

Type of Loading.

The type of loading has been specified in the " Essential clauses for a typical specification for a section included between two successive repeaters," but the C.C.I. desires to point out that on circuits of a length greater than 700 km., echo effects and transient phenomena are factors of increasing importance. It has not at its disposal sufficient data to justify a definite recommendation on this point, but in all doubtful cases the loading should be extra-light.

Type of Repeaters and Spacing of Repeaters.

The C.C.I. considers that the choice of the type of repeater (2-wire or 4-wire) depends to such an extent on the quality of the lines, etc. . . . that, in view of the numerical limits recommended at present for distortion, transient phenomena and echo effects, there is no need to specify any definite value of attenuation, above which the 2-wire system should be used instead of the 4-wire system, nor to specify the positions of repeater stations.

(b) Cross-talk.

Experiments have been made to fix the maximum tolerable value of cross-talk on long telephone circuits. The value to which these experiments have led corresponds to an attenuation of $b = \pm 6{\cdot}2$ or 54 TU. For this value, speech on one circuit can just be heard on the other circuit, but it becomes quite unintelligible, when heard from subscriber's instruments. In any case, it is extremely desirable to obtain a value of cross-talk corresponding to a higher attenuation and all practicable means should be made to attain this end.

It is considered that on circuits of a length less than 500 km., cross-talk should be considerably less than that corresponding to the above value (of attenuation).

APPENDIX B.

Points concerning the specification for complete circuits equipped with repeaters and which are to be made the object of further investigation :—

(*a*) Limits of distortion on 2-wire circuits.

(*b*) Conditions under which transient phenomena become detrimental.

(*c*) Permissible limits of cross-talk between circuits and between the pairs of " go " and " return " conductors of 4-wire circuits.

APPENDIX C.

CIRCUIT ATTENUATION.

Circuits of a length greater than 500 km. should have a mean over-all attenuation greater than $b = 4 \cdot 3$ or $37 \cdot 3$ TU for all frequencies exceeding by more than 10 per cent., the highest frequency which the circuit should transmit. For all frequencies which the circuit should transmit the period of growth of an alternating current suddenly applied should not exceed 30 milliseconds.

The Administrations interested are invited to verify the above figures.

APPENDIX D.

MEMORANDUM OF THE INTERNATIONAL STANDARD ELECTRIC CORPORATION CONCERNING LIMITS IMPOSED ON THE SPECIFICATION FOR COMPLETE SYSTEMS BY TRANSIENT PHENOMENA IN INTERNATIONAL TELEPHONY.

The German Administration has proposed that "for circuits over 500 km. in length, the values of the mean residual attenuation for all frequencies exceeding the highest frequency to be transmitted by more than 10 per cent. should be greater than $b = 4 \cdot 3$ or $37 \cdot 3$ TU."

The objectionable effect of transient phenomena does not depend directly upon the frequencies transmitted in any system, but on the ratio between the highest frequency transmitted without excessive attenuation and the critical frequency of the transmission circuit.

Definite values for the critical frequencies have already been fixed by the C.C.I. for international circuits.

We therefore propose that the limit $b = 4 \cdot 3$ or $37 \cdot 3$ TU should apply to frequencies between the critical frequency and a frequency, 14 per cent. below the critical frequency.

The German Administration has further proposed that "for all the frequencies to be transmitted, the building-up period of an alternating current, suddenly applied, shall not be greater than 30 milliseconds." The extent of the detrimental effect is thus limited in a satisfactory manner, but as the expression "frequencies transmitted" is not clearly defined, because the approach to the critical limit for the whole circuit is more or less progressive, and as the time of growth depends on the critical frequency of the line, we propose that the phrase should read "for all frequencies transmitted up to 78 per cent. of the critical frequency, etc."

APPENDIX E.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR THE SUPPLY OF LINE TRANSFORMERS.

This Specification concerns transformers to be used on circuits equipped with telephone repeaters.

General Clause.

1. The ratio of transformation shall be such, that when the transformer is connected to the circuits for which it has been designed, the impedance measured at the ends of the windings on the exchange side should be within the limits fixed by the C.C.I., that is to say, provisionally 800 ohms $\pm$ 12 per cent.

2. The efficiency for any frequency between 300 and 1,200 p.p.s. and for currents varying from 2 milliamperes to 0·03 milliamperes should be at least 75 per cent. when the transformer is connected to the impedances for which it has been designed.

3. The transformer should be balanced from the point of view of inductance, resistance and capacity in such a manner that the cross-talk between the windings corresponding to side circuits and to the phantom circuit, do not exceed the value corresponding to $b = 8{\cdot}5$ or 74 TU when these windings are connected to perfectly balanced non-inductive resistances, representing the lines.

4. The insulation resistance between any two windings or between any winding and the case (or the screen, if a screen is used) shall not be less than 500 megohms when it is measured with a d.c. voltage of 100 volts. The dielectric strength between the winding on the line side and the winding on the exchange side, as well as the dielectric strength between any winding and the case or the screen (if a screen is used) shall be sufficient for these windings to withstand the application of an alternating voltage of 500 volts at a commercial frequency.

5. The properties (or constants of the transformers) shall not vary to an appreciable extent under the action of the continuous or alternating currents which occur in practice.

6. Cross-talk between adjacent transformers shall be negligible.

Special Clauses.

7. Transformers designed for use in the line and network circuits of 2-wire repeater installations.

In 2-wire repeatered circuits, when a transformer is inserted on the line side and another transformer is inserted on the network side, these two transformers shall be selected in pairs, in such a way that the vector impedance measured at the terminals of the winding on the repeater side between 300 and 2,500 p.p.s. and under normal and symmetrical working conditions shall be the same within approximately $\pm$ 2 per cent., whatever may be conditions of current, temperature, etc., occurring in practice.

8. Transformers are designed to transmit signalling currents at a low frequency of about 16 to 25 p.p.s. The efficiency shall not be less than 55 per cent. for currents having a frequency of 16 to 25 p.p.s. under working conditions.

APPENDIX B.d.2 No. 5.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION OF GENERAL APPLICATION TO LOADING COILS FOR INTERNATIONAL TELEPHONE CABLES.

The loading coils shall be suitable for loading both side and phantom circuits. The coils employed shall be assembled to form a unit of loading, so that when this unit is inserted in any quad, both side and phantom circuits shall be loaded. The electrical requirements hereinafter specified apply to the side and phantom circuits of such a unit of loading.

The magnetic material employed shall be of the compressed iron dust type or other approved material having equally satisfactory characteristics.

Housing.

The coils shall be encased in suitable protective cases which shall be hermetically sealed. The cases shall be waterproof and able to withstand being buried in damp ground without deterioration.

Means shall be provided for easily connecting the loading units to the main cable.

Magnetic Stability.

The magnetic stability of the core material shall be such that the inductance of a coil shall not vary by more than $\pm$ two and one half ($2\frac{1}{2}$) per cent. after direct current of any value between zero (0) and two (2) amps. has been allowed to pass through one line winding. This test shall be made five (5) minutes after the cessation of the direct current. This is a destructive test and should be applied only to sample coils.

Inductance.

The inductance measured with a current of one (1) m.a. at 1,800 periods per second shall be equal to the values stated for side and phantom circuits, with a tolerance of $\pm$ (2) per cent.

Effective Resistance.

The effective resistance of the side or phantom circuit measured with a current of one (1) m.a. at 1,800 periods per second shall not exceed one hundred and fifty (150) ohms per henry of the specified inductance.

Cross-talk.

The cross-talk in potted loading coils shall be measured with an alternating current of not less than five (5) milliamperes at 800 p.p.s., or with speech, under conditions in which the side circuits are terminated with non-reactive resistance of twelve hundred (1,200) ohms and the phantom circuits with a non-reactive resistance of eight hundred (800) ohms. The incoming terminals of the circuit under test and the outgoing terminals of the apparatus used for comparison will be joined in parallel and to the source of current. In the correcting formula corresponding to this arrangement 1,200 ohms or 800 ohms will be taken as the value of Z_1 or Z_2, as the case may be.

In cases of dispute speech tests shall be taken as final.

The maxima values of attenuation, corresponding to the cross-talk values expressed in *b* or TU, shall not be less than the figures quoted below :—

	b	TU
Between side circuit and side circuit in the coil unit	9	78
Between side circuit and phantom circuit in the coil unit	8	69
Between phantom circuit and phantom circuit	9	78

Insulation Resistance.

The insulation resistance of any line winding of a loading coil unit against all other line windings (both in the same unit and in all other loading-coil units) and the case shall not be less than ten thousand (10,000) megohms. This test shall be made with a potential not less than one hundred (100) nor more than five hundred (500) volts at a temperature of not less than fifteen (15) degrees Centigrade (approximately 60° F.).

Dielectric Strength.

The insulating material between any two line windings shall withstand, without rupture, a difference of potential, with a R.M.S. value not exceeding five hundred (500) volts. This test shall be made with an alternating current of a frequency not less than fifty (50) cycles per second, the voltage being applied instantaneously.

The insulation between any line winding and the case shall withstand, without rupture, a difference of potential of any effective value not exceeding two thousand (2,000) volts, applied during two (2) minutes.

The maximum value of the testing voltage shall not differ by more than ten (10) per cent. from that of a true sine wave of the same R.M.S. value.

LIST OF TRANSMISSION QUESTIONS TO BE STUDIED.

Questions Concerning Standard Reference System.

The International Consultative Committee submits the following questions for study :—

1. How shall the primary Standard Reference System be compared with the fundamental system and at what intervals of time will it be necessary to make such comparative measurements ?
2. What are the different permissible methods of constructing secondary Reference Systems ?
3. How shall the secondary systems be compared to the primary systems or to the fundamental systems and at what intervals of time should these comparisons be repeated ?
4. How shall the working standards corresponding to the different types of commercial telephone connections existing in the different countries be constructed ?
   How shall these working standards be related to the fundamental, the primary and secondary systems, and at what intervals of time shall these calibrations be repeated ?
5. How can the practice coefficient of the different sets of observers making laboratory and voice tests be defined and determined ?
6. What tests (physical and physiological) shall be employed in recruiting observers in order to ascertain the state of their hearing and their voice ?
7. How can be defined and determined the mean correction factors corresponding to different languages in order that the results of tests of clearness made in different countries may be compared, taking account of the language used ?
8. Does the figure 0·05 volt per dyne per centimetre squared specified previously in the proposals of the Conference of London for the zero point of the transmitting system correspond well to the efficiency of the standard transmitting systems of commercial types used by the different Administrations in their working standards for every-day measurements ?
9. Does the figure 50 dynes per centimetre squared per volt specified for the zero point of the transmitting system correspond well to the efficiency of the standard receiving systems of commercial types used by the different Administrations in their working standards for every-day measurements ?
10. In measurements of transmission equivalents or transmission efficiency is it desirable to apply corrections to the results because of the difference in impedances between the apparatus measured and the corresponding parts of the reference system ?

Additional Transmission Questions.

Permissible limit of transmission loss caused by apparatus inserted in international telephone circuits either in series or parallel.

General conditions to be satisfied by overhead lines used for international circuits.

General conditions to be satisfied by sections of cable inserted in these overhead lines in regard to losses of efficiency and impedance irregularities.

Possibility of standardising systems of long-distance telephony.

C. LIST OF APPENDICES ON TRANSMISSION QUESTIONS.

C.a.1.	No. 1.	Method of measurement with single frequency, employed in Great Britain, as a substitute for voice tests.
C.a.1.	No. 2.	Method of measurement with single frequency, employed in Germany, as a substitute for voice tests.
C.a.1.	No. 3.	Note by the International Standard Electric Corporation regarding the choice of a single frequency to be used for routine transmission loss measurements.
C.a.1.	No. 4.	Note on crosstalk by the Service d'Etudes et de Recherches techniques Français.
C.b.1.		Different ways in which two Telephone Administrations can co-operate in the construction of a repeater section which crosses a frontier.
C.c.1.	No. 1.	Notes on the transmission testing by means of speech of telephone transmitters and receivers, as carried out in the British Post Office Engineering Department; with special reference to selection and maintenance of standards.
C.c.1.	No. 2α.	British Post Office method of measuring the transmission efficiency of a subscriber's installation from the central office.
C.c.1.	No. 2β.	British Post Office method for measuring the efficiency of a subscriber's station from the central office by means of alternating current.
C.c.1.	No. 3.	Method of testing subscribers' instruments from the central office (International Standard Electric Corporation).
C.c.1.	No. 4.	Method used by the German Administration for testing a complete subscriber's installation from the local telephone exchange.
C.c.3.	No. 1.	The switching of 4-wire circuits at terminal exchanges to similar circuits or to circuits of a different type. (International Standard Electric Corporation.)
C.c.3.	No. 2.	Through traffic for long-distance circuits effected at the through switching positions.
C.c.4.	No. 1.	Siemens & Halske echo suppressors for 4-wire circuits.
C.c.4.	No. 2.	Echo Suppressors for Long Telephone Circuits (International Standard Electric Corporation).
C.c.4.	No. 3.	Echo Suppressor (British Post Office System).
C.d	No. 2.	Report of the German Administration with reference to long-distance communications on extra light loaded toll cables.
C.e.	No. 1.	The Siemens Impulse Meter.
C.e.	No. 2.	Apparatus for the measurement of Speech Volume (British Post Office System).
C.f.	No. 1.	Voice Frequency Carrier Telegraph System for Cables (International Standard Electric Corporation).
C.f.	No. 2.	Metallic Polar-Duplex Telegraph System for Long Small-Gauge Cables (International Standard Electric Corporation).
C.f.	No. 3.	System of Earth Return Telegraphy, derived from Phantom Circuits, used by the German Administration.
C.f.	No. 4.	System of Telegraphy, derived from Telegraph Circuits, used by the German Administration (Siemens & Halske System).
C.f.	No. 5.	System of Voice Frequency Carrier Telegraphy used by the German Administration (Siemens & Halske System).

APPENDIX C.a.1 No. 1.

METHOD OF MEASUREMENT WITH SINGLE FREQUENCY, EMPLOYED IN GREAT BRITAIN AS A SUBSTITUTE FOR VOICE TESTS.

The suggestion to make use of a series of single frequency alternating-current tests in place of speech tests was made at an early stage in the art of telephone transmission measurement. In many cases such measurements are of considerable value, but, where resonant apparatus (such as transmitters and receivers) is present, serious errors will be introduced should one of the testing frequencies coincide with a resonant frequency.

In order to simulate speech it has been proposed to construct an apparatus which repeated rhythmically a series of frequencies covering the important speech-frequency range. This has the double advantage that any given frequency is not in operation sufficiently long to cause the resonance of any part of the circuit or apparatus under test to predominate unduly, and also to average up the results of a large number of frequencies. In 1915 and 1916 a considerable amount of work was done by means of a special series of interrupters driven from a machine of which the speed was rhythmically varied (*see* paper entitled " Telephonometry," by B. S. Cohen, Proceedings I.P.O.E.E., 1916), and later a special interrupter wheel was built such that when driven at a constant speed the speed of the interruptions varied rhythmically as the wheel rotated. This device has been in general use for some years for certain special tests. The frequency range is 600 p.p.s. to 1,300 p.p.s. repeated 300 times per minute. The disadvantages of this arrangement are that it is impossible accurately to duplicate the apparatus and there is little control over the magnitudes of the different frequencies. An interrupter also cannot be guaranteed to give the same A.C. output wave form from time to time.

It is now proposed to build oscillators which can be made to vary in frequency over a specified range by the continuous rotation of a small air condenser. It is found possible by the use of specially built iron cored inductances to make use of an air condenser of the order of 0·001 microfarad (max.) to vary the frequency between wide limits without seriously varying the output. An alternative arrangement which is being experimented with, and will probably prove the simplest in practice, is to rhythmically vary the inductance in the oscillator circuit by means of a rotating armature of stalloy. The capacity then, of course, takes the form of a condenser of fixed value. An oscillator is now being built with a continuously varying frequency range of about 600 p.p.s. to 2,500 p.p.s., which has been found to be a suitable range for the testing of transmitters and receivers. This is also to be used to operate a receiver, the acoustic output of which can be used for measurements of the efficiency of subscriber's telephone apparatus, as has been elsewhere described. A rhythm of at least 200 per minute appears to be necessary and there is no difficulty in getting steadv readings with commercial pointer type measuring instruments at this speed.

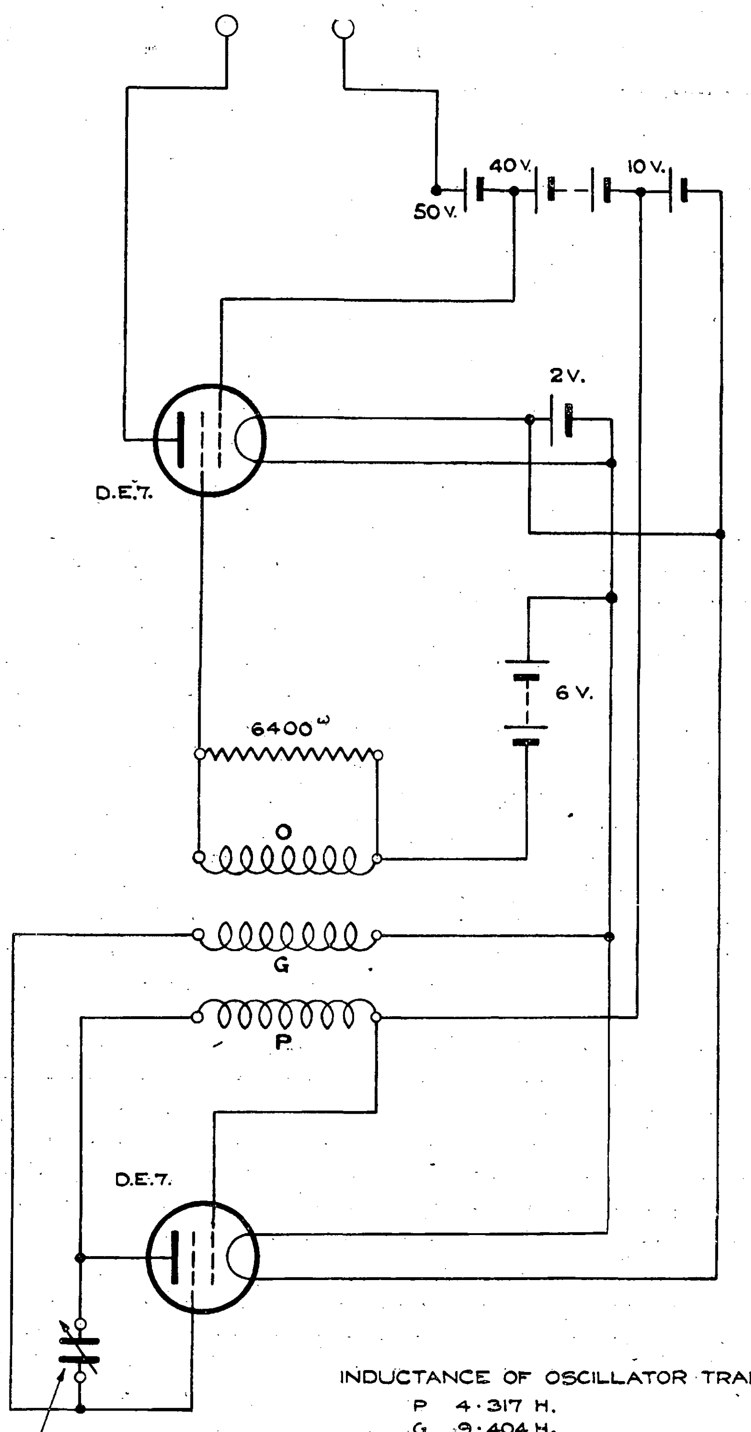
A similar rhythmic oscillator will be used for experiments on the measurement of cross-talk and it is proposed to operate this at a frequency range of 600 p.p.s. to over 2,500 p.p.s. in conformity with the results obtained in Germany for a series of single frequency measurements and put before the Conference by Dr. Breisig.

It is proposed to use the rhythmic oscillator for subscriber's instrument efficiency testing in conjunction with a thermionic valve-measuring instrument. With such an instrument incorporating a rectifying and amplifying valve and a continuous current moving coil pointer type instrument a measurable deflection can be obtained for ·01 volt. The circuit (Fig. 1, on page 103) contains two dull-emitter type four electrode valves used as oscillator and amplifier respectively, and this arrangement is suitable for a portable set owing to the low high-tension and low-tension battery consumption.

In the case of cross-talk measurements it will be necessary to measure values of the order of 40 millionths on a cross-talk meter, and if the oscillator output is 1 volt, this will represent ·00004 volt and will therefore require about 3,000 times further amplification. It is questionable whether a multi-stage amplifier to give this further amplification will be practically usable for field tests owing to complication, weight and liability to instability, and whilst experiments in this connection will be carried out it is expected that aural balances using a telephone receiver will prove the most practicable arrangement.

RHYTHMIC OSCILLATOR.

APPARATUS TAKEN TO SUBSCRIBER'S OFFICE.



0·001 μF MOTOR DRIVEN VARIABLE AIR CONDENSER.

INDUCTANCE OF OSCILLATOR TRANSFORMER

P 4·317 H.
G 9·404 H.
O 4·437 H.

FREQUENCY RANGE 600 – 1475 ~/SEC. APPROX:
OUTPUT 1·38 V. AT 600 ~/SEC. TO 1·5 V. AT 1475 ~/SEC. ON BELL RECEIVER (2000 OHMS).
SPEED OF CONDENSER 200 R.P.M.

APPENDIX C.a.1 No. 2.

METHOD OF MEASUREMENT WITH SINGLE FREQUENCY, EMPLOYED IN GERMANY AS A SUBSTITUTE FOR VOICE TESTS.

The German Postal Administration has had carried out some tests which have shown that measurements with the voice cannot produce reliable results. It is primarily the difference in electro-acoustic qualities of the telephone used in voice tests which causes unreliability.

For a given telephone the observations of from three to five independent observers do not differ from their mean by more than $b = 0 \cdot 2$ or $1 \cdot 7$ TU (rarely by $b = 0 \cdot 3$ or $2 \cdot 6$ TU) whatever may be the variation of the speaker and whatever the nature of the transmitting system.

On the other hand, the mean figures of the observers for one telephone differ from the mean figures of the same observers for another telephone by $b = 1 \cdot 5$ or 13 TU; even the mean differences for eight telephones are $b = 0 \cdot 4$ or $3 \cdot 5$ TU.

Special tests on two transmitters, which showed big differences, demonstrated that these had several resonant frequencies, differently situated in each.

It follows that if measurements are made with an oscillator having a multiple frequency output, the results obtained will not be better than when using the voice, since from amongst the multiplicity of frequencies produced one or another will suffer resonance or suppression more than the remainder, according to the particular properties of the diaphragm of the transmitter employed.

Recently another method has been tried, which gives results of practically the same value as with the voice, but in a reproducible form.

Measurements are made at a number of single sine wave frequencies within the voice spectrum. If the exact relative value of each frequency in the make-up of the language were known, it would be possible to combine the different measurements in such a manner that their sum or their mean would give a characteristic value for the case in point. But since these relative values are unknown and perhaps different for different languages, it is only possible to combine certain frequencies in different ways and to compare the mean thus obtained with the value obtained with the voice tests. Calculations have been made which were related to 28 different circuits comprising side circuits and phantom circuits whether medium or light loaded, balanced or not, and of loading coil cases, measured at the frequencies of 640, 800, 955, 1115, 1,280, 1,910 and 2,225 periods per second. Then combinations were made from the above. Those which gave an integral mean, differing the least from the values obtained with the voice, were those measured at the frequencies of 640, 800, 1,115 and 1,910 periods per second.

Since in each particular case a single frequency was used, results were independent of the telephone employed. However, because of the arbitrary choice, the mean calculated for the whole group of the above frequencies gives a mean difference of $b = 0 \cdot 2$ or $1 \cdot 7$ TU (maximum $b = 0 \cdot 6$ or $5 \cdot 2$ TU) compared with the figure obtained with the voice test. The maximum figure is then the same as that obtained for the differences of the mean of five observers, each one in turn using several telephones. The measurement at four single frequencies gives then for an observer with any telephone the same precision as the voice measurement with several observers, each using several telephones. But, besides the greater brevity of this method of calculating the value, the straightforward measurements have the advantage of being reproducible. If the method of calculation is fixed once for all, the true meaning of guarantee figures in tenders will be completely defined.

It is suggested that Administrations interested attempt to find for their particular conditions a similar combination of frequencies which will give by calculation a figure of b or TU sufficiently equal to that which will be found by measurements with the voice.

APPENDIX C.a.1 No. 3.

NOTE BY THE INTERNATIONAL STANDARD ELECTRIC CORPORATION REGARDING THE CHOICE OF A SINGLE FREQUENCY TO BE USED FOR ROUTINE TRANSMISSION LOSS MEASUREMENTS.

In the report of the June 1925 Meeting of the C.C.I., the opinion of the Sub-Commission handling this question reads as follows :

> "That it is desirable to have, for ordinary measurement, a current of definite frequency—and a frequency which is always the same—that this frequency should be as near as possible to that of the average frequency of spoken sounds."

The "ordinary measurement" referred to above is, of course, that necessary for the maintenance of the plant involved in an international cable system, and the various items of plant may be broadly divided under the following heads :

(1) Cable or open wire lines.
(2) Repeaters.
(3) Interposed or bridged apparatus.

This question of the relation between voice current losses and single frequency losses has been the subject of extensive investigations by the American Telephone and Telegraph Company. Very many tests have been made with various types of cables and apparatus. With each item tested a series of measurements was taken :

(*a*) With various single frequencies.
(*b*) With speech.

For each of these, a balance was obtained by adjusting an artificial line of 600 ohms impedance until it was found to introduce the same attenuation to the testing current as the cable or apparatus under test.

The result of these investigations from the standpoint of cable and open wires may be briefly stated as follows :

With cables loaded to a high cut-off point such as extra light loading on 1,830 m. spacing and with non-loaded open-wire lines, that is in cases where the attenuation frequency characteristic is approximately flat over a wide range, there is a very close correlation between talking tests and any single frequency between 700 cycles and 1,300 cycles.

With non-loaded cables and cables loaded to a cut-off frequency not higher than 2,300 cycles, that is cases where the attenuation frequency characteristic has a distinct slope, tests at 1,000 cycles give a much closer approximation of talking test results than tests at 800 cycles.

Cables loaded with 177 mh. side circuit coils on 1,830 m. spacing have a cut-off point higher than 2,300 cycles and thus fall between the two categories outlined above.

From the standpoint of Repeater Gain measurements, the gain frequency characteristics are either flat over a wide range or rise with frequency to an extent necessary to counteract the distortion on the cable with which they are associated. In either case the gain frequency characteristic is fairly constant between frequencies of 700 cycles and 1,000 cycles and any frequency within this range is equally satisfactory.

Interposed or Bridged Apparatus of the types normally occurring in practice, as, for example, repeating coils or bridged ringing apparatus, do not contribute to over-all loss measurements to any large extent, and in any case have attenuation frequency characteristics which, for the most part, are either flat over a wide range or so shaped that the sloping characteristic of the cable with which they are associated is corrected. In either case they may be neglected in the present question.

The conclusions which the A.T. & T. Co. have drawn from their investigations are that, as non-loaded cable and cable with a low cut-off point will enter into overall loss measurements, these types become the controlling factors. These types demand a definite frequency, whereas other types offer a wide choice of test frequencies. Consequently 1,000 cycles has been chosen as suitable for all types.

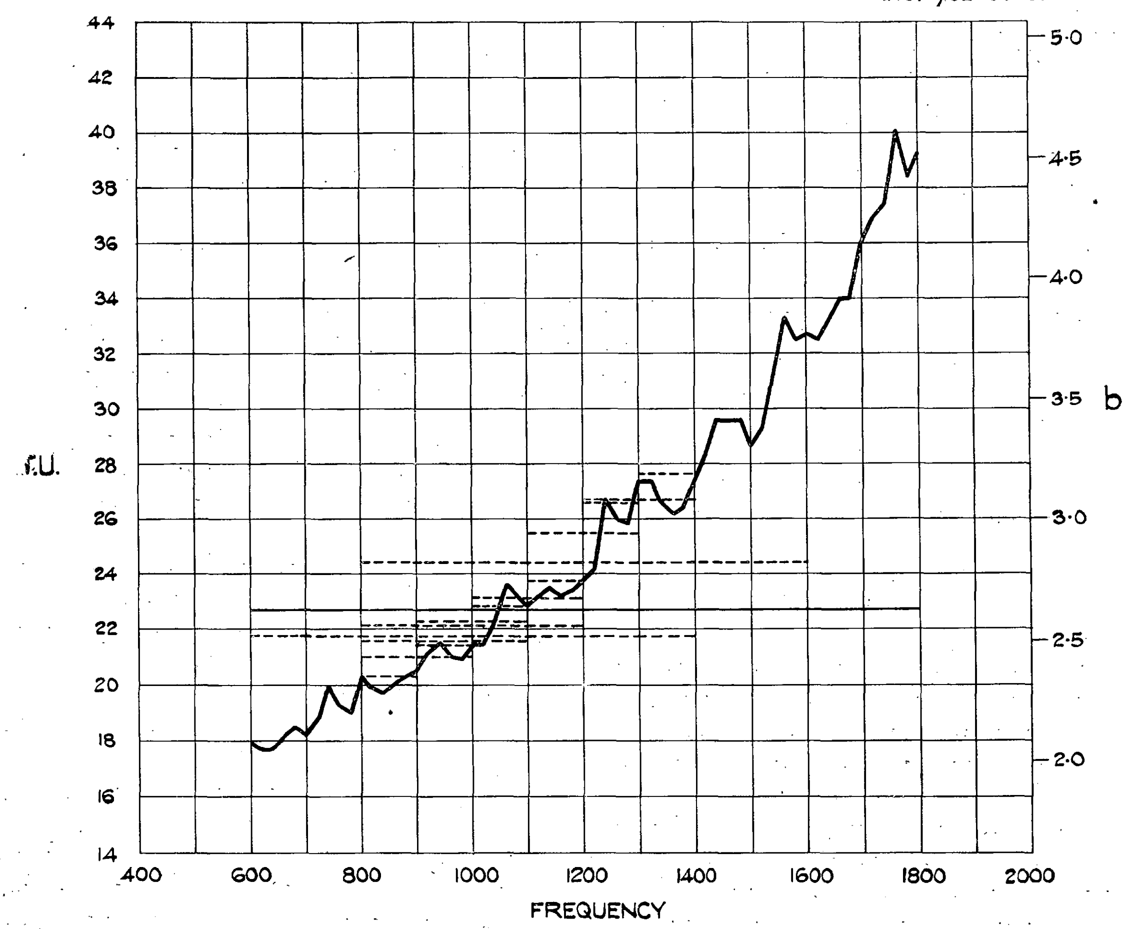
The attached memorandum gives samples of the test results which have led the A.T. & T. Co. to adopt the routine test frequency of 1,000 cycles.

Some Experimental Results obtained in the Search for a Suitable Single Frequency for Measuring Currents.

The attached curves show for certain typical types of facilities now in the plant results of single frequency transmission tests within a range of frequencies compared to voice tests. The full irregular curves show the transmission frequency runs, while the full horizontal line is the value obtained by talking tests. The dashed horizontal lines were obtained by frequency band measurements and need not be considered in the present discussion. The transmission equivalents measured are expressed on these curves in terms of miles of standard cable at 800 cycles.

Drawings Nos. 701–6610, 701–6623, 701–6617 and 701–6601 give measurements of typical circuits in the Boston–Washington cable. These circuits are of the low cut-off type having sloping transmission frequency characteristics. They do not, of course, represent the later developments in cable circuits, but are still in service and will continue to be used for some time to come.

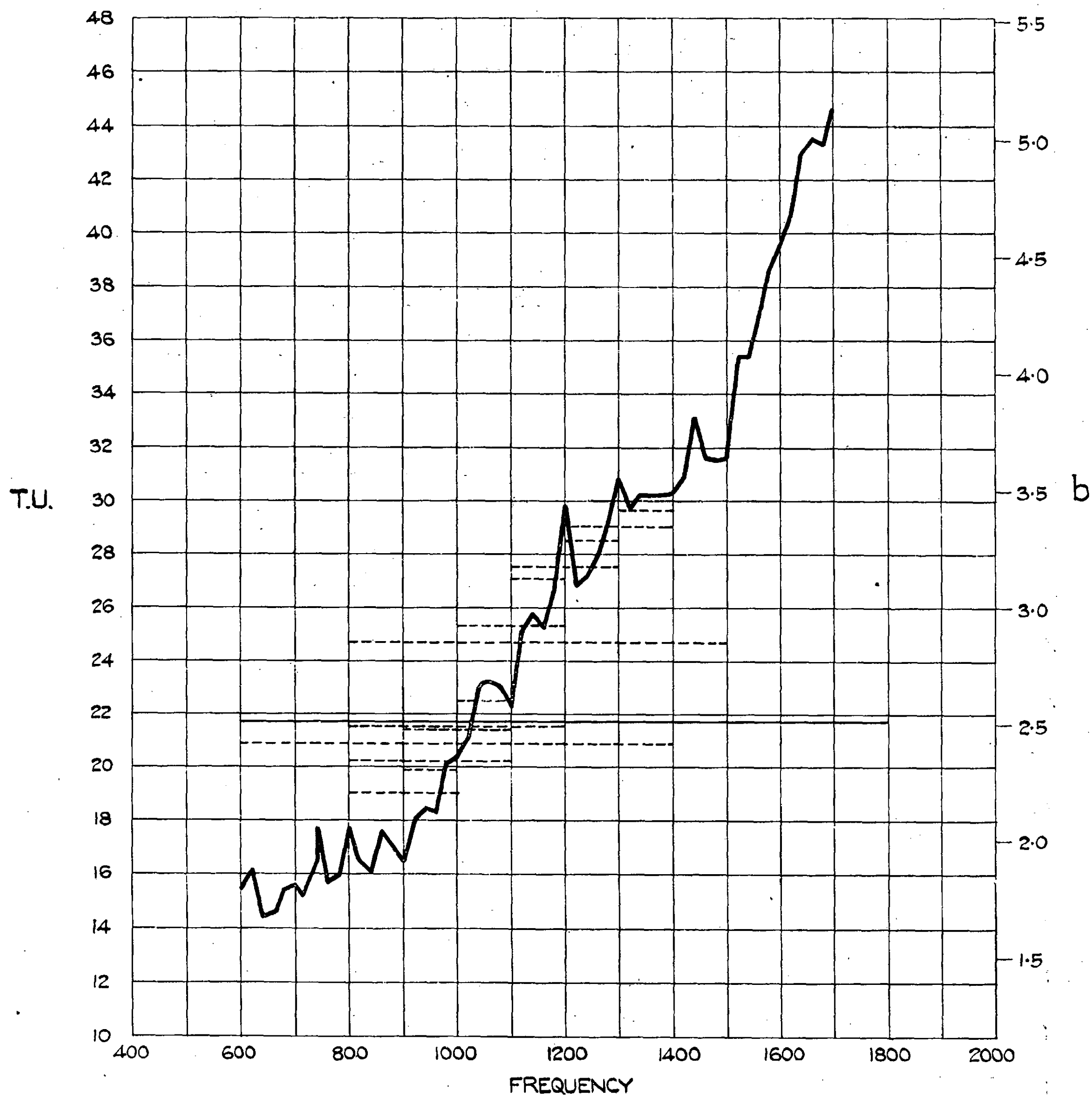
No. 701–6610.



TRANSMISSION MEASUREMENT.

CABLE—241·6 MILES.
13 GAUGE HEAVY LOADED SIDE.
THESE MEASUREMENTS WERE MADE FOR COMPARISON WITH SIMILAR MEASUREMENTS MADE SEPTEMBER 25, 1925, WITHOUT APPARATUS.

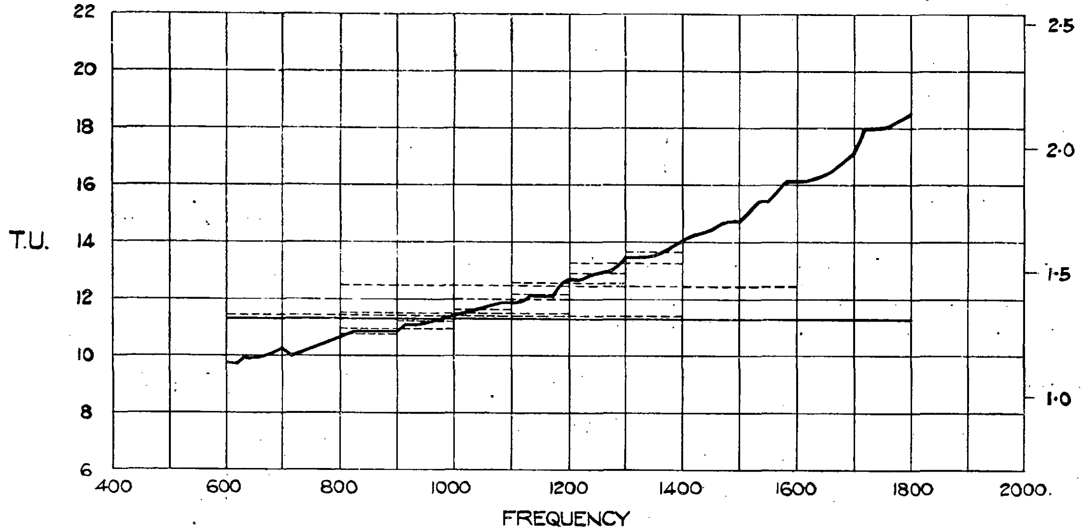
No. 701-6623.



TRANSMISSION MEASUREMENT.

19 GAUGE CABLE.
8 REPEATERS.

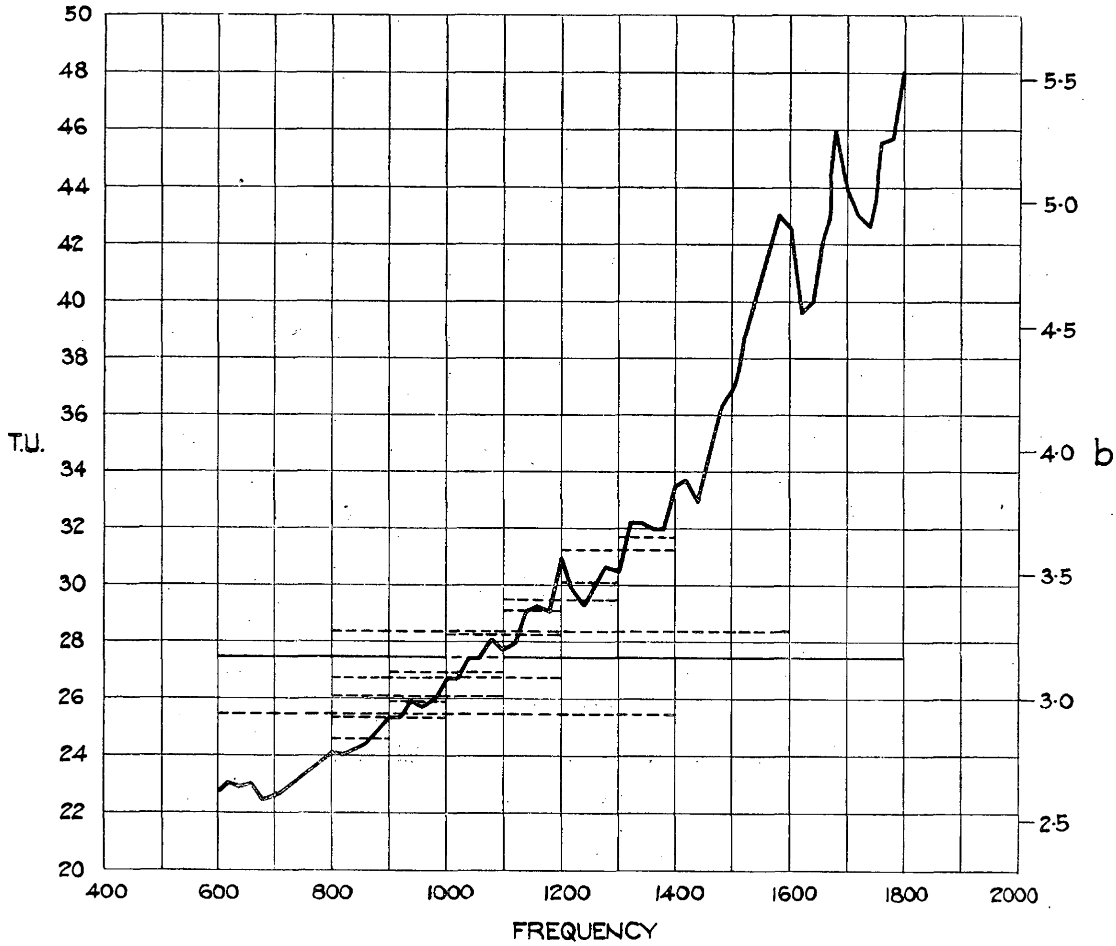
No. 701–6601.



TRANSMISSION MEASUREMENT.

CABLE—175 MILES.
10 GAUGE MEDIUM HEAVY LOADED SIDE, WITHOUT APPARATUS.

No. 701–6617.

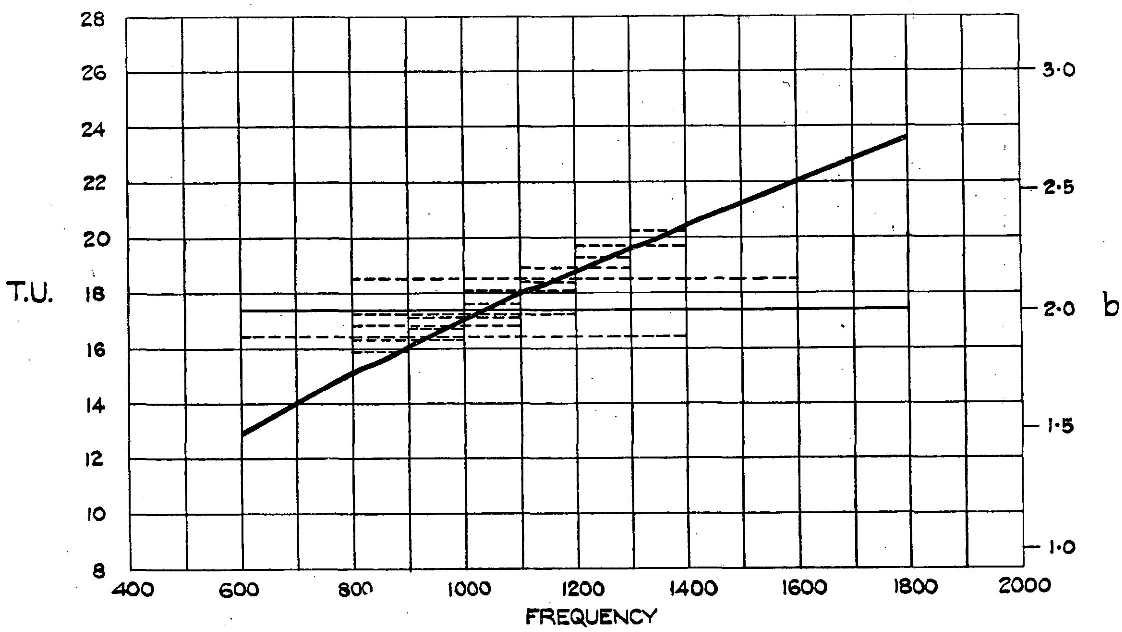


TRANSMISSION MEASUREMENT.

CABLE—300 MILES.
13 GAUGE MEDIUM HEAVY LOADED PHANTOM, WITHOUT APPARATUS.

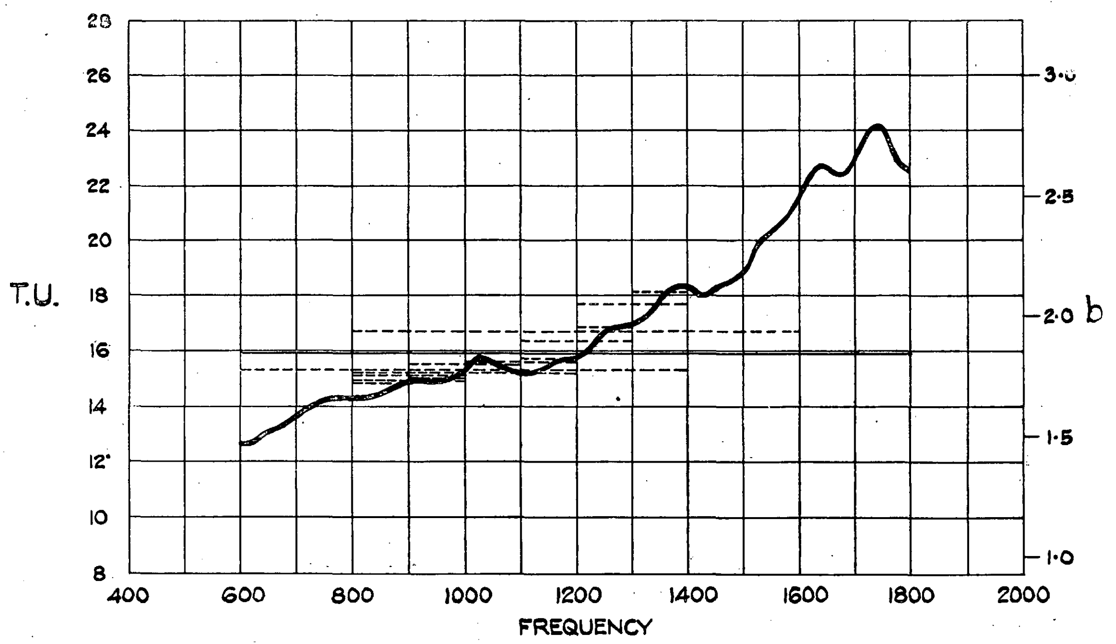
Drawing No. 701–6644 shows measurements of an artificial cable circuit, the characteristics of which are representative of non-loaded cable in the plant. Drawing No. 701–6633 shows

No. 701–6644.



TRANSMISSION MEASUREMENT.
16 MILES ARTIFICIAL CABLE.

No. 701–6633.

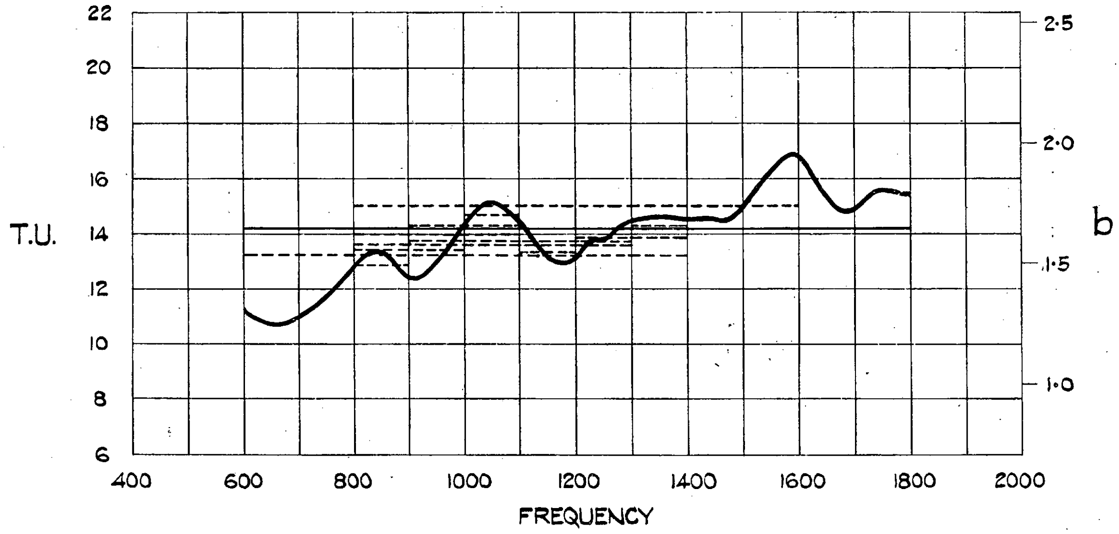


TRANSMISSION MEASUREMENT.

OPEN WIRE—326 MILES.
12 GAUGE LOADED SIDE.
INSULATION POOR AND CIRCUIT CHANGEABLE, WITHOUT APPARATUS.

measurements on a loaded open wire 104 copper circuit (2·64 mm), while Drawing No. 701–6630 is for a combination of loaded and non-loaded open wire. These types of open wire circuits are still quite extensively used in the plant.

No. 701–6630.



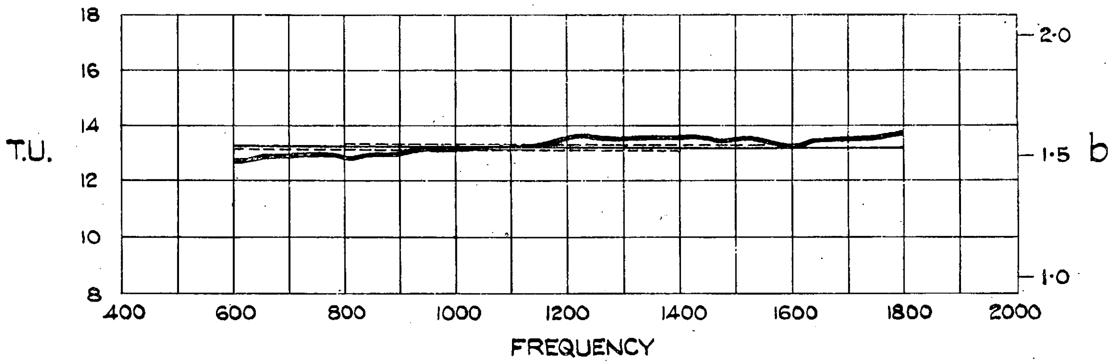
TRANSMISSION MEASUREMENT.

OPEN WIRE—218 MILES.
8 GAUGE NON-LOADED SIDE LOOPED TO 12 GAUGE LOADED SIDE,
WITHOUT APPARATUS.

In all of the drawings referred to above it will be noted that measurements at 1,000 cycles give appreciably better correlation with talking tests than do measurements at 800 cycles. For this reason, 1,000 cycles was chosen as a convenient value of measuring current frequency which would give results sufficiently close for all practical purposes to those which are obtained by talking tests.

Drawing No. 701–6629 shows results of tests of a non-loaded wire circuit which is of the type having the flat transmission frequency characteristics. This is also fairly representative of the later types of high cut-off cable circuits. It will be noted from this drawing

No. 701–6629.



TRANSMISSION MEASUREMENT.

OPEN WIRE LINE—226 MILES.

that fairly good correlation with talking tests is obtained over a wide range of frequency so that the value of measuring frequency used is not so important as in the case of the older type of circuits referred to above.

APPENDIX C.a.1 No. 4.

NOTE ON CROSS-TALK BY THE SERVICE D'ETUDES ET DE RECHERCHES TECHNIQUES FRANÇAIS.

General.

In accordance with the desire expressed by the C.C.I. during its session of 22–29 June, 1925, the Research Organisation of the French P.T.T. has undertaken some tests on cross-talk. The aim of these tests has been to determine:

(1) A method sufficiently practical, on the one hand, of determining the actual trouble introduced by cross-talk into a telephonic communication.

(2) A method sufficiently precise, on the other hand, to give a reliable technical basis for acceptance tests of a telephone system.

The tests undertaken have been of two kinds:

A. Comparison of test results obtained with the voice as a source, using a cross-talk meter, with various testers and different transmitters and receivers, as well as with test results obtained by means of a source of complex tone.

B. Comparison of the above test results, with cross-talk values measured at various single frequencies.

Results.

A.—(1) The tests which have been carried out on coil-loaded and non-loaded cables have shown that voice tests can give results which vary quite considerably, according to the testers and still more according to the types of transmitters and receivers employed. One may obtain current values or readings on the cross-talk meter varying to the extent of double the readings, which in attenuation units corresponds to $b = 0{\cdot}7$ or 6 TU. In general the variation is, however, less.

(2) If in place of testing with the voice, a simple low frequency vibrator giving sharp interruptions (25 to 100 p.p.s.) is used, it is found that the settings of the cross-talk meter are approximately the same, within limits of experimental error, as those corresponding with voice current measurements (within one division of the cross-talk meter*). Otherwise, they are practically independent of the frequency of the vibrator. This last fact, together with the agreement of the voice test results, may be due to the fact that transient phenomena are of great importance in their relationship to cross-talk; the judgment of the tester takes more account of the consonants, which correspond with the vibrator interruptions. Measurements with the vibrator are, however, easier and very much more simple and precise than voice measurements.

B. Comparisons between measurements made with the voice and at a single frequency, have led to the adoption of six frequencies: 700, 800, 900, 1,300, 1,400 and 1,500 p.p.s. and the formula expressing the trouble due to cross-talk is:

$$\delta_v = \frac{2(\delta_{700} + \delta_{800} + \delta_{900} + \delta_{1,300} + \delta_{1,400} + \delta_{1,500})}{10}$$

where $\delta 700$, $\delta 800$, etc., are the cross-talk values at the frequencies of 700, 800 p.p.s. etc.

The justifications for this choice are based on the following experimental data:—

(*a*) The selected frequencies either belong to that portion of the speech spectrum in which most of the speech energy occurs, or are those at which the sensitivity of the ear is maximum. The coefficient 2 bears upon those frequencies for which these two properties especially operate together.

* It is necessary to note that the cross-talk values of various systems tested were widely different: from 50 (or $b = 10{\cdot}0$ or $86{\cdot}8$ TU) to 2,000 (or $b = 6{\cdot}2$ or $53{\cdot}8$ TU).

(*b*) The cross-talk-frequency curves obtained on loaded cables show in general groups of well-defined maxima and minima, very close to one another (separated on the average by 100 to 200 p.p.s.). The choice of a few widely spaced frequencies might, in consequence, as a result of unfortunate coincidence, fall almost entirely on maxima or minima, and give a false result, either of too great or too small magnitude. On the contrary, the grouping of three frequencies close together gives a reasonable chance of taking account simultaneously of the maxima and minima, and there is a strong probability that the nett result will not overlook a trough or a crest of cross-talk, liable to be of importance on the observed cross-talk.

(*c*) The coefficients are simple, and experience has shown, so far, that their application is satisfactory.

The comparison of the mean values of the results obtained from voice tests, with figures obtained by the use of the above expression, show a satisfactory agreement. The following figures, obtained experimentally, are given as an example :—

Values of Cross-talk in Cross-talk Units.

Voice test results.	189	118	57	500	800	500	550	1,200	1,300
δ_v	180	113	50	580	750	520	480	1,050	1,150

The agreement reached is within 20 per cent. (or $b = 0{\cdot}2$ or $1{\cdot}7$ TU); the variation is thus less than that found in practice with voice tests.

Conclusion.

As a result of the foregoing summarised tests, it appears convenient at the time acceptance tests on telephone systems are made to adopt the following method of measuring cross-talk (at least, in so far as the French language is concerned) :—

(1) Measure the cross-talk on the whole of the system to be tested with a vibrator (or any other appropriate source of tone) and consider this simple and rapid test sufficient for all systems for which the values obtained are less than the values specified.

(2) For all systems showing cross-talk values greater than the prescribed limit, it is necessary to have recourse to a method independent of testers and apparatus, that is to say, relying upon sinusoidal currents at single frequencies. The formula given above will meet this need and will give in an independent manner a value of δ, which is satisfactory as a basis for arbitration between administrations and suppliers. The tests are comparatively lengthy, but as they are applied only to a small number of systems, their relative complication may be accepted.

Moreover, the formula might be more generally used and it might be agreed that it would essentially define the cross-talk observed and effectively disturbing during a telephonic communication (at least, in so far as the French language is concerned).

APPENDIX C.b.1.

DIFFERENT WAYS IN WHICH TWO TELEPHONE ADMINISTRATIONS CAN CO-OPERATE IN THE CONSTRUCTION OF A REPEATER SECTION WHICH CROSSES A FRONTIER.

Two types of repeater sections have been recommended by the C.C.I., as described in Appendix B.d.2, No. 3. These two types are referred to as Method No. 1 and Method No. 2, the essential features of which are indicated in the following tables:—

Method No. 1.	1·3 mm. Conductors.	0·9 mm. Conductors.
Nominal Mutual Capacity, Side, mf. per km.	0·0385	0·0385
,, ,, ,, Phantom, mf. per km.	0·625	0·0625
Nominal Loading Coil Spacing, metres	1,830	1,830
Loading Coil Inductance, Medium Heavy, Side, mh.	177	177
,, ,, ,, ,, ,, Phantom, mh.	63 or 107	63 or 107
,, ,, ,, Extra Light, Side, mh.	—	44
,, ,, ,, ,, ,, Phantom, mh.	—	25

With the above Method No. 1 the cables are usually balanced by the cross-splicing process and the loading coils are usually of the type which has the connecting leads brought out through a stub cable.

Method No. 2.	1·4 mm. Conductors.	0·9 mm. Conductors.
Nominal Mutual Capacity, Side, mf. per km.	0·0355	0·0355
,, ,, ,, Phantom, mf. per km.	0·0570	0·0540
Nominal Loading Coil Spacing, metres	2,000	2,000
Loading Coil Inductance, Medium Heavy, Side, mh.	190	200
,, ,, ,, ,, ,, Phantom, mh.	70	70
,, ,, ,, Extra Light, Side, mh.	—	50
,, ,, ,, ,, ,, Phantom, mh.	—	20

With the above Method No. 2 the cables are usually balanced by added condensers and the loading coils are usually of the type which includes a connecting chamber at the top of the pot.

The problem of designing a cross-frontier repeater section involves the use of one or other of these two methods, or a combination of the two, the cases which arise being as follows:—

(*a*) Both countries have adopted Method No. 1 as their national method. In such cases Method No. 1 would naturally be employed.

(*b*) Both countries have adopted Method No. 2 as their national method. In such cases Method No. 2 would naturally be employed.

(*c*) One country has adopted Method No. 1 and the other country has adopted Method No. 2. In these cases the cross-frontier section can be either to Method No. 1 or to Method No. 2, or a combination of the two Methods.

With regard to cases (*a*) and (*b*) above, the most satisfactory plan from both technical and economic points of view, is for one manufacturer to supply the whole repeater section. This plan should always be followed where the portion of the repeater section in one country is less than one-quarter of the total repeater section length and is strongly recommended in all cases. An agreement should, if necessary, be concluded beforehand, in order that the contracts concluded in each country shall be in harmony.

In those countries where national manufacture of telephone plant is considered to be of primary importance, this plan has the disadvantage that one country had to make the concession that its portion shall not be of national manufacture. Upon examination, however, this disadvantage appears to be a slight one only, since there are, or probably will be, several cables linking up the two countries, which would make it possible to bring about an approximate balance of plant supplied by the two countries.

The advantages of this plan are :—

(1) Better transmission qualities of the completed cable in virtue of the greater uniformity of the parts.

(2) Greater economy in the manufacture.

(3) That the contractor would give to the two Administrations guarantees for the overall characteristics of the whole repeater section.

In the event of the two countries not following the above recommendations, and each country constructing the cable to the frontier, then it will be most advisable to have the closest co-operation between the two contractors, particularly in the matter of loading-coil spacing. The actual juncture between the two parts of the repeater section should occur at a loading point. When this procedure is followed, each contractor will, of course, only guarantee the part which he has provided, and the allowable variations in electrical characteristics can cause an irregularity at the point of juncture. The amount of this irregularity will depend largely on chance due to differences in machines, etc., on the extent of the co-operation between the manufacturers and on the position of the juncture in respect to the ends of the repeater section.

With regard to case (*c*), the adoption of either Method No. 1 throughout the repeater section, or Method No. 2 throughout the repeater section, is recommended if the whole repeater section is constructed entirely by one contractor. The disadvantage here, however, is not only that of concessions to national manufacture but also involves the problem of maintaining a half-repeater section of a system different from that adopted generally throughout the country. In cases where this disadvantage is considered to be serious, the modifications outlined below to Methods No. 1 and No. 2 respectively are suggested.

The two new methods, which replace Methods No. 1 and No. 2 respectively, present some difficult problems if employed generally. Such difficulties are not present when limiting their use to sections where a frontier is to be crossed and one country has generally adopted Method No. 1 and the other country Method No. 2. The joining up of the two sections should take place either at the end of a loading section or in the middle splice of a loading section.

In the proposed new methods the case of the 0·9 mm. conductors is disregarded, because such circuits are used principally for 4-wire purposes. For 0·9 mm. 4-wire circuits there is no need for as rigid a balance as for 1·3 mm. 2-wire circuits; also the effect of an irregularity at the point of junction is less on account of the higher attenuation; therefore 0·9 mm. circuits may follow Method No. 1 and Method No. 2 respectively, without change, providing that the larger gauge conductors conform to Methods No. 1A and No. 2A respectively.

1A. Method to be adopted for the half repeater section in the country which has adopted Method No. 1. It is assumed that the normal method of balancing will be employed—for instance, cross-splicing—and that the normal type of loading coils will be used, for instance, with the connecting leads brought out through stub cables. The essential features for this half of the repeater section are given in the table below giving corresponding information to that given earlier for Method No. 1.

Half Repeater Section Adjacent to Method 1.

Method No. 1A.	1·4 mm. Conductors.
Nominal Mutual Capacity, Side, mf. per km.	0·0385
,, ,, ,, Phantom, mf. per km. ..	0·0625
Nominal Loading Spacing, metres	1,830
Loading Coil Inductance :—	
Alternative 1.	
Medium Heavy, Side, mh.	177
,, ,, Phantom, mh.	63 or 107
Alternative 2.	
Medium Heavy, Side, mh.	190
,, ,, Phantom, mh.	70

2A. Method to be adopted for the half repeater section in the country which has adopted Method No. 2. It is assumed that the normal method of balancing will be employed—for instance, by added condensers—and that the normal type of loading coils will be used—for instance, the type which includes a connecting chamber at the top of the pot. The essential features of this half of the repeater section are given in the table below giving corresponding information to that given earlier for Method No. 2.

Half Repeater Section Adjacent to Method 2.

Method No. 2A.	1·4 mm. Conductors.
Nominal Mutual Capacity, Side, mf. per km.	0·0355
,, ,, ,, Phantom, mf. per km. ..	0·0570
Nominal Loading Coil Spacing, metres	2,000
Loading Coil Inductance :—	
Alternative 1.	
Medium Heavy, Side, mh.	177
,, ,, Phantom, mh.	63 or 107
Alternative 2.	
Medium Heavy, Side, mh.	190
,, ,, Phantom, mh.	70

From the foregoing table it will be seen that Method No. 1A differs from Method No. 1 in the size of the conductor to be used for the larger gauge, but is otherwise standard, whereas Method No. 2A differs from Method No. 2 in the mutual capacity of the 0·9 mm. conductors.

It will be further noted that in both the above tables alternative values of loading coil inductance are given, but the same value must be used throughout the repeater section, although, as already stated, the type of loading coil case can be that normally employed.

By these means the nominal impedance and cut-off point of the two half-repeater sections will be practically identical and the only irregularity which will occur at the point of juncture will be that due to allowable manufacturing variations within the limits specified. It is not commercially possible to tighten these limits.

A repeater section constructed in accordance with the foregoing Methods 1A and 2A respectively for the two halves of the repeater section would have the electrical characteristics indicated below which are applicable to either Method 1A or Method 2A :

Cut-off Point.	Side.		Phantom.	
	Radians.	Periods per sec.	Radians.	Periods per sec.
With 177 mh. Side and 63 mh. Phantom ..	18,000	2,900	23,600	3,800
With 177 mh. Side and 107 mh. Phantom ..	18,000	2,900	18,000	2,900
With 190 mh. Side and 70 mh. Phantom ..	17,300	2,750	22,500	3,600

Impedance.	Impedance in Ohms.	
	Side.	Phantom.
With 177 mh. Side and 63 mh. Phantom ..	1,590	740
With 177 mh. Side and 107 mh. Phantom ..	1,590	970
With 190 mh. Side and 70 mh. Phantom ..	1,630	780

Attenuation.	Maximum Value for Average Attenuation, β per Km.			
	Side.		Phantom.	
	800 pps.	1,900 pps.	800 pps.	1,900 pps.
With 177 mh. Side and 63 mh. Phantom—				
1·4 mm. Conductors	0·0109	0·0148	0·0113	0·0134
0·9 mm. ,, ...	0·0217	0·0250	0·0229	0·0248
With 177 mh. Side and 107 mh. Phantom—				
1·4 mm. Conductors	0·0107	0·0145	0·0090	0·0124
0·9 mm. ,, ...	0·0215	0·0248	0·0178	0·0210
With 190 mh. Side and 70 mh. Phantom—				
1·4 mm. Conductors	0·0108	0·0148	0·0112	0·0134

With each half of the repeater section constructed in accordance with Methods 1A and 2A respectively, each contractor will, of course, only be responsible for his section of the cable. The degree of possible irregularity at the point of juncture will be no greater than in the case where the whole repeater section is to Method 1 or to Method 2 and each country constructs the part within its own territory.

Each of the plans discussed above has certain advantages for the manufacturer, for the installer and for the Administrations. The advantages for the manufacturers are that existing machine equipment can be used and methods and processes which are familiar to them. The advantage for the installation organisation is that the customary methods of installation can be used. Finally, the advantage accruing to the Administration is that the cross frontier repeater section is so designed that it forms as satisfactory a link as circumstances will permit between the two countries.

If one contractor undertakes the construction of the whole repeater section, then the satisfactory working of all circuits is guaranteed, whilst if the responsibility for the whole repeater section is divided between two countries, then the risk of there being any inferior circuits is reduced to a minimum and maintenance practices are in no wise complicated.

APPENDIX C.c.1 No. 1.

NOTES ON THE TRANSMISSION TESTING, BY MEANS OF SPEECH, OF TELEPHONE TRANSMITTERS AND RECEIVERS, AS CARRIED OUT IN THE BRITISH POST OFFICE ENGINEERING DEPARTMENT ; WITH SPECIAL REFERENCE TO SELECTION AND MAINTENANCE OF STANDARDS.

A description of the methods adopted for the maintenance of the efficiency of supplies of telephone instruments is given in Technical Instruction VIII, Part 1. The following information describes the methods in use in the Engineering Research Section.

General.

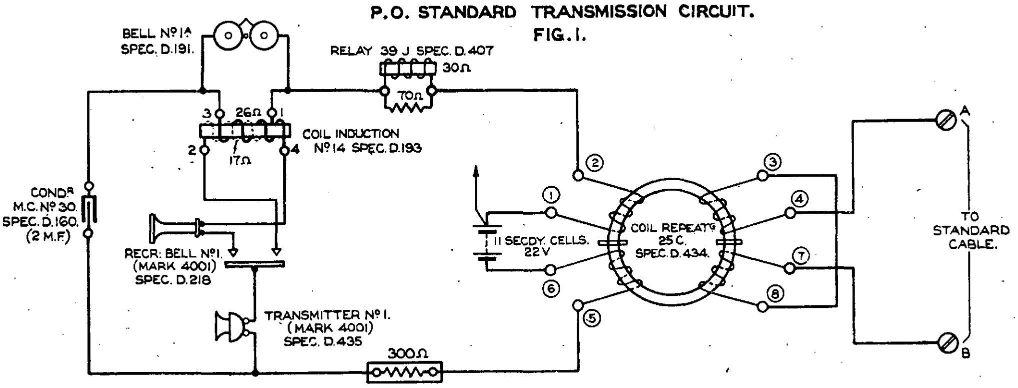
The ultimate testing of telephone instruments must be done by means of speech and listening, and the methods here described, covering these tests, are the result of many years' experience. In all, except minor testing, at least three observers, A, B, C, will always be employed. These speak to one another as follows : A—B, B—C, C—A, A—C, C—B, B—A. This series of six balances constitutes a " Set of six " and is the unit. Any number of these sets by the same or other observers may be used as required.

It is found that a definite routine of test, in which the test is succeeded by an interval, is necessary, if testing is to be carried on satisfactorily all day. The set of six occupies usually from 20 to 30 minutes, and a 30-minute interval then follows. During any one balance, say A—B, A's duty consists solely in the speaking, B's in the listening, while C makes the necessary cable adjustments and enters up results.

Circuit used.

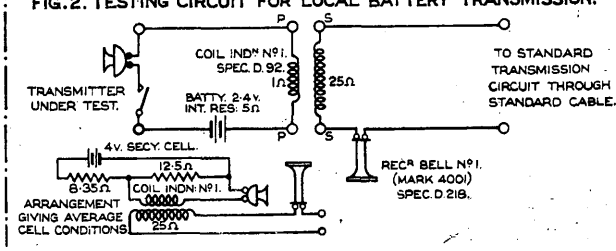
Unless the necessity of the test requires otherwise, all testing is carried out on the " Standard Circuit " shown diagrammatically in Fig. 1 and Fig. 2. An artificial cable is usually employed having constants substantially equal to those of " Standard Cable," viz. :— R = 88 ohms, C = 0·054 mfd., L = 0·001 henry, G = 1 microhm per loop mile. A minimum length of 30 miles ($b = 3 \cdot 18$ or 27·6 TU) is used, a short additional variable length being capable of being thrown at will into either " Test " or " Standard " side.

P.O. STANDARD TRANSMISSION CIRCUIT.
FIG. 1.



NOTE:- WINDINGS 1-2 & 5-6 OF COIL REPEATING 25 C. EACH COMPLETELY OCCUPY ONE HALF OF THE CORE AND ARE COVERED RESPECTIVELY BY WINDINGS 3-4 & 7-8.

FIG. 2. TESTING CIRCUIT FOR LOCAL BATTERY TRANSMISSION.



Switching Arrangements.

Special care is necessary with these. Particulars given in Technical Instruction VIII, Vol. 1, are similar to those employed in the Research Section, with a few modifications :—

(1) The standard instrument or part is connected to the "Make" side of the switching relays, and the test instrument is therefore the one normally in circuit.

(2) Signalling from the listener is done by means of three press buttons marked "Better," "Balance," and "Worse" respectively, the operation of any one releasing the last signal given and lighting a lamp before the recording observer, the lamp being marked to correspond with the button pressed. A separate speaking circuit between the two ends enables conversation to be carried on if required.

(3) A reversing key is fitted by means of which "Test" and "Standard" can be interchanged without the knowledge of the listener, the lamps being automatically reversed at the same time. The use of this key is important and materially reduces the possibility of a biassed result. It is of value even when there is sufficient tone difference for the observer to detect that the reversal has been made, as it interferes with any tendency on the part of the observer to be biassed by the signals he has previously given.

All switching of apparatus or cable is carried out by means of telephone relays fitted with special platinum contacts under fairly heavy pressure. These relays are protected from dust in sealed boxes, the contact springs being brought out to terminals outside.

Details of Testing.

Transmission tests are made for Volume Efficiency, Resistance, Articulation, Frying, Packing and Side Tone, as required.

(1) **Volume Efficiency.**

The sounds used for volume efficiency measurements are the numbers 1, 2, 3, 4, 5, repeated successively, first on the test instrument and then on the standard. These sounds are convenient to use and have been found satisfactory and sufficiently representative in practice. The volume of sound used is slightly greater than that of normal telephone speech to correspond with conditions during a conversation over a long line.

The method of balancing is as follows :—

The 30 miles ($b = 3 \cdot 18$ or $27 \cdot 6$ TU) of standard cable, as previously stated, can be placed in either circuit. In addition, the short variable length can be added in series with the 30 miles ($b = 3 \cdot 18$ or $27 \cdot 6$ TU) on either Test or Standard circuit. The circuit is connected so that, for example, in one position of the switches there are 30 miles ($b = 3 \cdot 18$ or $27 \cdot 6$ TU) in the standard circuit and in the other position 30 plus 3 ($b = 3 \cdot 5$ or $30 \cdot 5$ TU, total) in the test. After about three counts alternately on each circuit the observer may, for example, signal "Worse." The 3 miles ($b = 0 \cdot 32$ or $2 \cdot 8$ TU) might then be transferred to the standard circuit and a signal "Better" obtained. The variable cable is then reduced and the process continued, though not, of course, in any definite routine, until the observer gives "Balance" over a certain range. The two extremes of this range (which may be from one to four or five miles of standard cable, depending upon conditions), one being "Better" and one "Worse" will be checked, and the true "Balance" is considered to be the mean between these extremes. The object is to work inwards from the extremes, these latter being determined with definiteness by means of the double check.

It is sometimes necessary to discard the first few counts or possibly the first complete balance A to B, if the instruments take some little time to settle to a stable condition. Freak balances also sometimes occur and must be checked.

The number of "Sets of six" taken varies, depending upon the accuracy required, but in calibrating standards it is never less than two, using two different standards.

Whenever possible those portions of the circuit which can be so treated are used both on Test and Standard circuits, to avoid errors due to differences between these parts and to avoid the necessity of using calibrated apparatus where it is not essential. Transmitters, except when required for speaking upon, are always replaced by 50 ohm resistances to stabilise the conditions. The reception efficiency of an instrument, for example, is affected by the value of its associated transmitter. Extraneous noise is also thus reduced.

Calibrated parts are only used where essential—for example, in testing receivers a non-calibrated but standard type transmitter will be used at the Sending end.

(2) **Resistance.** (Transmitters.)

This is obtained by measuring the difference of potential across the transmitter, and the current through it, during the counting of the 1, 2, 3, 4, 5. The test is usually made immediately after the volume test. On account of the variation in resistance with different volumes of speech, the resistance tests are made with a volume as near the normal as possible; it should not fall below normal. Dead-Beat Weston Instruments Model No. 1 are used. The limiting condition for C.B. transmitters is a maximum of 80 ohms when 0·025 amperes is flowing and the diaphragm is tilted 25° from the vertical. For this test an additional resistance must be added to the local line. In addition, measurements are usually made on a 300 ohm local with the diaphragm both vertical and tilted to 25°.

(3) **Articulation.**

As a result of considerable experiment the following method has now been adopted :—

A large number (still being added to) of lists of monosyllabic syllables has been prepared. Each list contains 25 syllables containing sounds which occur in the correct proportion found in ordinary English. Where necessary, sounds which have been found to have an equal difficulty in transmission replace one another. The lists are all practically equal in difficulty and in occurrence of sound, but for the greatest accuracy two or more pairs will be used. Each syllable is composed as follows :—Consonant—vowel—consonant. All speech can be split up into syllables of this type if an imaginary unsounded consonant be added to the vocabulary.

The sounds were based on those occurring in representative newspaper articles.

The test consists in one observer slowly reading out a list to another, who writes down what he hears. Comparison of the percentage of sounds correctly received over Standard and Test circuits gives a measure of the articulation. So far it has not been possible to make the test other than a comparative one. A good standard with the observers making these tests passes about 60 per cent.

(4) **Frying, Packing and Side Tone.**

No specific tests are applied for these, but comparison is made with a standard. Bad packing is indicated during the volume test by the wandering of the balance, but speaking in a quieter tone will bring out the fault more noticeably. The tests are carried out on zero local line and the position of the transmitter may be varied between vertical and 25° with the vertical.

The Selection and Maintenance of Standards.

Selection. (Transmitters.)

The only transmitters so far used as standards have been the Western Electric Company's C.B. Transmitters Mark 4001. The standards now in use were originally derived from average supplies of transmitters, and all new standards are calibrated from these. When new standards are required, a batch of transmitters is taken and tested for frying, packing and side tone. These tests are made on a zero local line. After this test, a transmitter, standardised for volume, is never used on a local line of less than 300 ohms. In making transmission tests on standard transmitters these should always have the diaphragm in a vertical position.

The Standard transmitters are tapped on the case with a pencil by each observer before speaking. A transmission test is then made in the usual manner on a 300 ohm local line. If the transmitter is not worse than 3 S.M. ($b = 0 \cdot 32$ or $2 \cdot 8$ TU) below Standard, and passes the resistance test, it is made up into permanent form, *i.e.*, a proper lead is fitted and the back fixed on with cheese-headed perforated screws, and a sealing cord passed through them and sealed. This transmitter is then tested periodically for volume and resistance about every month for about 9 months; should no variability or other fault have developed in that time, it is finally calibrated against two standards, and becomes a Standard transmitter.

The Research Section maintains 60 Standard transmitters separated into three groups, A, B, and C, of 20 each. In addition, 25 American Standard transmitters (W.E. Co. No. 229) are held and checked annually against the others.

Each group of 20 is divided up into 6 primary, 6 secondary and 8 working Standards. The primaries are used mainly for calibration of the secondaries; the secondaries for calibration of standards for other Departments of the Post Office and outside Administrations, and working standards. The working standards are used for all normal work requiring a Standard Transmitter, as, for example, in checking the efficiency of samples from Contractors' supplies.

Periodical Recalibrations.

Group A, the oldest group, is recalibrated every three months. The actual calibration is somewhat involved, advantage being taken of the fact that each transmitter is tested against a number of others to make small adjustments of the value of individual transmitters. Each secondary standard is tested against each primary, assuming the primary efficiencies. The mean efficiency of the 6 secondaries is thus obtained 6 times against the 6 different primaries. Any small differences found between these mean values and the mean of these means will be due, apart from errors in testing, to the fact that the efficiency figure taken for the primary concerned is incorrect. The primary efficiencies are therefore modified to bring the means to equality.

The efficiencies of the individual secondaries are then modified in accordance with the modified primary figures.

Each working standard is then tested against two secondary standards.

A table is then prepared showing the mean change in the efficiency of the standards since their last calibration. This total mean change of the 20 transmitters should be practically zero, and if it is not so, a common figure is added to each to bring the mean to zero. The final mean change of each section, primary, secondary and worker should be small, of the order of $0 \cdot 3$ S.M. ($b = 0 \cdot 03$ or $0 \cdot 3$ TU) or less. This has been found usually to be the case. Any discrepancies can usually be traced to individual variations of one instrument, and due allowance made for it. Periodical examinations of the records of the standards are made to ensure that no cumulative error occurs in one direction.

Groups B and C are of equal age. B is treated precisely as A, whereas C is not used at all for ordinary testing but is kept as a control unit to determine whether any ageing occurs between used and unused standards. Group C is calibrated every six months.

Group D, the 25 American standards, are not split up into sections, but are used as a block for a check against the A group.

Once annually the groups are tested one against another as follows :—

A versus B.
A ,, C.
B ,, C.
A ,, D.

This test is used solely as a check of the relative efficiencies of the groups. The efficiencies of the transmitters are ignored and the test carried out simply as follows: A_1 *v.* B_1, A_2 *v.* B_2, A_3 *v.* B_3, and so on.

Selection of Receivers.

The methods of selection are the same as those for transmitters.

The ordinary cap is replaced with one having no groove. After the preliminary test the inside of the cup, coils, &c., are washed over with thin shellac varnish and carefully dried. This fixes any loose particles of filings or dust. The receiver cord is fitted and the cap sealed.

No specific articulation test is made, but during the selection tests the articulation is observed and no receiver inferior to standard is accepted.

Maintenance.

So far, on account of the lesser liability to variation of receivers, it has not been found necessary to keep more than 20 standards, divided into three groups, as in the case of transmitters. These are re-tested every six months.

Storage of Standards.

All standards are kept, when not in use, in a closed room in which the temperature is not allowed to fall below 60° F.

APPENDIX C.c.1 No. 2α.

BRITISH POST OFFICE METHOD OF MEASURING THE TRANSMISSION EFFICIENCY OF A SUBSCRIBER'S INSTALLATION FROM THE CENTRAL OFFICE.

General.

The testing set described was designed to measure the over-all sending efficiency from a subscriber's office. A condition laid down was that the test should be made from the exchange. The set was the outcome of a desire to obtain, in a simple manner, information as to the efficiency of telephone apparatus in commercial use. To obtain all the necessary information about the transmission of the instrument, it is obviously necessary to measure both sending and receiving efficiency, but as for the latter it will be essential, either to visit the subscriber's office, or to secure his co-operation, preliminary efforts were concentrated upon the sending efficiency. Experience shows that the transmitter is liable to far more variation and deterioration than the receiver, so that the sending test is the more important of the two. Details are given in Appendix C.c.1 No. 2 β of a proposed transmission set, which is actually in course of design, to measure the receiver efficiency.

Transmission Testing Set for Measuring Sending Efficiency of Subscriber's Installation.

This set is based upon the measurement at the local exchange of the voltage induced there by the subscriber speaking on a normal telephone call. It will be noted the test includes both the telephone apparatus and the subscriber himself. This is of great importance as faulty speaking on the part of the subscriber is likely to be far more harmful than faults due to apparatus. The two can be separated in any individual case, when required, by instructing the subscriber to speak correctly, or by sending an officer to do so.

The subscriber's line is tapped by means of a high impedance transformer and the voltage amplified by means of a valve and passed thence to a special valve rectifier. This consists of a normal type grid leak rectifier except that the leak is caused to be put into circuit by the incoming speech currents from the subscriber and is normally not in circuit. This is effected by a standard type B relay of high resistance which is operated by the amplified and rectified speech currents in a second circuit connected with the first as shown in the diagram attached. This subsidiary circuit is adjusted so that the relay operates with the faintest speech which the set is arranged to test. The rectifier in this second circuit operates by anode rectification. A high resistance microammeter is inserted in the plate circuit of the first rectifying valve, the normal plate current being biassed out as shown.

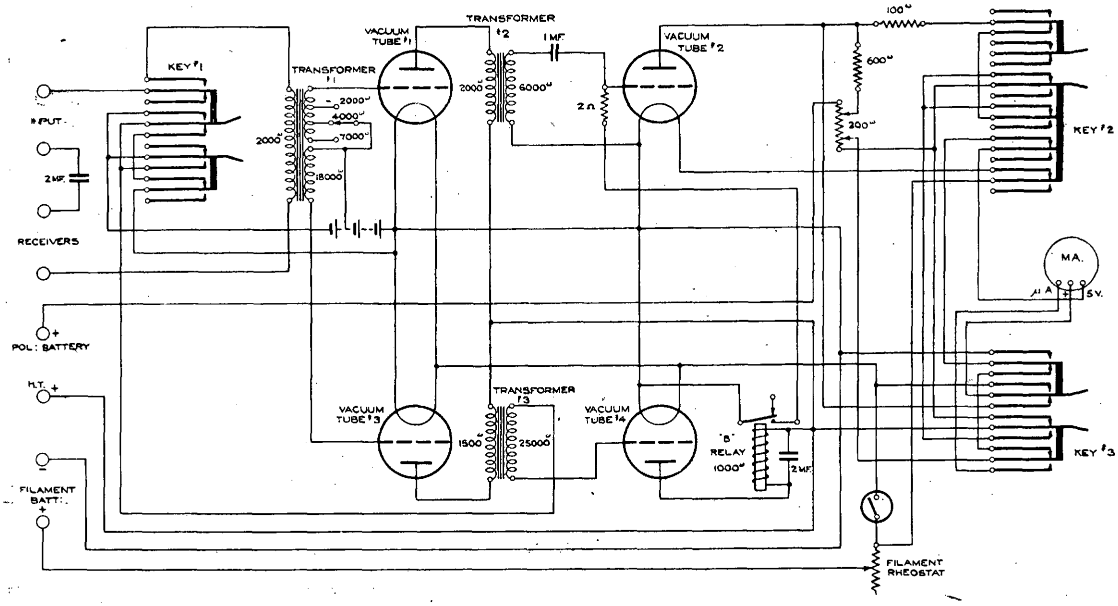
The operation of the circuit is as follows :—

Incoming speech currents cause the B relay to operate, hence putting the grid leak into circuit; the speech current voltage, amplified in valve A, is rectified in B, and causes a proportionate deflection on the microammeter. Should the speech cease, the grid leak is immediately open circuited on the relay, leaving the grid of valve B negatively charged. With a high valve and condenser insulation this voltage is only very slowly dissipated, and hence the microammeter reading remains at what it was immediately prior to the opening of the grid leak circuit. Should the speech become fainter, the grid leak remains in circuit but the rectifier grid voltage reduces proportionately and hence also the microammeter reading.

By suitable setting of the condenser and grid leak resistances it is possible to adjust the conditions so that with steady incoming speech the microammeter gives a steady reading in a few seconds. It will be seen, therefore, that provided the incoming speech is constant for this time, what is indicated on the instrument is the average maximum incoming voltage.

The microammeter is calibrated directly in standard miles. The average voltage impressed upon the line, using an instrument with zero allowance, zero local line resistance and with average speakers talking in a standard manner, was measured and gives the zero of the scale. The rest is obtained by adding the appropriate lengths of standard cable.

An explanatory diagram of connections is shown in Fig. 1.



TRANSMISSION TESTING SET,
FOR MEASURING THE OUTPUT FROM SUBSCRIBER'S TELEPHONE.

FIG. 1.

Fig. 2 shows the external appearance of the set and Fig. 3 its internal arrangement.

Results.

Tests have been made on working lines on two exchanges. It was found that, after making all due allowances for all apparatus and lines in circuit, the sending efficiency in the one exchange is $b = 0 \cdot 66$ or $5 \cdot 7$ TU below its nominal value, and in the case of the other $b = 0 \cdot 59$ or $5 \cdot 1$ TU worse. These two exchanges were Central Battery exchanges, and Central Battery transmitters are accepted $b = 0 \cdot 37$ or $3 \cdot 2$ TU below standard, so that these figures may reasonably be reduced to $b = 0 \cdot 29$ or $2 \cdot 5$ TU and $b = 0 \cdot 22$ or $1 \cdot 9$ TU, respectively. Several examples of very poor transmission were met with.

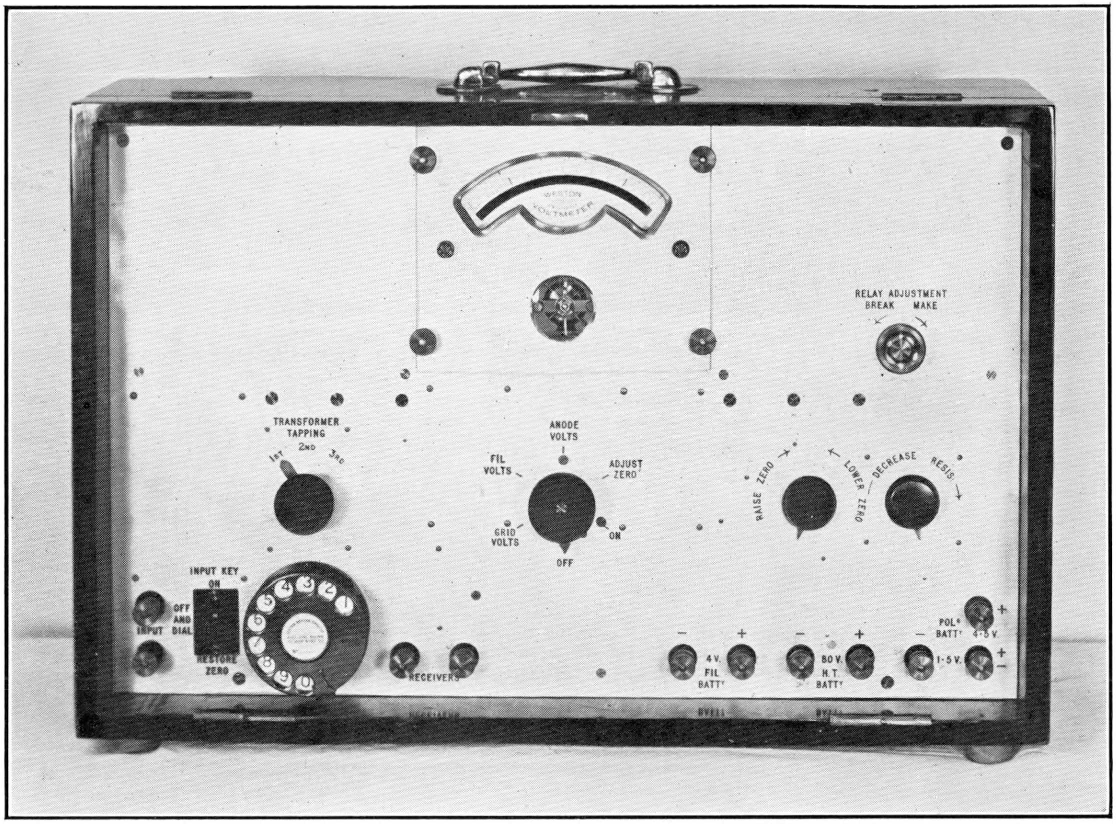

WESTON
VOLTMETER
RELAY ADJUSTMENT
BREAK MAKE
TRANSFORMER
TAPPING
1ST 2ND 3RD
ANODE
VOLTS
FIL
VOLTS
ADJUST
ZERO
GRID
VOLTS
ON
OFF
RAISE ZERO
LOWER ZERO
DECREASE
RESIS
INPUT KEY
ON
OFF
AND
DIAL
INPUT
RESTORE
ZERO
RECEIVERS
4 V.
FIL
BATT.
80 V.
H.T.
BATT.
POL.
BATT.
4·5 V.
1·5 V.

FIG. 2.

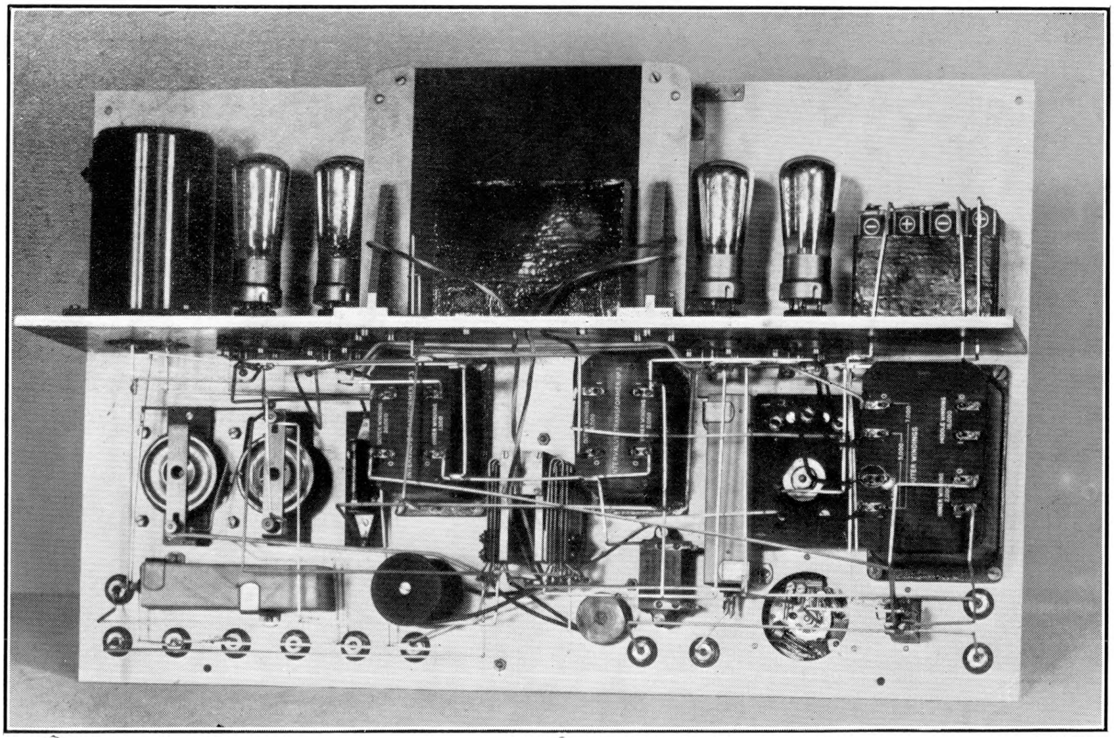


FIG. 3.

APPENDIX C.c.I No. 2β.

BRITISH POST OFFICE METHOD FOR MEASURING THE EFFICIENCY OF A SUBSCRIBER'S STATION FROM THE CENTRAL OFFICE BY MEANS OF ALTERNATING CURRENT.

1. **General Method of Test.**

The procedure is briefly as follows :—

A small portable valve oscillator set operates a special receiver to form an acoustic generator. This apparatus is taken to the subscriber's office and applied in turn to the transmitter and receiver, and finally to a standardised receiver which is temporarily substituted for the subscriber's receiver. The voltages generated are transmitted to the exchange, and, after amplification and rectification, produce deflections upon a direct current needle instrument. These deflections are reduced to equality by means of a potentiometer, calibrated in *b*, TU or S.M., and from these readings the efficiency of the set, both for sending and receiving, is obtained in terms of the efficiency of the standardised receiver.

2. **Apparatus Details.**

The oscillator is of normal type, except that the tuning inductance is built on iron stampings in order to obtain such a value of inductance that an air condenser with a maximum capacity of 0·001 mfd. will be sufficient for tuning. The condenser is continuously driven by clockwork at about 120 r.p.m., with the result that the oscillator output varies in frequency from 600 to 1,500 cycles per second. Over this range the voltage output does not vary 10 per cent. This range of frequencies covers the fundamental resonances of normal pattern receivers and transmitters. This appears to be an essential condition.

The actual sound is produced by a receiver operated from the oscillator. In the receiver the space behind the diaphragm is nearly filled, so as to raise the natural frequency above that of the oscillator. To this receiver is attached an arrangement for coupling it to either the receiver or transmitter under test, the coupling device being so designed as to put an acoustic load on the apparatus under test of the same order as would be obtained in normal use.

The measuring set used at the exchange contains two amplifying valves and one anode rectifier, all transformer-coupled. Two potentiometers (arranged to give 0 to 20 S.M. in five S.M. steps and 0 to 5 S.M. in $\frac{1}{2}$ S.M. steps), control the input. The measuring instrument is arranged as a fixed deflection instrument, *i.e.*, the input is altered by means of the potentiometers until a given deflection is obtained on the instrument. The position of the potentiometers is then taken as the reading. A switch is provided to arrange for the difference between the output from transmitters and receivers.

The part of the apparatus, which is taken to the subscriber's premises, is a little complicated and heavy. It is therefore proposed to simplify the design and investigate its suitability. The new apparatus will comprise a direct acoustic source rather than a rhythmic oscillator. Further details of this research with the results obtained will be communicated.

3. **Results.**

A test of 45 receivers by means of this apparatus has given the following results :—

The maximum variation in efficiency between this and a speech test was 3·5 TU (0·4*b*) and the mean variation, neglecting signs, 1 TU (0·11*b*).

Tests of 73 C.B. transmitters gave the following results :—

The maximum variation in efficiency between this and a speech test was 6·2 TU (0·71*b*) and the mean variation, neglecting signs, 1·8 T.U. (0·21*b*).

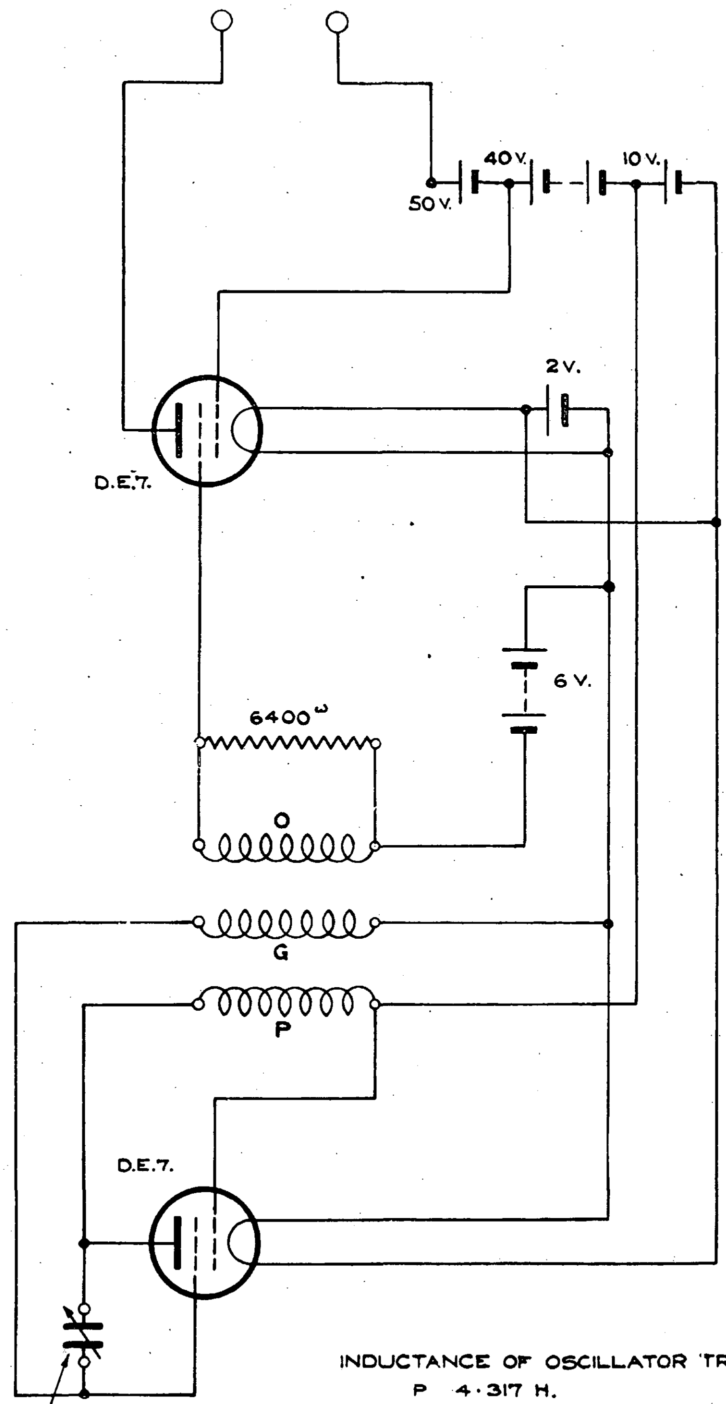
Sixty-three per cent. of the transmitters tested were within 1·2 T.U. (0·14*b*) of their true value, 85 per cent. within 2·5 T.U. (0·3*b*) of their true value.

These results include, of course, the natural variations which are to be expected in such apparatus and are quite accurate enough for the commercial testing under consideration.

Fig. 1 shows the circuit of the oscillator and Fig. 2 the voltmeter circuit.

RHYTHMIC OSCILLATOR.

APPARATUS TAKEN TO SUBSCRIBER'S OFFICE.



0·001 µF. MOTOR DRIVEN VARIABLE AIR CONDENSER.

INDUCTANCE OF OSCILLATOR TRANSFORMER

P 4·317 H.
G 9·404 H.
O 4·437 H.

FREQUENCY RANGE 600 - 1475 ~/SEC. APPROX:
OUTPUT 1·38 V. AT 600 ~/SEC. TO 1·5 V. AT 1475 ~/SEC. ON BELL RECEIVER (2000 OHMS).
SPEED OF CONDENSER 200 R.P.M.

FIG. 1.

THREE-VALVE MEASURING SET FOR A.C. TESTS ON SUBSCRIBER'S APPARATUS.

APPARATUS IN TEST ROOM.

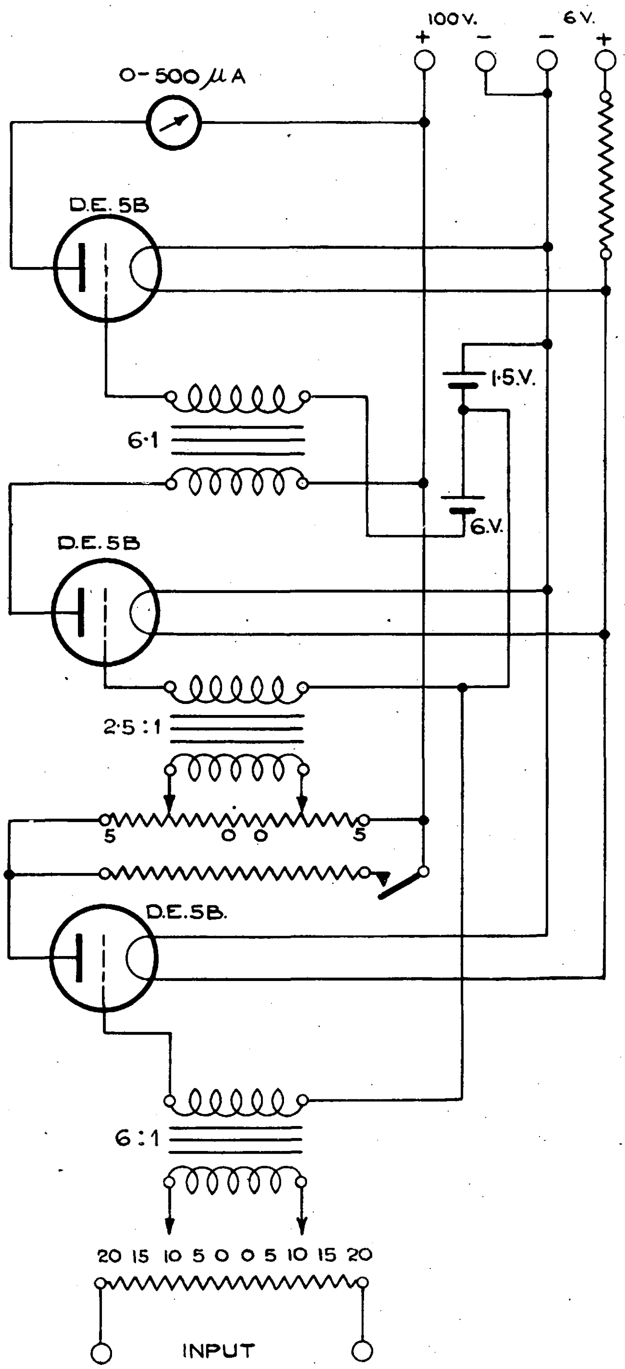
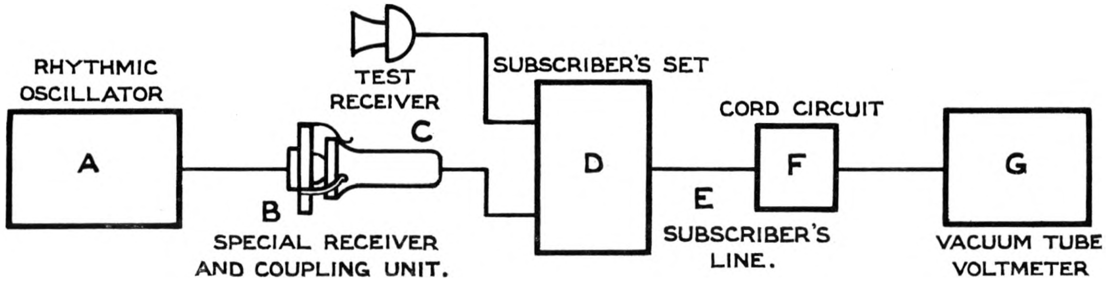


Fig. 2.



The frequency of a vacuum tube oscillator which operates a special receiver is varied rhythmically between 600 and 1,500 p.p.s. at 150 revolutions per minute.

The acoustic output of this receiver is applied by means of a special coupling unit either to the transmitter or receiver which is being tested.

The resulting output voltage is measured at the central office by means of a special vacuum tube voltmeter and the efficiency if the transmitter or receiver is determined by comparison with a standard receiver.

ALTERNATING CURRENT TEST OF THE TRANSMITTING AND RECEIVING EFFICIENCY OF A SUBSCRIBER'S SET.

FIG. 3.

General views of the apparatus are shown in Fig. 4 and Fig. 5.

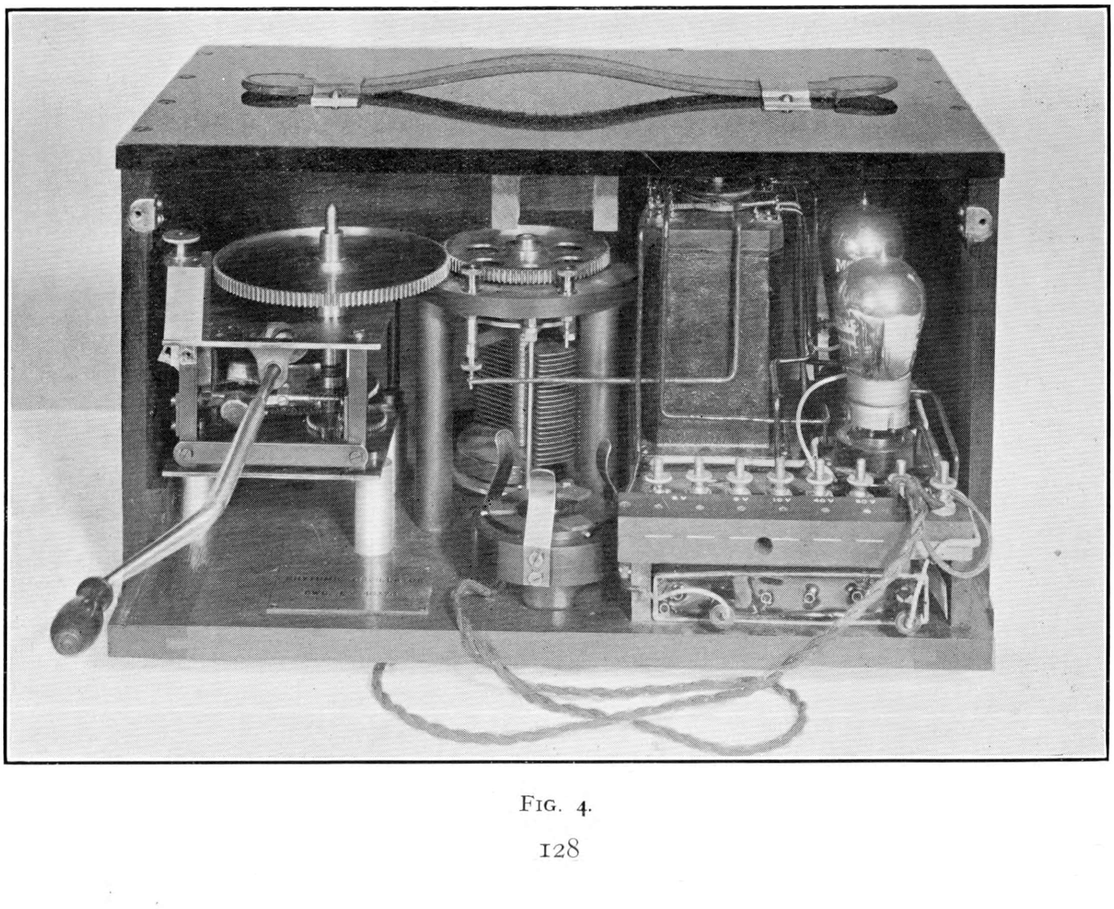


FIG. 4.

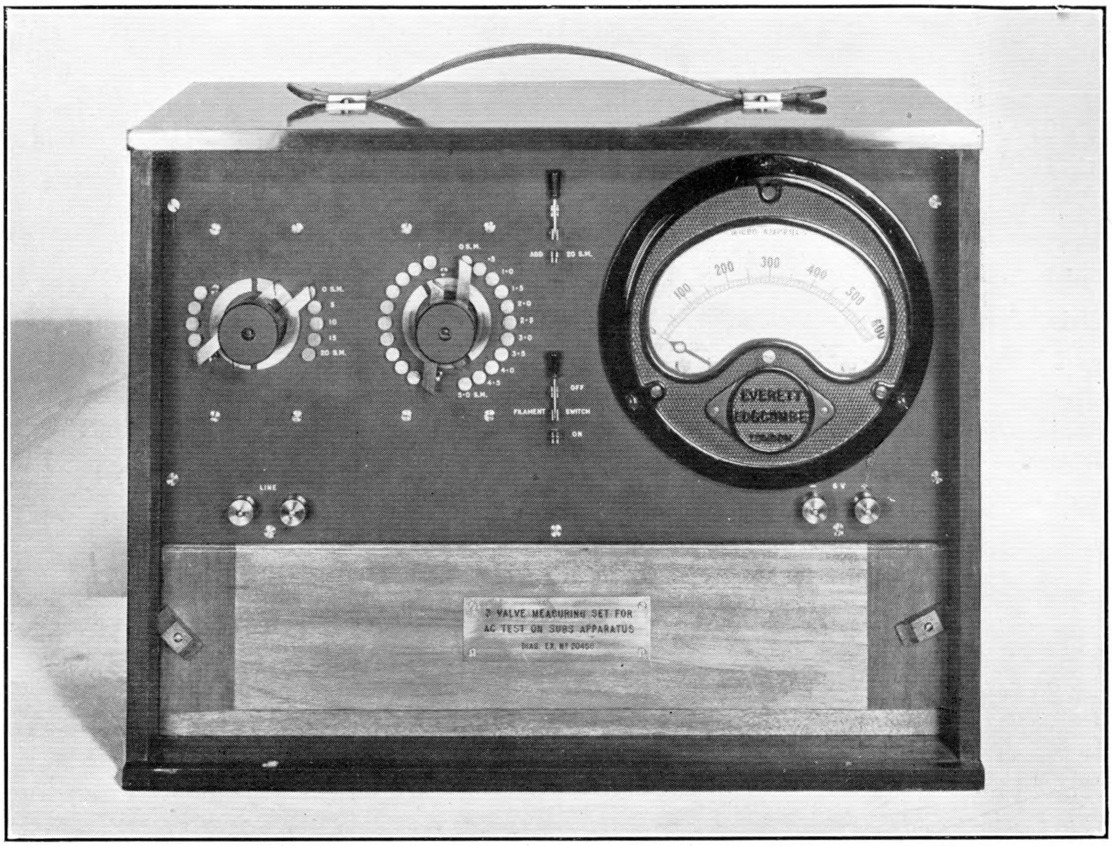

100
200
300
400
500
600
EVERETT
EDGCUMBE
LONDON
OFF
FILAMENT SWITCH
ON
LINE
VALVE MEASURING SET FOR
AC TEST ON SUBS APPARATUS

FIG. 5.

APPENDIX C.c.1 No. 3.

METHOD OF TESTING SUBSCRIBERS' INSTRUMENTS FROM THE CENTRAL OFFICE.

(International Standard Electric Corporation.)

The International Standard Electric Corporation is now developing a method of testing subscribers' instruments from the Central Office. All the testing equipment is located at the Central Office, except a reference instrument, which is taken to the subscriber's premises and there replaces his instrument during part of the test.

The method consists fundamentally in the correlation between the direct current resistance of the carbon transmitter and its alternating current output. There is no simplex transmission involved and all the measuring as mentioned above is done at the Central Office.

Briefly, the method of testing depends upon the measurement at the Central Office of the direct current resistance of the subscribers' transmitters. A band of frequencies is sent from the Central Office over the subscriber's loop through a transformer in series with a condenser to a standard receiver at the subscriber station.

In the transmitter test, sound from this standard receiver is used to agitate the transmitter. The standard receiver is coupled to the transmitter under test by means of a coupling unit so constructed that it will screw into a transmitter in place of the mouth-piece. By means of a spring device the receiver is held in place at the other end of the coupler. The resistance of the transmitter is measured directly on a meter at the Central Office. This meter may be calibrated in ohms regardless of the length of loop. Knowing the correlation between transmitter efficiency and the direct current resistance of the transmitter, when agitated by a given sound from the standard receiver, the efficiency of the transmitter can be found.

For testing the efficiency of the subscriber's receiver, it is planned to agitate the transmitter first with a standard receiver and then with the subscriber's receiver under test. The transmitter is agitated to a certain number of ohms by the standard receiver with a certain loop voltage applied at the Central Office. The standard receiver is then replaced by the subscriber's receiver and the loop voltage varied until the transmitter again indicates the same resistance. The ratio of loop voltages should give a measure of the efficiency of the subscriber's receiver because a low efficiency receiver would require larger current to produce the same agitation.

METHOD USED BY THE GERMAN ADMINISTRATION FOR TESTING A COMPLETE SUBSCRIBER'S INSTALLATION FROM THE LOCAL TELEPHONE EXCHANGE.

The tests described below are for the sole purpose of ascertaining whether or no the subscriber's station as a whole is in good condition.

As shown in Fig. 1, the test set, comprising the transmitter M. and the receiver T., is connected to the subscriber's station A through (1) an artificial line B, which is adjustable in four steps : $b = 2$; $2{\cdot}5$; 3; $3{\cdot}5$ ($17{\cdot}3$, $21{\cdot}7$, 26, 30 TU), and (2) a repeating coil Tr, the

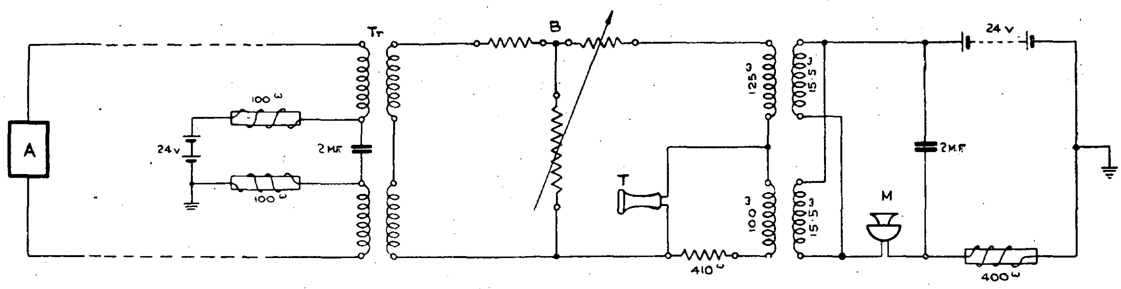


Fig. 1.

secondary winding of which obtains its current supply from the central battery of the exchange. The tests are carried out between one tester, operating the above described test set, and another tester who is stationed at the subscriber's set under test. All the subscribers' instruments are tested, in turn, once a year, unless there are reasons for special tests. The two testers carry out a speaking test, while the attenuation of the circuit is being gradually increased. Up to a distance of 4 to 5 km. of subscriber's loop, satisfactory transmission should be obtained with a maximum value $b = 3{\cdot}5$ or 30 TU in the artificial line ; for longer loops the corresponding maximum value should be $b = 3{\cdot}0$ or 26 TU. If these values are not obtained, special tests are made in order to locate the fault.

Although this method depends a good deal on personal factors, it has given very satisfactory results. Since the tests are carried out by men who are capable of judging the grade of transmission and since the attenuation artificially introduced is of considerable magnitude, it is hardly possible that a defect in the line or the apparatus will escape notice.

This method has the great advantage that it does not require special apparatus nor lengthy preparation.

For other purposes, for example, tests on various types of transmitters and receivers, more exact testing methods are, of course, to be recommended.

APPENDIX C.c.3 No. 1.

THE SWITCHING OF 4-WIRE CIRCUITS, AT TERMINAL EXCHANGES TO SIMILAR CIRCUITS OR TO CIRCUITS OF A DIFFERENT TYPE.

(International Standard Electric Corporation.)

I. Introduction.

1. General Considerations.

The general considerations involved and a number of specific problems are covered in articles which have already been published. This includes information on transmission levels, echo currents, transients, equipment practice, transmission regulation, etc., and we would refer to the following articles published in "Electrical Communication":

"Telephone Repeaters," by Bancroft Gherardi (Vol. 1, No. 1, Page 6, August 1922).

"Telephone Transmission over Long Cable Circuits," by A. B. Clark (Vol. 1, No. 3, Page 26, February 1923).

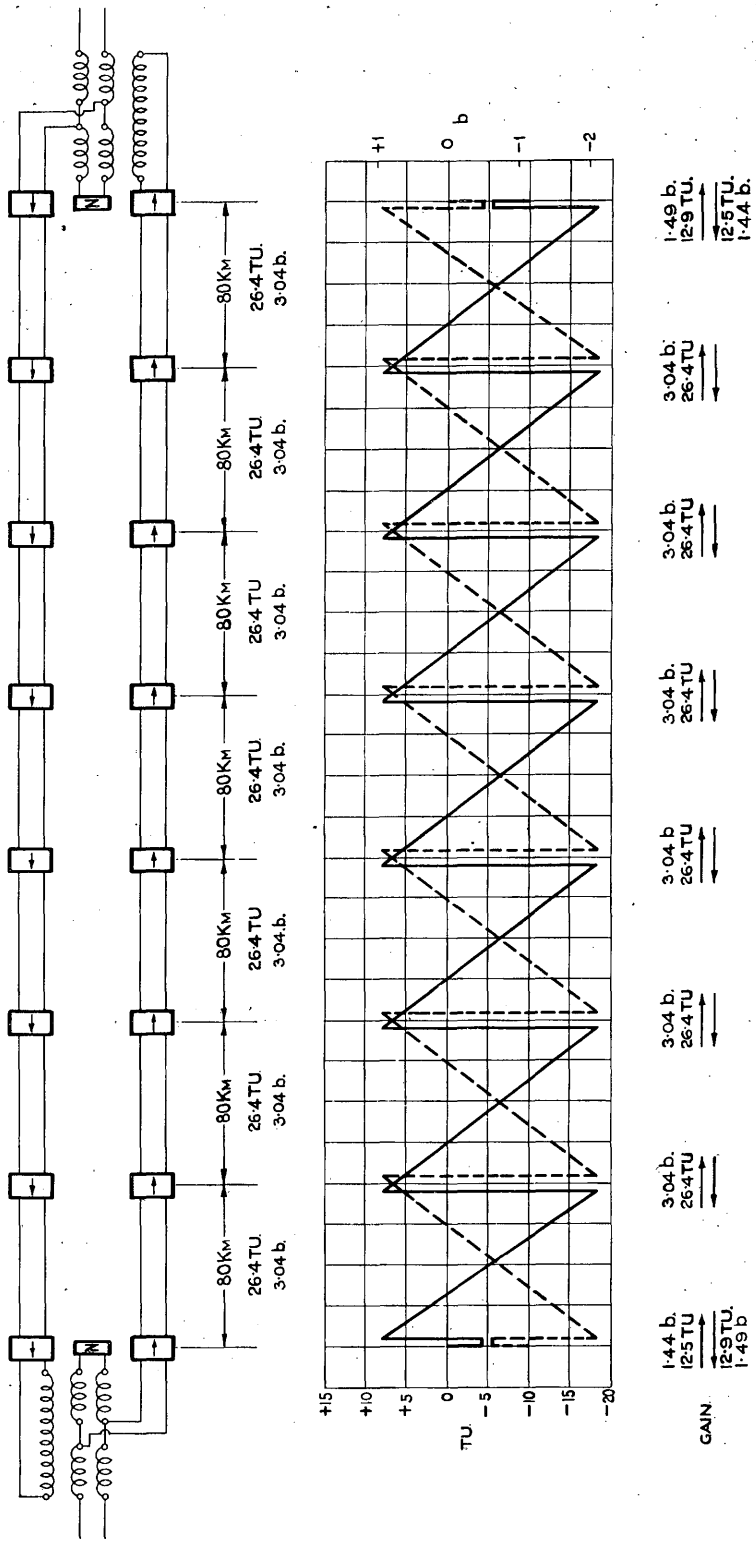
"Telephone Transmission over Long Distances," by H. S. Osborne (Vol. 2, No. 2, Page 81, October 1923).

and to articles published in the "Bell System Technical Journal" in addition to those mentioned above, as follows:

"Philadelphia–Pittsburg Section of New York–Chicago Cable," by J. J. Pilliod (Vol. 1, No. 1, Page 60, July 1922).

"Telephone Equipment for Long Cable Circuits," by C. S. Demarest (Vol. 2, No. 3, Page 112, July 1923).

The loading, size of conductor, impedance, etc., employed on the 4-wire system described hereafter are in accordance with the recommendations of the C.C.I.* In Fig. 1 is given a complete 4-wire circuit in schematic form showing the hybrid coil termination, the 2-wire



TRANSMISSION LEVEL DIAGRAM FOR 4 WIRE 0·9 MM. H-44-25. SIDE CIRCUIT.

Fig. 1.

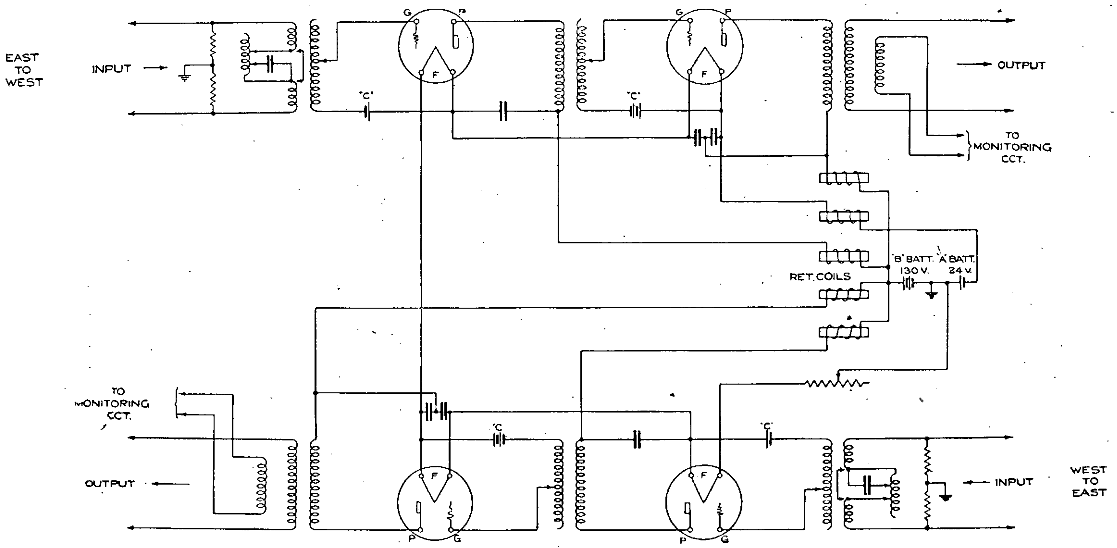
* Essential clauses for a typical specification for Repeater Sections of Loaded International Telephone Cable.

line and its balancing network. This drawing also shows the transmission level diagram for the circuit and gives the repeater spacing line and apparatus losses, repeater gains and overall equivalent.

The brief description of the apparatus contained in such a system which follows below, as far as the repeater or associated apparatus is concerned, is applicable to any station whether it be an intermediate or terminating station. This is an important point since it will be seen that by engineering a system on this basis, manufacture, installation instructions and maintenance are considerably simplified.

2. Repeater Unit.

The 4-wire repeater unit has the two one-way amplifiers mounted on the same panel, care being taken to segregate the wiring of the one amplifier from that of the other. The circuit of the unit is shown in schematic form on Fig. 2, and a photograph of a 4-wire repeater installation is shown in Fig. 9.



4-WIRE REPEATER CIRCUIT. SCHEMATIC DIAGRAM.

FIG. 2.

The gain of the unit is controlled by tappings on the input and inter-stage transformers and a fine control is obtained by resistances in the output circuit. By these means any value of 1,000 cycle gain may be obtained in steps of $b = 0 \cdot 035$ or $0 \cdot 3$ TU from a minimum value of $b = 0 \cdot 6$ or $5 \cdot 2$ TU to a maximum value of $b = 4 \cdot 4$ or $38 \cdot 2$ TU.

The unit is primarily designed as a repeater for extra-light loaded circuits and when used for this purpose the retardation coil and condenser shown in the centre of the input transformer are short-circuited. The slope of the gain frequency characteristic in this condition is such that it takes care of the distortion as well as the attenuation of the previous repeater section by means of the gain setting and this independently of the length of the section. When the unit is used on medium-heavy loaded circuits the retardation coil and condenser previously mentioned are brought into circuit and are connected so that the unit gives the correct equalisation for the preceding repeater section.

In some very long circuits the degree of equalisation which is obtained by these means is not sufficient at frequencies in the order of 200 cycles and it is necessary to add low-frequency equalisers. These are located with the input line repeating coils in the equipment and are shown on Fig. 3.

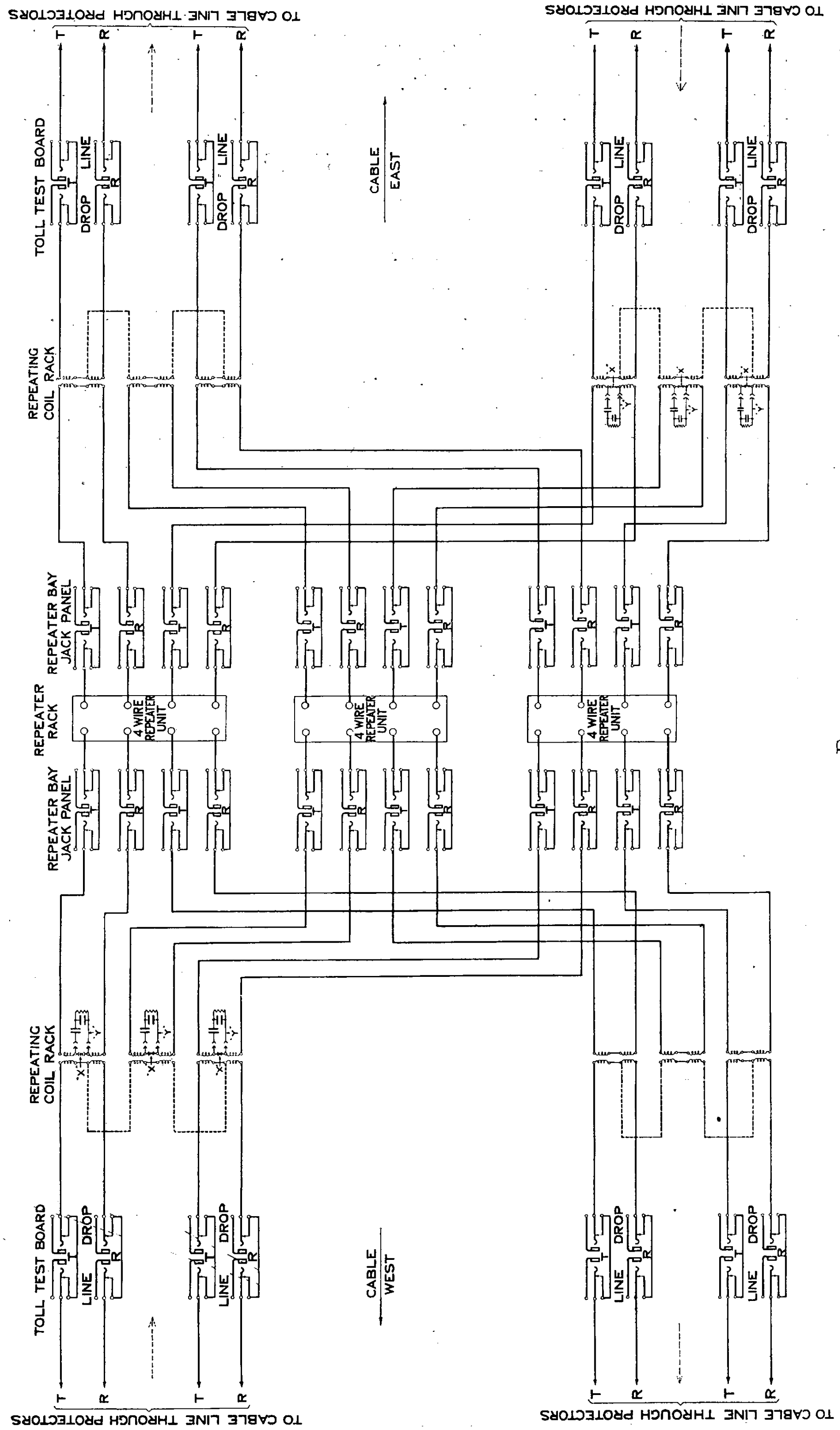


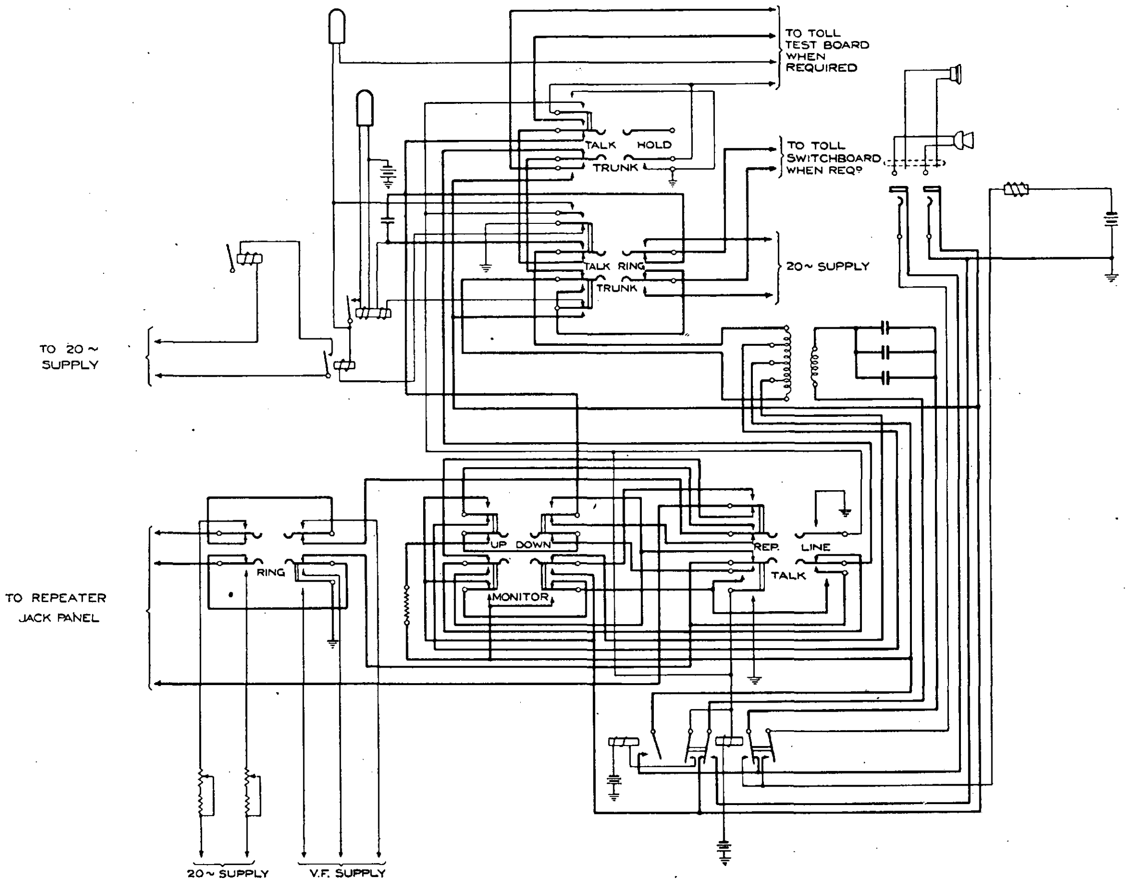
FIG. 3.

The plate-circuit retardation coils, shown in Fig. 2, are in the form of relays which give an alarm when either filament or plate batteries fail. The regular maintenance of the filament current and voltage, the plate current and voltage and the grid voltage is carried out by means of keys from the station meter panel. This panel is universal in type and method of operation for both 2-wire and 4-wire repeaters.

Fig. 3 shows the method of cabling a phantom group of 4-wire circuits in a through station. The input circuits are kept separate from the output circuits throughout the station and the repeating coils for the two types of circuits are located on separate bays. In applying this diagram for terminal offices it is only necessary to substitute the terminating sets and voice frequency ringers for the input and output groups of repeating coils serving one direction.

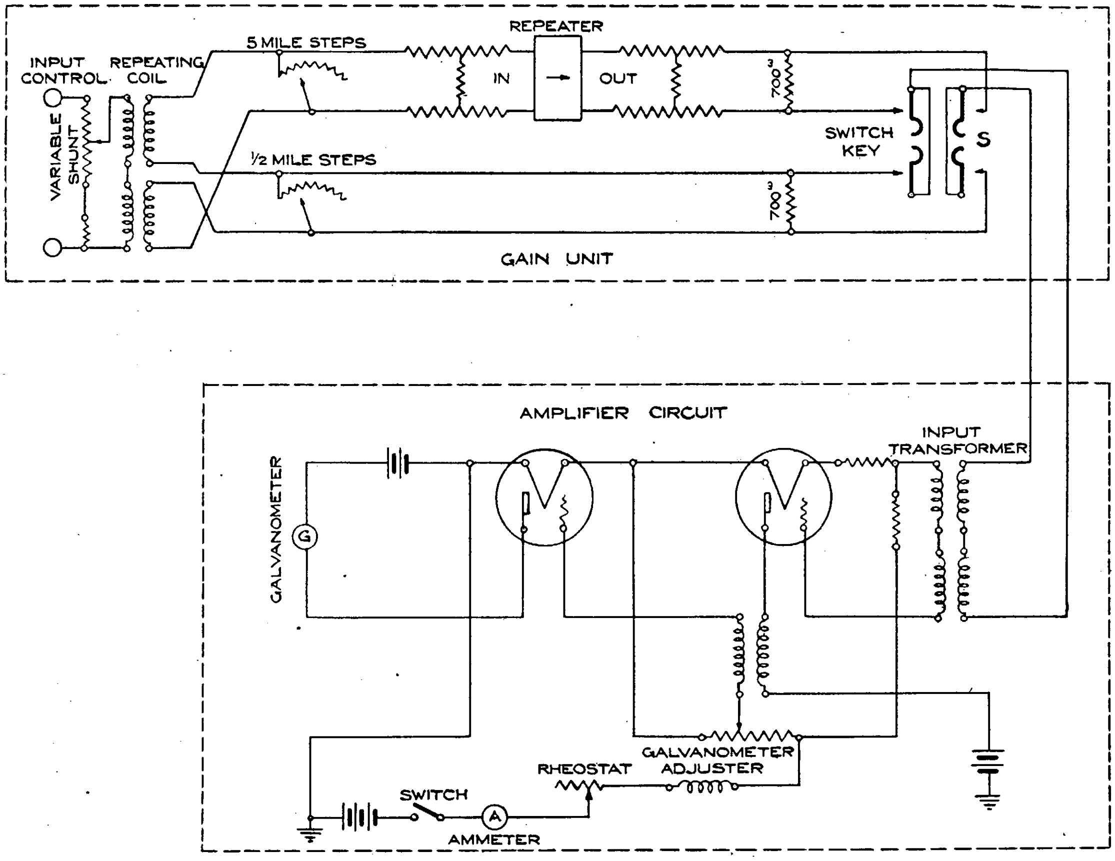
3. Testing and Control Apparatus.

(a) **Telephone and Trunk Panel.**—In addition to the current supply meters mentioned above, a telephone and trunk panel is provided for the use of the repeater attendant. This panel is universal for both 2-wire and 4-wire repeaters and, in the case of 2-wire cord circuit repeaters, equivalent control keys are available at the operator's position. The panel gives the attendant facilities for monitoring on any unit in either direction as desired or in both directions simultaneously and for talking and ringing on the lines. The circuit which is shown in detail in Fig. 4 also provides means for communication with the Toll Test Board and the Toll Board, as well as means for receiving calls from these points.



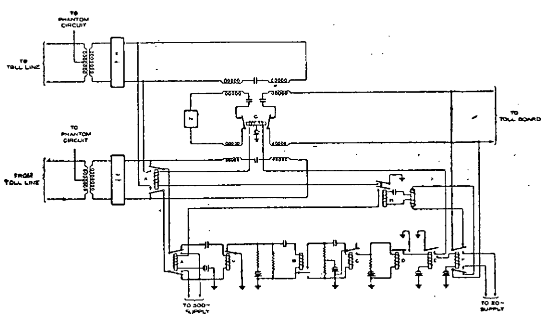
REPEATER ATTENDANT'S TELEPHONE AND TRUNK CIRCUIT.

FIG. 4.



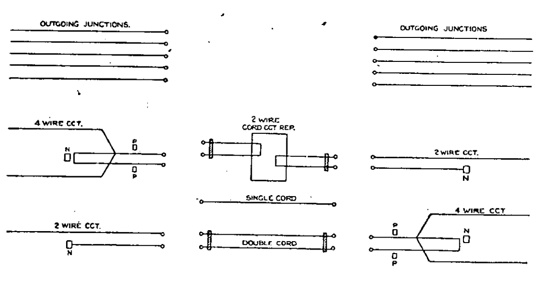
CIRCUIT OF REPEATER GAIN MEASURING SET.

FIG. 5.



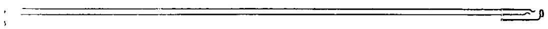
SCHEMATIC 4-WIRE TERMINATION WITH 500 ~ AND 20 ~ RINGING.

FIG. 6.

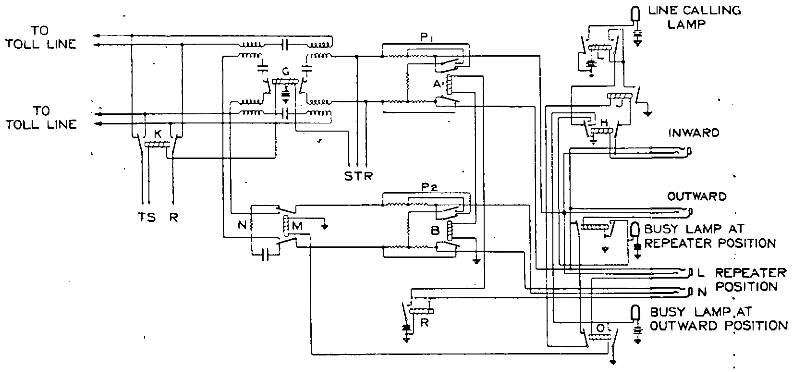


KEY DIAGRAM OF SWITCHING CONNECTIONS 4-WIRE AND 2-WIRE.

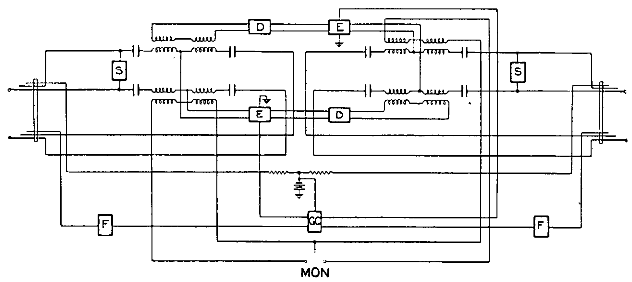
FIG 7.



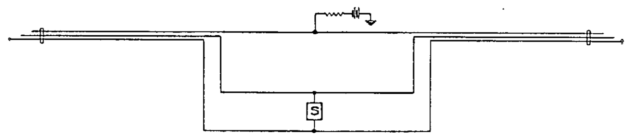
OUTGOING JUNCTION



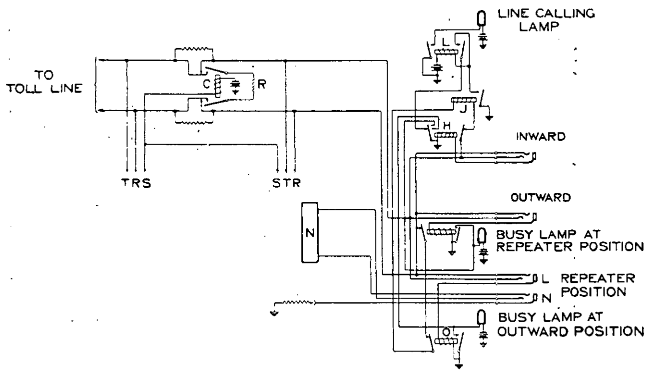
4 WIRE CIRCUIT



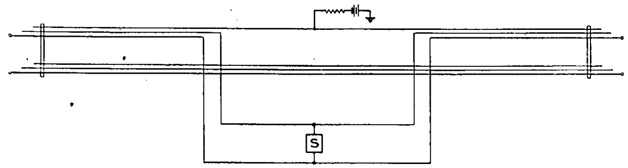
2 WIRE CORD CIRCUIT REPEATER



SINGLE CORD



2 WIRE CIRCUIT



DOUBLE CORD

SCHEMATIC DIAGRAM OF SWITCHING CONNECTIONS

4 WIRE & 2 WIRE

FIG. 8.

One of these panels is shown (in Fig. 9) mounted in the centre of the right-hand bay on the repeater installation.

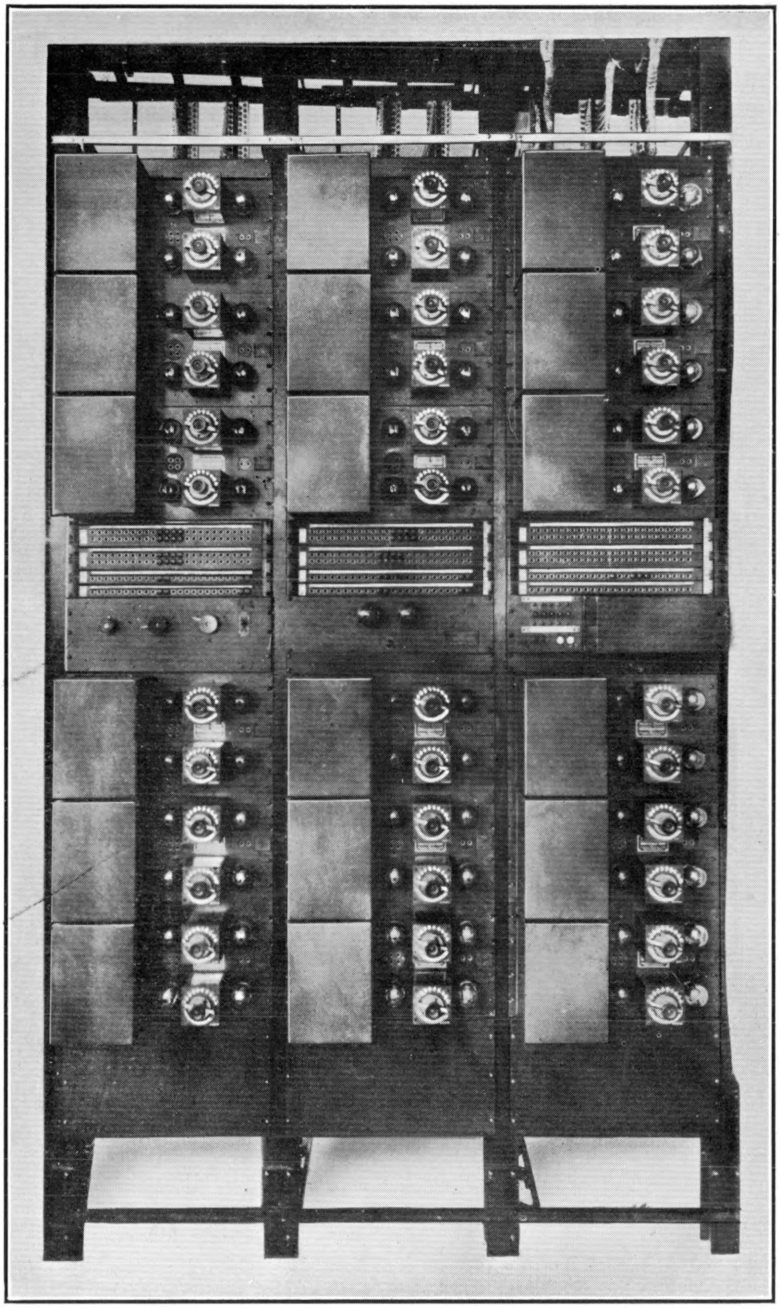


FIG. 9.—Repeater Mounting Rack.

(b) **Gain Measuring Set.**—The gain of the unit is measured periodically by means of a gain measuring set, the circuit of which is shown on Fig. 5. The repeater, having been patched to the gain set jacks, the gain at 1,000 cycles per second is measured as follows. The switching key S is operated and the two measuring dials are moved until the same deflection of rectified current is read on the meter G for both positions of the key. The gain of the repeater is then read off from the two measuring dials. The set is designed so that an accuracy of b = 0· 5 or 0·22 TU can be obtained.

In the repeater photograph, previously mentioned, the 1,000-cycle oscillator and the measuring panel are shown in the centre and left-hand bays respectively. The amplifier-detector unit is not shown, this being located in the next bay. This same gain measuring set is used for maintaining both 2-wire and 4-wire repeaters.

(c) **Toll Test Board.**—At all stations, both intermediate and terminating, toll test boards are required for the maintenance of the lines and to permit patching of circuits when necessary. The photograph (Fig. 10) shows a typical two-position board.

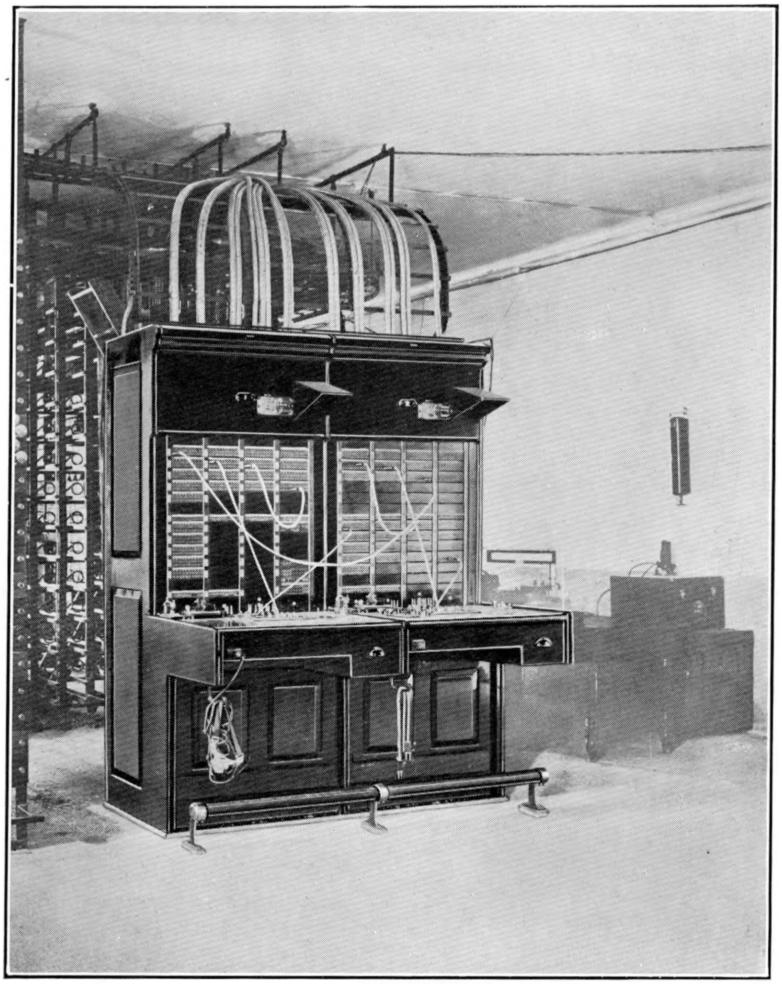


FIG. 10.—Toll Test Board.

A new method of mounting for toll test-board apparatus is being developed, in which the vertical equipment shown in the photograph is mounted on standard 19-in. (483 mm.) bays and a 19-in. (483 mm.) unit keyshelf is employed to take care of the keyshelf equipment. This arrangement is being developed to meet the wishes of Administrations who prefer such a method of mounting.

(d) **Transmission Testing Apparatus.**—Transmission testing apparatus is usually mounted on a separate desk, but recently-developed apparatus can either be placed on 19-in. racks or can be mounted in desk form if desired. This apparatus, which is mentioned in a memorandum, entitled "Considerations regarding Provisional Limits of Impedance," is designed so that it can be used for making transmission loss measurements and energy level measurements and includes a variable frequency oscillator for making line-impedance measurements, etc.

(e) **Voice Frequency Signalling.**—The voice frequency signalling system used on 2-wire and 4-wire circuits is 500/20 cycles per second, in accordance with the recommendations of the C.C.I. The circuit of the ringing apparatus is shown on Fig. 6, connected to the terminating set at the end of a 4-wire circuit.

The following is a brief description of the manner in which this circuit operates. An incoming ring from the one-way channel of the 4-wire circuit passes over the back contacts of relays K and A to the 500-cycle voice frequency relay V. This relay has its magnetic and mechanical systems so combined that it offers a high impedance and small loss to the line even at the frequency of response.

The 500/20 cycle ringing system impresses on the line 500 cycles for 1/40 second, followed by a pause of 1/40 second, and this relay is designed to follow the received impulses, responding to the alternating current and coming to rest during the pauses. In spite of these severe requirements the relay is of stable construction without being cumbersome.

The operation of relay V causes the polarised tuned relay B to operate and send 20 cycles to the 20-cycle tuned relay C. This, in turn, operates a train of relays D, E, F and G. Relay E causes relay G to operate, thus breaking the talking circuit, while relay F breaks off relay H from the 2-wire portion of the circuit and at the same time puts the local supply of 20-cycle current to the toll-board. The whole of this receiving circuit is so designed that it is immune from false operation due to speech currents, line noise, switch-hook clicks, etc. In the opposite direction 20-cycle current coming from the toll-board causes the tuned relay H to operate, which, in turn, operates relays A, K and G. Relay G again breaks the talking circuit, while relay A takes the receiving relay V off the circuit and sends 500/20 current through the front contacts of relay K to the outgoing 4-wire channel.

A testing panel is provided to test the operation of the receiving circuit both from the 500/20 cycle and the 20-cycle directions, and also to test the time delay of the receiving circuits as a whole.

(f) **4-Wire Terminating Set.**—The 4-wire terminating set consists of two repeating coils and four condensers and acts as a filter as well as the equivalent of a hybrid coil for joining the 2-wire circuit to the 4-wire circuits.

II. Terminal Station Switching.

1. General.

The problem which has to be met when considering the switching of circuits which may have to be done at a terminating station is shown on a key diagram given on Fig. 7.

The toll-board must be equipped so that it can handle any or all of the types of connection shown thereon in such a manner that, given a method of operating to be employed, the handling is carried out in the simplest and most reliable way from the operating standpoint, and the least number of types of jacks and cords are used by the operators concerned. The following types of connection are required at terminating points, though, as mentioned, they may not all be required at any one point simultaneously.

(1) 4-wire toll circuits to local subscribers through outgoing junctions.
(2) 4-wire toll circuits to 2-wire toll circuits with a 2-wire cord circuit repeater.
(3) 4-wire toll circuits to 2-wire toll circuits direct.
(4) 4-wire toll circuits to 4-wire toll circuits with a 2-wire cord circuit repeater.
(5) 4-wire toll circuits to 4-wire toll circuits direct.
(6) 2-wire toll circuits to 2-wire toll circuits with a 2-wire cord circuit repeater.
(7) 2-wire toll circuits to 2-wire toll circuits direct.
(8) 2-wire toll circuits to local subscribers through outgoing junctions.

It will be seen from Fig. 7 that all these types of connections can be carried out by means of three types of cords and two types of jacks, as follows:—

(a) Connections (1), (3), (7) and (8) are done by means of a plain single cord from single jacks.

(*b*) Connections (2), (4) and (6) are done by means of a double cord equipped with a 2-wire cord circuit repeater from double jacks.

(*c*) Connection (5) is done by means of a plain double cord from double jacks.

It should be noted that, although single and double jacks are mentioned above, they are actually the same type of individual jack, but two of them are used, when it is necessary, to reach the network side of a 4-wire terminating set or the network of a 2-wire line requiring a cord circuit repeater.

In describing in detail the manner in which the various connections are made, Fig. 8 has been prepared showing in schematic form the various types of circuits and the cords mentioned above. The individual terminating circuits will be described first, followed by a brief description of the cords, and then the operating methods involved will be given in detail.

2. **Terminating Circuits.**

(a) **Outgoing Junction.**—This consists solely of lines running from the toll operator's position to various local exchanges.

(b) **4-Wire Terminating Circuits.**—A 4-wire termination consists only of the two repeating coils and four condensers, which together form the combined hybrid coil and filter, together with the two relays which are used in connection with the 500/20 cycle ringing system, as previously described under 3 (*e*).

At stations where only connections (1) and (3) are required, a compromise network N is permanently connected to the terminating set and the 2-wire branch is multiplied to the Toll Board at the Inward and Outward positions. A visual busy circuit is provided between the Inward and Outward positions so that the Outward operator knows when the line is engaged at the Inward position. This simple circuit is not shown separately, but can be very easily followed from the schematic of the circuit given, which is used for other types of connection.

At stations where connections (2), (4) or (5) are required the circuit shown on Fig. 8 is used. The 2-wire line is brought out through the pad P_1, which is normally short-circuited to the toll-board, where it is multipled to the Inward, Outward and Repeater or Switching position. The network leads are normally connected to the compromise network N, but when required they appear at the Repeater position, being taken through a pad P_2. This pad is put in circuit when necessary, as will be described later when dealing with the operation of the circuit as a whole. The usual line calling equipment is shown and also the method by which a busy signal is given from position to position as may be desired.

(c) **2-Wire Terminating Circuit.**—The method of terminating 2-wire lines which require cord-circuit repeaters is also shown on Fig. 8. The 500/20 cycle ringer is shown connected to the line having a cut-off relay C between its 500/20 cycle and 20-cycle branches. The ringer circuit is identical with that previously described, except that relay C takes the place of relays G and K and performs the same functions. When relay C operates it places a resistance R across the line, so that if a 2-wire repeater is located at a short electrical distance away, excessive echo-currents are not present during the ringing period.

The 2-wire line is multiplied to the Inward, Outward and Repeater positions in the same manner as the 4-wire line circuit and the 2-wire network appears on jacks at the Repeater position. The same method of calling and giving busy signals is used for the 2-wire circuit as for the 4-wire circuit.

3. **Connecting Cord Circuits.**

(a) **Single Cord.**—This cord is provided with keys for Ringing, Talking and Monitoring and with a high impedance supervisory relay S so that the operator can be called from either direction when the cord is up. The sleeve circuit of the cord is provided with battery fed through a suitable resistance.

(b) **Double Cord.**—The line connection of this cord is equipped in the same manner as the single cord just described and the network connection consists of tip, ring and sleeve wires led straight through without any apparatus.

(c) **Cord Circuit Repeater Cord.**—The cord circuit repeater cord consists of two similar portions each ending in a double plug. The line and network connections from each hybrid coil are brought out to one double plug which is used to plug into the double jacks mentioned previously as being located at the repeater position.

The line sleeve circuit of each double plug carries a battery through a suitable resistance for operating the busy signal to the other position, while the network sleeve furnishes battery to the switching relays for the pads and is connected in the opposite direction through a train of relays to the operator's gain control key. Where automatic gain regulation is used, this is done through the network sleeve connection by means of the relay or resistance, shown in the 4-wire and 2-wire terminating circuits, but in this case the relay train does not go through the gain control key *GC* before reaching the repeater gain control apparatus.

The operation of key *GC* causes battery to be put on the network sleeve, at the same time lighting the repeater filaments. The repeater attendant is provided with talking and ringing keys on each line connection as shown, while the monitoring circuit during conversation is taken from the fourth winding of the hybrid coils as in normal repeater practice.

4. Operating Methods.

(a) **General.**—It will be realised that operating methods will differ in detail from case to case, depending on the size of the station involved and the preferred method of operating of each individual Administration. In describing the operating methods given below, it is assumed that order wires exist between the inward and repeater positions for use when necessary and that the normal routing of traffic is done by the usual docket system. In the succeeding paragraphs the different types of switching, as given in (1) will be dealt with individually in the same order as they appear in that paragraph.

(b) **4-Wire to Outgoing Junction.**—This connection is handled from the inward position by means of the single cord described under 3 (a). The answering cord is inserted in the inward jack of the 4-wire line and the sleeve battery causes relay *H* to operate, thus breaking off the 20-cycle response relay *J* from the line and releasing the locking relay *L* and putting out the line calling lamp. The operating of relay *H* puts an earth on the busy lamps at the repeater position and at the outward position, to show these operators that the line is engaged. The calling cord is inserted in the jack of the outgoing junction and the call completed in the normal manner.

For clearing purposes, a supervisory relay *S* is located across tip and ring of the single cord, and this relay can be operated by ringing current coming from either back or front cord to light a lamp, indicating that the connection is to be broken down.

(c) **4-Wire to 2-Wire with Cord Circuit Repeater.**—This connection is handled from the repeater position by means of the double cord-circuit repeater cord described under 3 (c). Assuming that the allocation of traffic is done by means of dockets and the line being free, the operator inserts the back cord into the line and network jacks of the 4-wire circuit. Battery on the line plug sleeve causes relays *O* and *M* to operate, giving a busy signal at the outward position and breaking the response relay *J* from the line, at the same time removing the compromise network *N* from the 4-wire terminating set and bringing the network leads through to the network jack. The operator then rings on the line from the ringing key shown, and the 20-cycle current from her key operates the voice frequency ringer in the manner previously described. The same operations take place upon the 2-wire side, by means of the front cord, although in this case the network is already connected directly to the network jacks.

When both terminal stations are on the line, the operator either moves her gain key if the unit is manually operated or puts the automatic gain selection apparatus in working order. In either case battery is supplied to the network sleeve of the cords. In the case of automatic gain selection, this operates battery relays which set the gain of the unit for the particular combination of circuits set up and operates relays *A* and *B* in the 4-wire terminating circuit through relay *R*. When automatic gain selection is not used, relays *A* and *B* only are operated. These relays bring into circuit artificial line pads P_1 and P_2, which are inserted in order to ensure that the gain given by the cord circuit repeater is the actual gain added to the connection.

This is necessary from the method of connection used. As will be seen from the diagram the double cord connects the 2-wire line terminals of the 4-wire hybrid coil to the line terminals of the repeater hybrid coils and the network terminals of the 4-wire hybrid coil to the network terminals of the repeater hybrid coil. This results in a perfect balance and the elimination of the losses, due to the split energy, in both hybrid coils and a consequent gain of approximately $b = 0 \cdot 7$ or $6 \cdot 0$ TU over and above the gain put in by the repeater. Pads P_1 and P_2, having an equivalent loss, are therefore inserted so that the energy levels upon the completed circuit are not interfered with.

The perfect balance mentioned above eliminates the possibility of echo currents being produced by the 2-wire repeater.

The cord circuit repeater operator can monitor on the connection through the fourth winding of the hybrid coils and receives clearing signals from either direction by means of the supervisory relay S connected across tip and ring of the line plugs of her cords.

(d) **4-Wire to 2-Wire Toll Circuits Direct.**—This connection is carried out in exactly the same manner as that described under 4 (b).

(e) **4-Wire to 4-Wire with a Cord Circuit Repeater.**—This operation is carried out in the same manner as that described under 4 (c), except that the front double plug is inserted in the line and network jack of a second 4-wire line rather than of a 2-line wire and the operating in this case is the same as described for the operations of the back cord in 4 (c).

(f) **4-Wire to 4-Wire Direct.**—This connection is made between the two 4-wire double jacks by means of the double cord shown in Fig. 8. As will be seen, this cord is only equipped with battery on the line sleeve so that only relays M and O operate when the double cord is inserted in the jacks. The result is, that the two 4-wire terminating circuits are connected together line-to-line and network-to-network while busy signals are given at the outward positions.

If the two 4-wire circuits, being connected together, are of suitable loading, etc., so that they can be used as a 4-wire circuit over the entire distance of the switched connection to give an equivalent over that distance within the limits for long circuits, it will be seen that by means of the switching cord described, an overall circuit can be obtained which meets the required overall equivalent. As an example, let us consider a circuit from London to Rome with a switching point in Paris. The circuit, as a whole, would be engineered so that it is capable of giving an equivalent of, say, $b = 1 \cdot 3$ or $11 \cdot 3$ TU between London and Rome. This means, of course, that the sections London–Paris and Paris–Rome could be worked at a lower equivalent than $b = 1 \cdot 3$ or $11 \cdot 3$ TU, since each portion of the circuit is designed for a greater distance than that for which it is being used. Let the equivalent between London and Paris from toll-board to toll-board equal $b = 0 \cdot 99$ or $8 \cdot 6$ TU and from Paris to Rome toll-board to toll-board $b = 1 \cdot 00$ or $8 \cdot 7$ TU, then if the circuits were switched together from the 2-wire line jacks only, the overall equivalent would be the sum of these two, namely: $b = 1 \cdot 99$ or $17 \cdot 3$ TU, but the method of connection indicated above allows a gain of $b = 0 \cdot 69$ or 6 TU to be obtained due to the elimination of the terminating set losses so that the overall equivalent will be $b = 1 \cdot 3$ or $11 \cdot 3$ TU.

The tip and ring of the line cord are equipped with ringing, talking and monitoring keys and a supervisory relay S which allows clearing signals to be received from either direction.

(g) **2-Wire to 2-Wire with Cord Circuit Repeater.**—This connection is made in the same manner as that described under 4 (c), except that two 2-wire circuits with networks are employed instead of one 4-wire and one 2-wire.

(h) **2-Wire to 2-Wire Direct.**—This connection is made with the single cord in the same manner as described in 4 (b).

(i) **2-Wire to Local Subscriber.**—This connection is carried out in exactly the same manner as that described under 4 (b).

THROUGH TRAFFIC FOR LONG DISTANCE CIRCUITS EFFECTED AT THE THROUGH SWITCHING POSITIONS.

(Cord Circuit Repeaters.)

For through traffic on long distance circuits it is necessary to have special repeater arrangements which, unlike tandem repeaters, are connected on the junction circuits. The cords on toll positions may be considered as being junctions, and it is for this reason that these devices are called "Cord Circuit Repeaters."

The cord circuit repeaters can be arranged in various ways :—

(1) The repeaters can be placed actually in the toll position cords.

(2) They can be co-ordinated at will at the different toll positions with the help of selective apparatus.

(3) Special through-switching positions can be used which are designed solely for use with cord circuit repeaters and which are connected to the toll positions by service lines, etc.

In each case it is necessary to take into account the fact that to establish through communications it is necessary to connect together the different types of toll circuit, for example, a 2-wire system to a 2-wire system, a 2-wire system to a 4-wire system, and a 4-wire system to a 4-wire system.

The arrangement described has been adopted by the German Telephone Administration and has been constructed by Messrs. Siemens & Halske, Siemensstadt, Berlin. It consists of an application of the method mentioned above under (3).

Those parts of the cord circuit repeaters which are manually operated, that is to say, the multiple jacks, the cords, the plugs, and the keys, the gain control rheostats, and the ringing arrangements are located on the special positions, whose dimensions correspond to those of the toll positions. These switchboards, called "Through Switching Positions," can house as many as 10 double-cords according to the importance of the traffic to be handled. All the cords are mounted in such a manner that it is possible to utilise the same double cords for each type of connection which it is required to make,—a 2-wire system to a 2-wire system, a 4-wire system to a 2-wire system, and a 4-wire system to a 4-wire system. The repeaters with their accessories are not located in the switchboards, but are mounted on special racks.

Before giving a detailed description of the operations, we will allude to the manner in which cord circuit repeaters of the type described above are employed.

Toll lines which are liable to be switched on the through-switching positions are terminated at the normal toll positions of the toll office. The operator replies to the request of the subscriber and puts him in communication with the local subscriber required, or she establishes on the through switching positions the direct connection between two distant offices.

Under service conditions the establishment of a direct communication through the cord circuit repeaters is effected according to the regulations applying to international traffic in so far as the sequence of operations to be observed is concerned. The preparation and the monitoring of the through communication should be effected by the toll operator, controlling the most important toll line. In borrowing the service lines of the through switching position, this operator asks for the multiple jack connection of her required toll line. A communication being established, the operator, controlling the through switching position, monitors for an instant to assure herself that the line is not singing. She can control the degree of amplification by means of the gain-control rheostat provided with each double cord. The supervision of the conversation so far as the commencement and the end are concerned, as well as the maintenance of intelligibility, is in the hands of the toll supervising operator and not of the operator controlling the cord circuit repeaters. In the event of defective articulation being noticed in the course of a conversation, the supervising operator should, by means of the service line, request the operator at the through switching position to regulate the transmission gain.

It is necessary to add to these remarks that the number of toll multiple jacks on the through positions depends on the number of lines which are provided for repeatering by the cord circuit repeaters. It is only these lines which pass through the through switching position. The connections between the through switching positions and the toll positions are effected on the toll switchboards by multiple lines, each one of which passes across a pair of jacks; each multiple line being connected with a double cord at the through switching position. The only object of these lines is to connect the toll operator with the toll line originating at the through switching position in such a manner that she can supervise a conversation.

Description of the Operations.

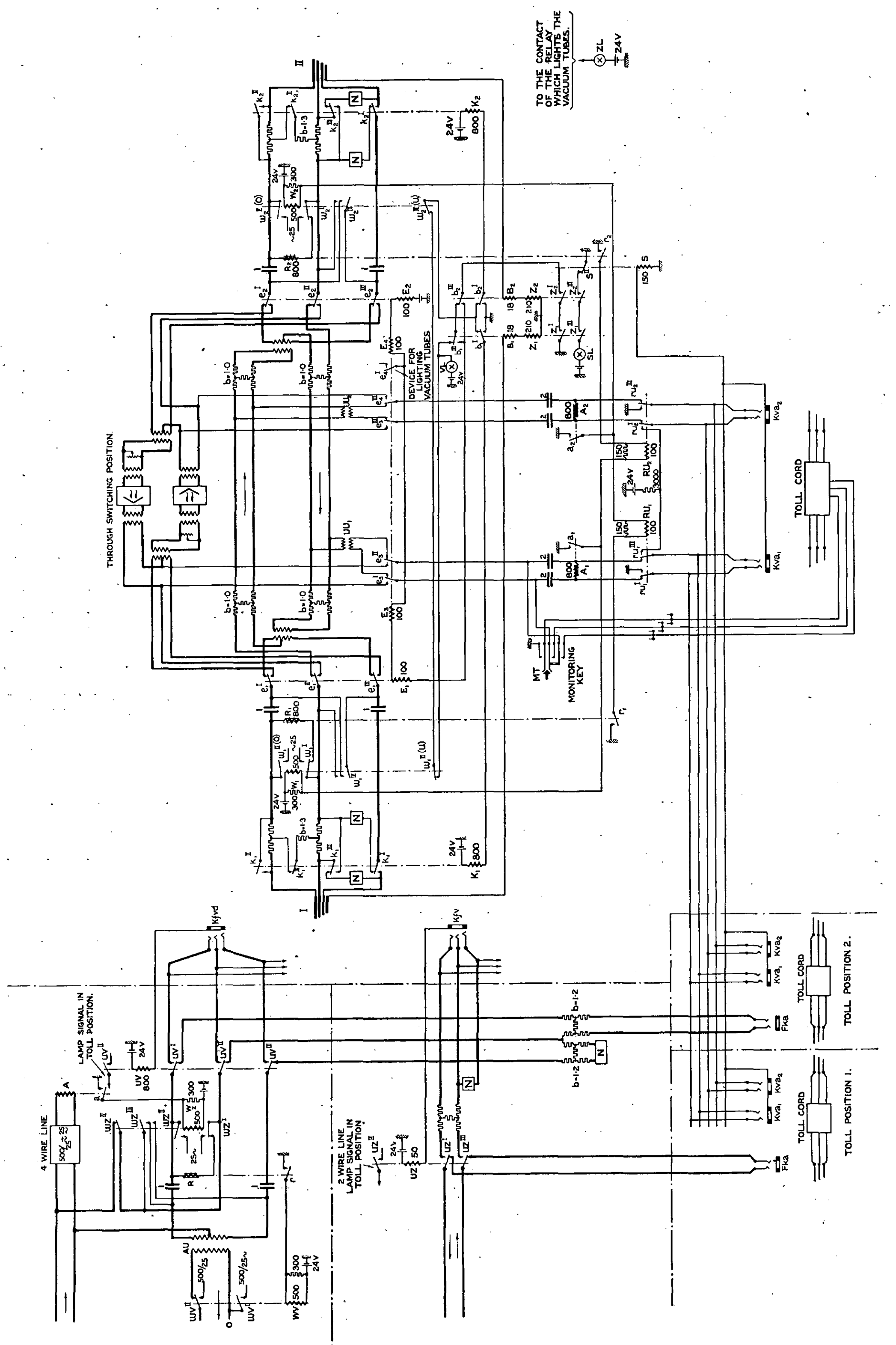
Referring to the schematic (Fig. 1), through traffic is dealt with in the following manner:—

The call coming from any toll circuit (4-wire or 2-wire) arrives at the toll position. The operator A_1 replies to the call of the operator at the corresponding position. Let us suppose that she has been asked for the establishment of a through communication on a toll line, terminating at the toll position of an operator A_2. Operator A_1 communicates with Operator A_2 using the service line to ask her if the required toll line is free. If it is, Operator A_1 communicates by means of the service line with an operator V at the through switching position to request her to establish the required communication. Operator A_1 inserts the plugs of her double toll cord in the monitoring jacks associated with the through switching double cord used by Operator V. The cord is allocated to her by Operator V by means of the service line. As stated above, all the toll line available for through traffic should be connected to the multiple. For each double cord at the through positions, two monitoring multiple jacks are provided in the toll positions. Toll operator A_1 can monitor by means of these jacks the through communication with the help of her double toll cord.

For through traffic it is of little importance whether the lines to be connected through the cord circuit repeaters are of the 4-wire or the 2-wire type. On the through switching double cord the necessary switching apparatus for each case are always automatically connected. To this end, the change-over relays UV of the 4-wire circuits have a higher resistance than the change-over relays VZ of the 2-wire circuits. Relays B_1 and B_2 on the through switching double cord depend for their operation on this difference of resistance such that they operate when they are connected to 2-wire circuits and do not operate when they are connected to 4-wire circuits. It is therefore not necessary to make any distinction between the multiple jack of a 2-wire circuit and that of a 4-wire circuit. Thus the double cord may be employed equally well for the establishment of calls between 4-wire circuits or between 2-wire circuits, as for the connection of these two types of circuit together.

I. Connection between two 4-Wire Circuits.

Let us suppose that a call has come through the toll position as usual, that operator A_1 has replied to a request by means of her ordinary double cord inserted in the toll jack Kfa and that she is in touch with operator V of the through switching position to request her to interconnect two given circuits. Let us suppose further that they are 4-wire circuits. Operator V inserts plugs I and II in the through jacks $Kfvd$. This operation results in relays UV operating on the lines and relays Z_1–Z_2 on the double cords (relays B_1 and B_2 receive insufficient current and do not operate). Relays UV connect through their change-over contacts I–III, the 4-wire circuits to be switched with the 4 contact through jacks $Kfvd$. The toll position receives through the operating contact uv^{II} a signal indicating that the toll line in question is available for the through connection. Lamp S_1 lights at the through position through the contacts Z_1^{III}—Z_2^{III}—s^{II}. Relays K_1 and K_2 operate through b_1^{I} and b_2^{I}. By means of their contacts $k_1^{I\text{-}III}$ and $k_2^{I\text{-}III}$ they disconnect the artificial lines of $b = 1\cdot3$ or $11\cdot3$ TU which are located on the two sides of the cord. Communication is thus



CIRCUIT · DIAGRAM OF SIEMENS CORD CIRCUIT REPEATER.

FIG. I.

established; considered from direction *I* it proceeds across contacts e_1^{I-III} towards the double 4-wire and 2-wire terminating apparatus, and from there through contacts e_2^{I-III} towards direction *II*. At the through switching position lamp *VL* lights through:

$$(-)\{-VL - b_1^{III} - B_2^{III} - Z_2 - z_1^{I} - (+)\}$$

indicating to the operator that a connection between two 4-wire circuits exists and that it is not necessary to adjust the amplification by means of the rheostat. Each time, to assure herself that the communication is satisfactory, she throws, for a moment, the monitoring key MT to test with the help of her telephone set if the line is quiet. After having been informed by operator V which of the through double cords has been used to establish her communication, toll operator A_1 inserts the plugs of the toll double cord in the supervisory jacks Kva_1 and Kva_2 associated with the agreed double cord. In this manner she connects herself across the monitoring repeating coils UU_1 and UU_2 on the double terminating apparatus, so that she can break in at any moment on the conversation. Relay S now being operated, lamp SL at the through position is extinguished for the duration of the conversation.

Signalling.

If supervising operator A_1 desires to call in direction I, she sends across the contacts ru_1^{I} and ru_1^{II} an alternating current of 25 cycles to relay A_1, while throwing the calling key I. The relay A_1 operates and causes the operation in turn of relay W_1 across contact a_1. Relay W_1 sends calling current in direction I across contacts w_1^{I} and w_1^{II}. The other direction is blocked for the alternating current of 25 cycles by a 1 mf. condenser. To prevent singing on the line, the three talking circuits are short-circuited during the ringing by the double operating contact w_1^{III} behind the ringing current blocking condenser. When contact w_1^{III} is opened the circuit passing through relays K_1 and K_2 is interrupted. The armatures of these relays fall back and, with the help of their contacts k_1^{I-III} and k_2^{I-III}, place in circuit again the artificial line, having an attenuation $b = 1 \cdot 3$ or $11 \cdot 3$ TU, to attenuate the ringing current. This measure is necessary because the ringing current terminal receiving apparatus is always only a short distance away.

The arrangement is similar when the call goes in direction II. It arrives from the toll position at relay A_2 via jack Kva_2. Relay A_2 causes the operation of relay W_2 which ends the ringing current in direction II as has been described for direction I.

Clearing Signal.

Let us suppose that the signalling current for the clearing signal comes from direction I. The signalling current actuates relay R_1 which operates relays W_2 and RU_1 through a contact r_1. Relay W_2 sends signalling current in direction II, at the same time connecting in circuit an artificial line, having an attenuation $b = 1 \cdot 3$ or $11 \cdot 3$ TU. Relay RU_1 puts b to earth and puts voltage on the wire a of the supervisory line through its contacts ru_1^{I} and ru_1^{III}. In this manner a clearing relay on the toll double cord of operator A_1 is operated, and the clearing lamp lights. A signalling current coming from direction II operates in the same manner. It sends the signal in direction I and lights clearing lamp II on the toll double cord of operator A_1.

To cut the communication, operator A_1 withdraws the plugs from jacks Kva_1 and Kva_2. The armature of relay S on the through double cord falls back and the associated clearing lamp SLv lights at the position of operator V, contacts z_1^{III} and z_2^{III} being again closed. After this, operator V at the through position can disconnect. After the withdrawal of the plugs, relays Z_1 and Z_2, and consequently K_1 and K_2, fall back and lamps VL and SL are extinguished. All the apparatus is returned to the normal position. On the toll lines from the moment of clearing the armatures of relays UV have fallen back and reversed the toll lines at the toll positions with the help of change-over contacts.

II. Connection between two 2-Wire Circuits.

At the request of operator A_1, operator V inserts her plugs in jack Kfv of the lines to be connected. On the line side, change-over relays UZ operate and connect the long-distance lines corresponding with toll jacks Fka back to the through connecting jacks Kfv. Simultaneously each relay UZ sends a signal to the toll position through a contact MZ^{II}. On the through double cord relays Z_1 and Z_2 and relays B_1 and B_2 operate. Relays E_1, E_2, E_3 and

E_4 are operated through contacts $Z_1^{I} - Z_2^{II} - b_2^{III}$; relay K_1 attracts its armature by means of b_1^{I}, as does relay K_2 via b_2^{I}. Contacts e_1^{I-III} and e_2^{I-III} connect the talking circuits of the double terminal apparatus to the repeater. The filament current for the repeater itself passes through the contact e_1^{I}. The operator at the through switching position is informed of this by the lighting of lamp *ZL*. The two artificial lines of $b = 1 \cdot 3$ or $11 \cdot 3$ TU are disconnected from the lines through the contacts of relays K_1 and K_2. A connection is now established through an intermediate two-wire repeater.

By depressing for a moment monitoring key *MT*, operator *V* assures herself that the conversation is satisfactory. The supervisory lines passing through jacks Kva_1 and Kva_2 are connected to the two output transformers of the 2-wire repeater across the contacts e_3^{I}, e_3^{II}, e_3^{III} and e_4^{III}, and are thus connected as in the case of ordinary intermediate repeaters.

Signalling.

Supervising operator A_1 can ring in both directions. All the operations take place as indicated under *I*, with the exception of the fact that the ringing current is not attenuated, since relays K_1 and K_2 remain operated during the ringing period.

Clearing Signal.

As has been said under *I*, the signal coming from one direction is transmitted in the other direction and a clearing signal is given to operator A_1 at the toll position by means of relays RU_1 or RU_2 over the supervisory lines. As soon as operator A_1 has withdrawn the monitoring plugs, and lamp *SL* is lit at the through switching position (the armature of relay *S* having fallen back), operator *V* can cut the through communication by withdrawing her plugs. The double cord falls idle and the long-distance lines are returned to the toll positions by change-over relays *UZ*.

III. Connection between 4-Wire Circuits and 2-Wire Circuits.

Operator *V* at the through switching position inserts plug *I* in jack *Kfvd* of a 4-wire circuit, and plug *II* in jack *Kfv* of a 2-wire circuit. As a result of this relay *UV* is operated on the 4-wire circuit and relay *UZ* on the 2-wire circuit. The two lines are thus prepared for through switching. Toll operators A_1 and A_2 and operator V_2 receive their supervisory signals as in *I*. In the double through switching cord, relay Z_1 operates when plug *I* of the 4-wire circuit is inserted, and relays Z_2 and B_2 when plug *II* of the 2-wire circuit is inserted. Relays E_1, E_2, E_3 and E_4 operate through contacts $b_2^{III} - Z_2^{I} - Z_1^{I}$ and connect the talking circuits (as well as the supervisory circuits) to the repeater whose valves are lit as in *II*. Through the closing of contacts b_1^{I}, relay K_2 is operated and the artificial line of $b = 1 \cdot 3$ or $11 \cdot 3$ TU, connected between the repeater and the 2-wire circuit is removed. On the 4-wire side, on the contrary, the artificial line remains permanently in circuit since relay K_1 does not operate. The lighting of lamp *ZL* indicates to operator *V* that the repeater valves are lit. By throwing for a moment the monitoring key she assures herself that the communication is satisfactory.

Calling and Clearing Signal.

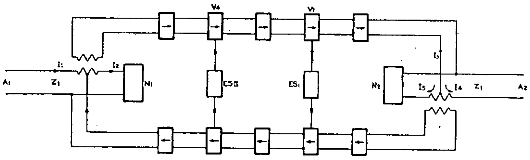
Calling, clearing signal and clearance are effected as is indicated under I.

SIEMENS & HALSKE ECHO SUPPRESSORS FOR 4-WIRE CIRCUITS.

I. Principle of the Echo Suppressor.

Echo suppressors are manufactured by Siemens & Halske to suppress echo phenomena in telephone circuits. These suppressors operate as pure electronic relays in the same manner as amplifiers. In contrast with other systems which use mechanical relays, they have the advantage of very low installation and maintenance cost and great reliability.

The general principle of the echo suppressor is shown in Fig. 1. Echo suppressors I and II suppress the gain of the repeater operating on the unused conversation channel. Considering a conversation coming from A_1 and passing to A_2, a portion of the telephone current enters the echo suppressors I, after passing V_1, where it is amplified and detected. The corresponding direct-current voltage makes the grid of the amplifier V_3 very negative. The effect of this change of potential is shown in Fig. 3. The curve shows the gain of a normal 4-wire repeater



GENERAL ARRANGEMENT OF 4 WIRE CIRCUIT SHOWING ECHO-SUPPRESSORS.

FIG. 1.

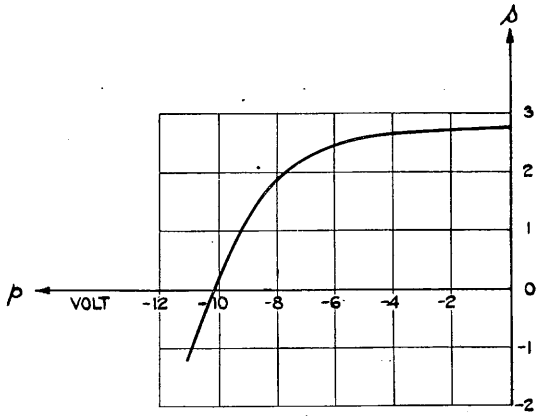
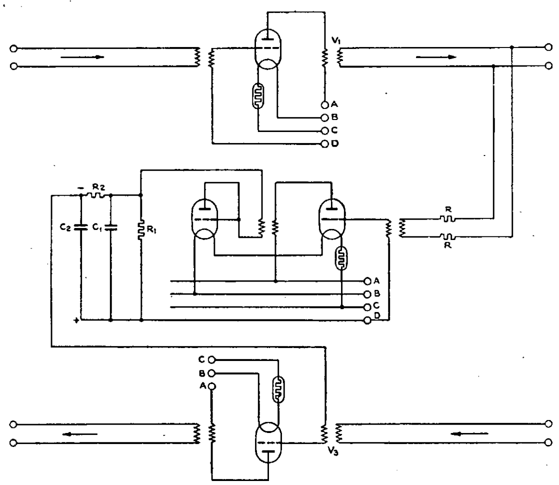


FIG. 3.

as a function of the additional voltage on the grid. As the negative grid voltage becomes more negative, the gain diminishes and at about -10 volts, finally becomes a rapidly increasing loss. The reduction of the gain shows itself immediately in the weakening of the echo currents—in other words, the reduction is equal to the weakening of the echo currents. Beyond about -10 volts the echo is practically completely suppressed.

Fig. 2 shows a schematic of the echo suppressor.



SCHEMATIC DIAGRAM OF ECHO SUPPRESSOR.

FIG. 2.

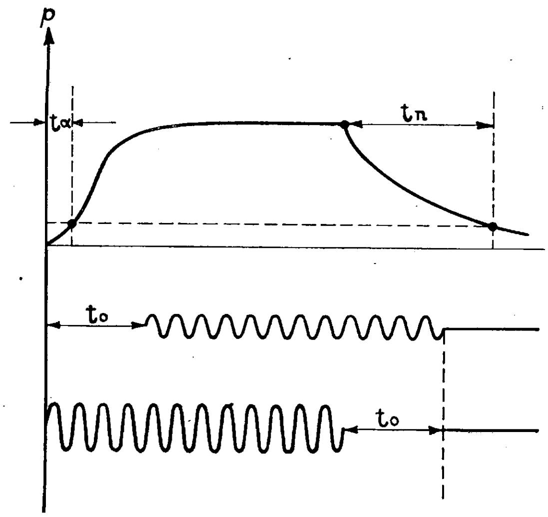


FIG. 4.

It contains an amplifier tube and a detector tube. The input circuit comprises resistances R and the input transformer; it is designed so that the loss on the telephone circuit caused by the introduction of the echo suppressor shall be less than $b = 0{\cdot}05$ (0·43 TU). The amplifier is tuned so that the maximum gain occurs at about 800 cycles. In this way the possibility of disturbance by stray currents is greatly reduced.

The detector tube plate circuit is closed by the delay arrangement R_1, R_2, C_1, C_2, from which is taken the direct-current voltage for changing the grid potential. On the one hand, the delay arrangement provides that the action of the suppressor is rapid in producing a jamming impulse on the return circuit; on the other hand, it maintains the voltage until the last echo currents have got back to the repeater, which is controlled by the suppressor. Fig. 4 shows the operation of this circuit. The lower curve represents the talking current leaving the amplifier V_1, a portion of which arrives in the form of an echo at repeater V_3 after a certain time t_o. The upper curve shows the direct-current voltage p as a function of time, at the echo suppressor output. If p exceeds a certain value (the jamming voltage) the repeater V_3 is then practically blocked. This must take place in a time t_a which is little less than the time of the echo path t_o; the " time of operation " t_a must therefore be :—

$$t_a < t_o.$$

If the effect of talking current stops, then the condensers in the delay circuit discharge and the direct-current voltage furnished by the suppressor diminishes. Repeater V_3 remains jammed up to the time when the voltage becomes less than the jamming voltage. This time is called the " delay " time of the suppressor t_n; naturally, it must be greater than the time of the echo path :—

$$t_n > t_o.$$

In order that the conditions relating to t_a and t_n shall be met in the practical case, it is necessary to make the condenser C_2 in the output circuit of the suppressor conform to the given conditions. In particular, the value of the transmission level at the suppressor input is very important, as well as the distance of the echo suppressor from the receiving station. The following table gives the capacity of the output condenser necessary for medium loaded cables :—

Repeater Station.	Time of echo path (milli-seconds).	Transmission Level.				
		− 1·0 or − 8·7 TU.	− 0·5 or − 4·3 TU.	0	+ 0·5 or + 4·3 TU.	+ 1·0 or + 8·7 T.U.
1	25	0·10	0·05	0·05	0·05	0·05
2	50	0·20	0·05	0·05	0·05	0·05
3	75	0·35	0·10	0·05	0·05	0·05
4	100	—	0·20	0·10	0·10	0·10

For the installation of echo suppressors in repeater stations on line 4 above, away from the receiving station t_n must be greater than 100 milli-seconds. As observations have shown, this value is the upper limit which must not be exceeded in telephone communications, if we consider the possibility of a rapid interchange of questions and answers.

II. Construction.

A. The Echo Suppressor.

The different portions of the echo suppressor are mounted on an iron plate, 200 mm. wide by 250 mm. high. The amplifier tube, the detector tube (B.O. type) and the ballast lamp (type E.W. 20) are mounted on the front of the panel under a perforated sheet-iron cover, which can be opened upwards. Below this dust cover a second dust cover covers a condenser support which takes the amplifier plate circuit condenser and the output condensers. On the rear of the mounting plate are mounted the input transformer, the inter-stage transformer, the plate circuit choke coil, and the series and shunt resistances in the output circuit. Connection with the input and output circuits and the batteries is made by means of terminal tags. The apparatus mounted on the rear of the mounting plate are protected from dust and damage by a removable dust cover.

B. Echo Suppressor Rack.

Twenty echo suppressors are mounted on one rack as well as the testing and maintenance apparatus. This rack is similar in external construction to the normal repeater rack. The different apparatus units are mounted on the rack as follows :—

(*a*) 10 echo suppressors (*ES*) occupy the upper and lower rows.

(*b*) The remaining space in the centre contains the measuring instruments—that is to say:

1. Ammeter A_1 with a suppressed zero, for measuring the filament current of the amplifier and detector tubes. Scale 0·8 to 1·3 amps.

2. An ammeter A_2 for measuring the direct plate current of the amplifier. Scale 0 to 15 milliamps.

3. A voltmeter V_1 for measuring the plate current of the detector. This instrument is calibrated as a voltmeter and measures the change of grid voltage on the grid of the 4-wire amplifier which is jammed. Scale 0 to 90 volts.

4. A voltmeter V_2 with scales 0 to 25 volts and 0 to 250 volts for the supply voltages.

5. A switch (*V.U*) for the voltmeter. By means of this switch and the voltmeter V_2, all the voltages which are needed can be measured on the echo suppressor rack, namely: the direct-current grid voltages (GB_1 and GB_2) of the suppressor amplifiers (4 to 6 volts), the filament voltage *HB* of the amplifier and detector tubes (12 volts) and the plate voltage *AB* of the amplifier tubes (220 volts).

6. Shunt resistances for the measuring instruments. These are mounted on the back of the measuring instrument panel. All the instruments have a horizontal scale.

7. A jack (*AK*). This is multipled to the appropriate amplifier racks. By means of a normal repeater station microtelephone set, an additional control of the echo suppressors is furnished.

(*c*) On the left and right of the measuring instrument panel there are 10 filament supply keys H.S. for the amplifier and detector tubes, 10 plate supply keys A.S. for the amplifiers and 10 plate supply keys G.S. for the detectors. These 60 keys are 3-position keys giving: cut-off, operation and measurement for the circuit current. The key is non-locking in the measuring position and returns automatically to the operate position.

(*d*) Above the measuring instrument panel is a fuse mounting taking 20 fuses S_1 for the filament circuits; these are normal 3 amp. fuses mounted on steatite with an alarm contact.

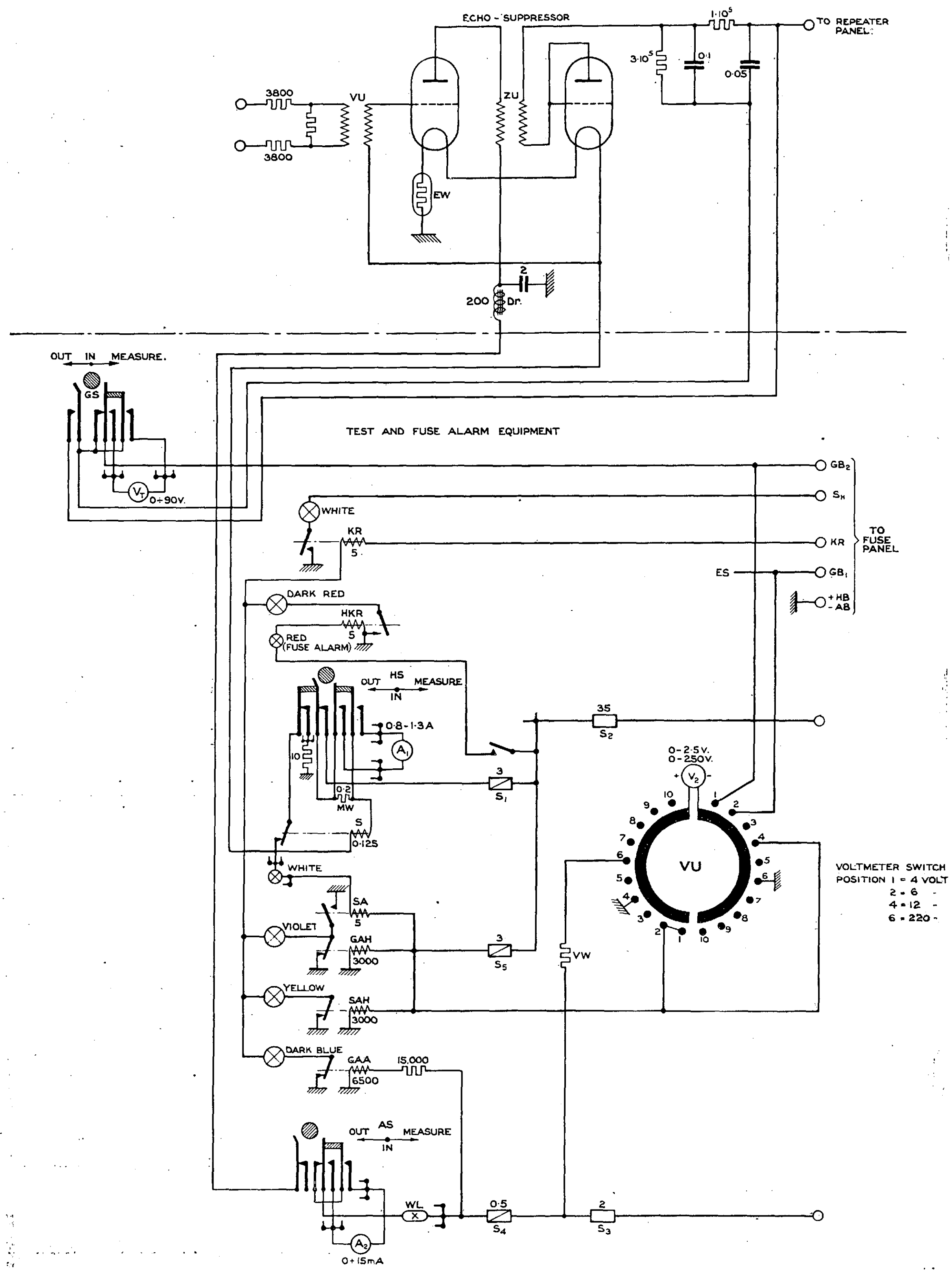
(*e*) Above the fuse panel are 20 normal W.I. lamps (resistance lamps) in series with the amplifier plate circuits.

(*f*) To left and right of the fuses and resistance lamps are the main fuses and corresponding alarm lamps as follows: a 35-amp. fuse (S_2) in the filament circuit, a 2-amp. fuse (S_3) and a ·5-amp. fuse (S_4) in the plate circuits, and a 3-amp. fuse (S_5) in the alarm circuit.

(*g*) Below the measuring instrument panel are mounted several strips of no-current relays S for the filament circuits, a plate voltage pilot relay (G.A.A.), a filament voltage pilot relay (S.A.H.), a relay (G.A.H.) to control the 35-amp. fuse (S_2), and alarm relays (S.A., H.K.R., and K.R.). The relay assembly is protected by an ordinary dust cover. The alarm circuits are similar to those used on the battery supply of a repeater station.

(*h*) Ammeter shunt resistance of 0·2 ohm are mounted under a protecting cover.

(*i*) The working voltages are lead to the rack from terminals located in the upper part of the echo suppressor rack. Telephone circuits and grid voltage circuits are connected to the echo suppressors by connecting blocks which are mounted in the usual manner at the top of the rack. They are covered by a special plate carrying the main pilot lamp in the centre. The pilot lamp is lighted by an alarm relay when any failure takes place.



ECHO - SUPPRESSOR
TO REPEATER PANEL.
3800
VU
ZU
EW
200
Dr.
OUT IN MEASURE.
GS
0÷90V.
TEST AND FUSE ALARM EQUIPMENT
WHITE
KR
DARK RED
HKR
RED (FUSE ALARM)
HS
OUT MEASURE IN
0·8-1·3A
MW
WHITE
SA
VIOLET
GAH
3000
YELLOW
SAH
DARK BLUE
GAA
6500
15,000
AS
OUT MEASURE IN
WL
0÷15mA
GB2
SH
KR
GB1
ES
+HB -AB
TO FUSE PANEL
0-2·5V.
0-250V.
VW
VOLTMETER SWITCH
POSITION 1 = 4 VOLT
2 = 6 -
4 = 12 -
6 = 220 -

FIG. 5.

L 3

APPENDIX C.c.4 No. 2.

ECHO SUPPRESSORS FOR LONG TELEPHONE CIRCUITS.*

By A. B. CLARK,† Member A.I.E.E., and R. C. MATHES,‡ Associate A.I.E.E.

Synopsis.—A device has been developed by the Bell System for suppressing "echo" effects which may be encountered under certain conditions in telephone circuits which are electrically very long. This device has been given the name "echo suppressor" and consists of relays in combination with vacuum tubes, which are operated by the voice currents so as to block the echoes without disturbing the main transmission.

This paper gives a brief description of this device, together with a discussion of its possibilities and limitations. A number of echo suppressors have been operated on commercial telephone circuits for a considerable period so that their practicability has been demonstrated.

TABLE OF CONTENTS.

Introduction.

In designing telephone circuits which are electrically very long, an important problem is presented by the necessity of avoiding serious "echo" effects. Echo effects are caused by reflections of voice waves which take place whenever electrical irregularities are encountered in telephone circuits. The effects produced are very similar to echoes of sound waves. Some of the reflected waves return to the receiver of the talker's telephone so that if the effects are severe, he may hear an echo of his own words. Other reflected waves enter the receiver of the listener's telephone and, if severe, cause the listener to hear an echo following the directly received transmission.

Reflections of voice waves occur in all practical telephone circuits. It is only in telephone circuits of such length as to require a number of repeaters, however, that echo effects become serious. The fact that the circuits are electrically very long makes the time lag of the echoes appreciable. At the same time, the telephone repeaters overcome the high attenuation of these long circuits and, consequently, make the echoes louder. The seriousness of the effect is a function both of the time lag and the volume of the echoes relative to the direct transmission.

A brief discussion of these echo effects was given in a paper§ presented before this Institute about two years ago, and in a later paper|| some examples of their relative effects in practical telephone circuits were given. In these papers the importance of keeping electrical irregularities within proper limits was pointed out as was also the advantage gained by using circuits having a high velocity of propagation so that the lag of the echoes is reduced.

As a supplement to these methods, a device to which has been given the name "echo suppressor" was developed by the Bell System, along lines suggested by John Mills.¶ In all

* Presented at the Spring Convention of the A.I.E.E., St. Louis, Mo., April 13–17, 1925. Published in the *Journal of the A.I.E.E.*, June, 1925.

† American Telephone and Telegraph Co., New York City.

‡ Bell Telephone Laboratories, Inc., New York City.

§ "Telephone Transmission over Long Cable Circuits," by A B. Clark, *Transactions A.I.E.E.*, Vol. XLII, page 86.

|| "Telephone Transmission over Long Distances," by H. S. Osborne, *Transactions A.I.E.E.*, Vol. XLII, page 984.

¶ U.S. Patent No. 1,434,790, John Mills, "Two-Way Transmission with Repeaters." Issued Nov. 7, 1922.

practical telephone circuits involving more than a single repeater there are points where the transmission in the two directions passes through two separate paths. At these points the direct transmission passes through one path while only reflected currents or echoes pass through the other. The echo suppressor is located at one of these points. In this device, the voice currents, with the help of vacuum tubes, are caused to actuate relays which cut off the echoes in the return path without disturbing the other path through which passes the main transmission.

This paper, after briefly reviewing the nature of echo effects in four-wire circuits, explains, in a general way, how an echo suppressor functions on such a circuit. The four-wire echo suppressor is then described together with some variations in its design for use under special conditions and with other circuits. This is followed by a discussion of the possibilities and limitations of echo suppressors, both on four-wire and other types of telephone circuits.

Review of Nature of Echo Effects in Four-Wire Circuit.

Fig. 1 illustrates the way echo currents may be set up and circulate in a four-wire circuit. In this figure, *a* shows a four-wire circuit in diagrammatic form. The squares at the extreme right and left are intended to represent the telephone sets used by two subscribers at the terminals *W* and *E*. The squares marked *N* represent electrical networks which simulate or balance, more or less perfectly, the impedances of the two telephone lines terminating in the instruments at *W* and *E*. In the four-wire circuit, the squares with arrows represent one-way repeaters. At each terminal the two separate one-way circuits comprising the four-wire circuit are joined together by means of the familiar balanced transformers. When *W* talks, the transmission passes directly to *E* over the upper pair of wires in the four-wire circuit while, when *E* talks, the direct transmission passes over the lower pair of wires.

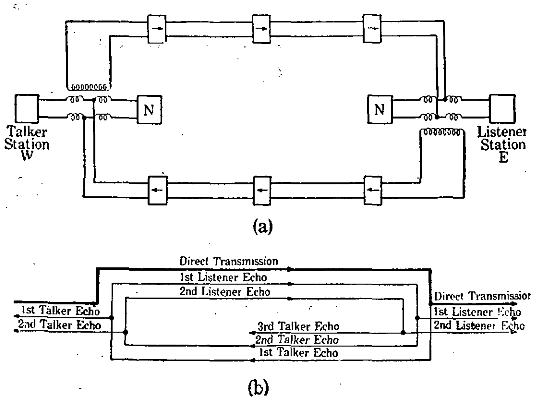


FIG. 1.—Echoes in Four-Wire Circuit.

Below the diagram of the four-wire circuit is given another diagram *b* showing the path of the direct transmission as well as the paths of the echoes which are set up when *W* talks to *E*. The heavy line in the diagram represents the path of the direct transmission through the upper pair of wires in the four-wire circuit. In a practical four-wire circuit it might require, say, 0·05 second for the voice currents to make this journey. This would be the case if the four-wire circuit were 1,000 miles (1,600 km.) long in cable with extra-light loading —coils of 0·044 henry spaced 6,000 feet (1·8 km.) apart. Cable circuits loaded in this way have a velocity of propagation of about 20,000 miles (32,000 km.) per second.

When the voice currents reach the distant end of the four-wire circuit, the larger part goes to the listener at *E*. If the balance between the line and network at the distant terminal is not perfect, however, a portion of the currents will travel back over the lower pair of wires toward *W* as an echo. This echo will, in the case assumed, reach the receiver of the telephone at station *W* 0·1 second after the original voice wave is impressed on the line at that station. The path of this echo is labelled " 1st Talker Echo." It is evident that if this echo is loud enough it may seriously distract the talker.

If the balance between the line and the network at Station *W* is also not perfect, part of this first echo will travel back over the upper pair of wires to Station *E*, the path of this echo being labelled " 1st Listener Echo." The listener at *E* will hear this echo, if strong enough to be audible, 0·1 second after he hears the direct transmission. Evidently, if this echo is sufficiently loud as compared to the direct transmission, it will cause difficulty in understanding.

When the " 1st Listener Echo " arrives at the end of the four-wire circuit, there is still another reflection of part of the current which occurs producing the " 2nd Talker Echo."

This process is repeated, producing successive echoes which are received at both terminals *W* and *E* as indicated, the successive echoes getting weaker and weaker.

Action of Echo Suppressor on Four-Wire Circuit.

An echo suppressor will now be applied to the four-wire circuit and consideration given to its action and to its effect on the echoes. Fig. 2 shows a four-wire circuit which it will be assumed is exactly like the one shown in Fig. 1, with the exception that an echo suppressor has been applied to it. As before, the diagram *a* shows the four-wire circuit, while, below this, another diagram *b* shows the paths of the direct transmission and of the echo.

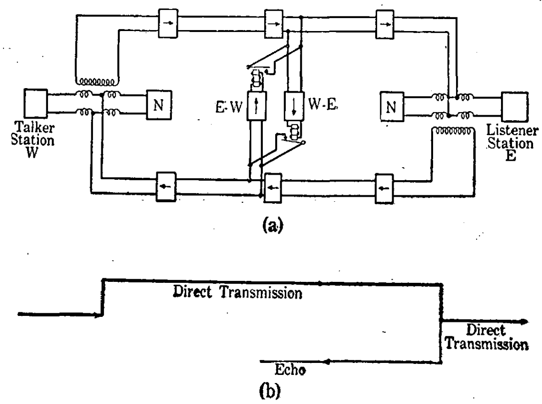


FIG. 2.—Echo Suppressor Cutting off Echo in Four-Wire Circuit.

In Fig 2A the echo suppressor is shown in very simple diagrammatic form. It will be described later in detail. For the present it is sufficient to explain that the echo suppressor consists of two similar high impedance vacuum tube amplifier-detectors bridged across the two sides of the four-wire circuit, each amplifier-detector having associated with it a relay which operates whenever alternating voltage of sufficient strength is impressed across the input. The operation of either relay places a short circuit across the side of the four-wire circuit opposite to the one to which the input of its particular amplifier-detector is connected. This short circuit blocks the transmission flowing in one side of the four-wire circuit and, at the same time, renders the other amplifier-detector inoperative.

Normally, the contacts of the two relays are open, so that talking may be done in either direction over the circuit. When *W* begins to talk, the condition illustrated in the figure is produced. *W*'s voice currents, when they reach the middle of the circuit, cause the relay associated with amplifier-detector *W-E* to operate, thus placing a short circuit across the lower pair of wires in the four-wire circuit. The direct transmission from *W* to *E* is not affected at all, passing on to Station *E* where it is heard by the listener. The echo, which starts back from Station *E*, travels toward Station *W* as far as the point where the echo suppressor is connected to the circuit. It is stopped there, however, by the short circuit which the echo suppressor has applied.

In the same way, when *E* talks, his voice currents actuate the amplifier-detector marked *E-W* and apply a short circuit to the upper pair of wires, thus preventing the passage of the echo current around the circuit.

The circuit shown in Fig. 2A is one of the more convenient for satisfying the fundamental operating conditions of an echo suppressor. These may be stated as follows: When no one is talking, free paths should exist for transmission in either direction and each suppressing relay should be ready to act at the passage of speech over the side of the circuit with which it is associated. When speech passes in one direction over the circuit the resulting operation of the corresponding half of the suppressor should not only interrupt the continuity of the opposite side of the circuit, but at the same time prevent the other half of the suppressor from functioning. The latter condition is desirable as otherwise the returning echo might have enough energy at times to operate the opposite part of the suppressor circuit and so interrupt the direct transmission. Outside of this restriction the selection of the points from which the echo suppressor input currents are derived and the points at which the relay control functions are applied is governed only by such considerations as economy of apparatus and convenience. In general, it is the more economical arrangement to have a single relay, which interrupts the path through which the echoes return, also remove the speech input from the suppressor by such a relative association of parts as shown in Fig. 2A.

It will be noticed that, as a finite time is needed for the switching operation, there is a possibility, if the two subscribers begin talking simultaneously, of both halves of the suppressor being operated together and remaining operated, with both sides of the circuit cut off, for a time equal to the release time of the relays. However, for the times of operation and release, which are found desirable from other considerations, it has been found that no apparent difficulty has been caused by this effect.

Because of the fact that an appreciable time is required for the voice currents to travel, it will be seen that exceeding fast operation of the relays is not necessary. In the example given, if it is assumed that the echo suppressor is connected to the circuit at its midpoint, the echo requires 0·05 second to reach the point where the short circuit is applied, after the voice currents reach the input of the amplifier detector. The echoes will be cut off by the relays, therefor, even if the latter require as long as 0·05 second for operation. If the echo suppressor is nearer to the end of the four-wire circuit this operating time would need to be somewhat shorter. In practical four-wire circuits it is seldom that an operating time shorter than about 0·02 second is required. It is an easy matter to secure this speed of operation with standard telephone relays.

The diagram also shows that, in order to completely cut off the echo, the echo suppressor relay must not open, after talk ceases, until the complete train of echoes has reached the point where the short circuit is applied. In the example given, the length of time required to reach the point where this relay applied the short circuit after the voice currents pass the input of the amplifier detector is 0·05 second. It is seldom that this lag is greater than 0·1 second in practical four-wire circuits.

It is seen from the above two paragraphs that it is desirable for a four-wire echo suppressor to possess a moderately short operating time and a longer releasing time. How this is accomplished will be described in what follows.

Description of Four-Wire Echo Suppressor.

In Fig. 3 is shown a circuit diagram of one half of the echo suppressor, which is shown complete but in less detail in Fig. 2A. It consists of two vacuum tubes operating in tandem, the first functioning as an amplifier and the second as a combined amplifier and detector.

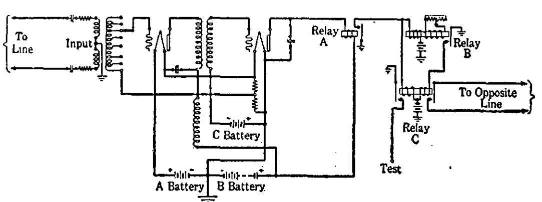


Fig. 3.—Circuit Diagram of One-Half of a Four-Wire Echo Suppressor.

As was shown in Fig. 2A the voltage impressed on this amplifier detector combination is derived from speech currents passing over one side of the circuit while the relay controlled by this combination short circuits the other half of the circuit.

The voltage input to the amplifier tube is supplied through a transformer which is broadly tuned by series condensers to produce a circuit efficient at the more important voice frequencies but inefficient at other frequencies, particularly below 500 cycles per second. The circuit thus functions to minimize the effect of noise currents on the operation of the relays. Likewise, in the interstage transformer coupling, emphasis has been placed on securing the maximum voltage step up to the detector grid in this same frequency region. To avoid any harmful reaction upon the transmission characteristics of the main circuit which might result from bridging on an input circuit whose impedance varies so greatly over the speech frequency range, this circuit is arranged to have a high impedance. The input transformer is also provided with a series of taps on one of the windings, thus affording a simple means of varying the sensitivity of the device.

The detector tube is operated with a sufficiently large negative grid potential to reduce its space current to zero, or nearly so, when no input is applied to the circuit. Accordingly, relay *A* which is connected in the plate circuit is normally in a released condition. When speech currents are applied to the circuit the voltage on the grid of this tube fluctuates. Those variations which make the grid more negative produce no effect but those which make it more positive allow pulses of current to pass through relay *A* tending to operate it. A condenser is bridged from plate to filament of this tube, the purpose of which is to average these rectified half waves of applied speech so as to insure smooth and positive operation of the relay.

When speech is applied to the circuit the resulting operation of relay *A* does two things. It causes the operation of relay *C* by connecting a ground to one of its windings, and it likewise operates relay *B*. The operation of relay *C* short circuits the opposite line. The time required for the operation of relay *C*, in response to a sustained alternating E.M.F. suddenly applied

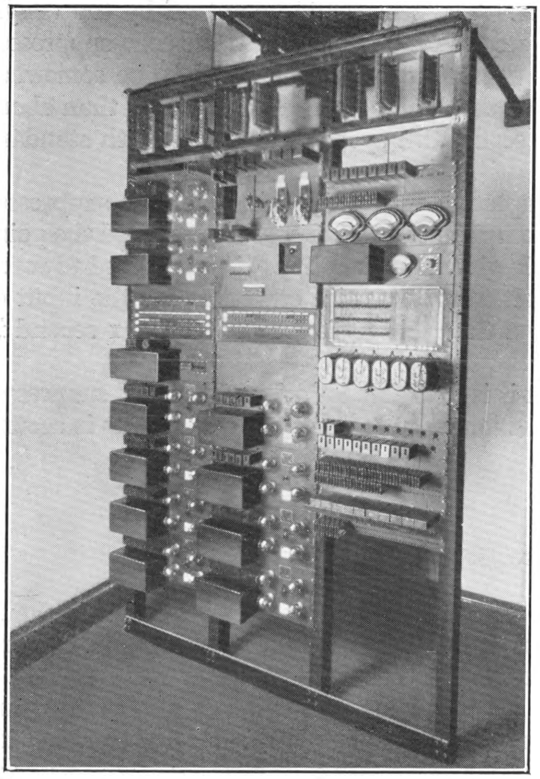


FIG. 4—Installation at Harrisburg, Pa.

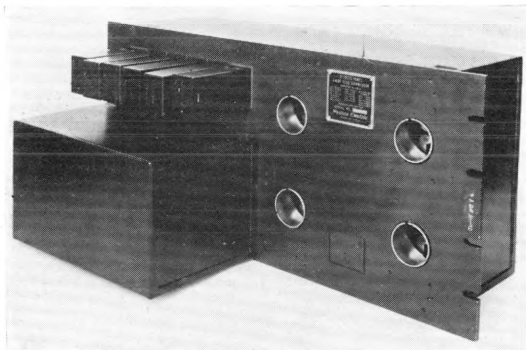


FIG. 5.—Front View of Echo Suppressor Panel.

to the input of the amplifier-detector, is about 0·02 second. As was pointed out above, operation in this length of time takes care of conditions in the large majority of cases encountered on four-wire circuits.

The function of relay *B* is to provide a delay in the release of relay *C* after speech has ceased to be applied to the suppressor circuit input and relay *A* has released. Its operation in response to that of *A*, it will be noticed, connects ground to a second winding on relay *C*, which will then in turn remain operated as long as the relay *B* maintains this auxiliary current after the relay *A* has released. Relay *B* is made slow releasing by an auxiliary winding closed through a low resistance, and its time of release can be adjusted over a considerable range to meet different operating conditions by changing the value of this resistance. Differing adjustments are rarely called for in practice and these relays are normally set for a releasing time of 0·1 second.

A number of echo suppressors have been installed at Harrisburg, Pa., where they are now in service on a group of four-wire circuits. Fig. 4 is an illustration of this installation of four-wire echo suppressors. Fig. 5 shows a close-up view of an individual panel from the front. Both halves of the suppressor working on a single circuit are mounted together on one panel. The method of mounting and the type of equipment in the echo suppressors are in general quite like the standard for the four-wire circuits with which they operate. Although in Fig. 3 the battery supply circuits are shown individual to this set, in the actual installation common batteries are used. The four filaments of the tubes on one panel are operated in series from the 24-volt battery.

The operation and maintenance of these devices involve little that is different from standard repeater equipment. There is one test, however, which is employed in checking the times of functioning which perhaps deserves special mention. This test involves observing the time needed for the suppressor to go through any number of complete cycles of operation release. To make this test, the short-circuiting contacts of relay *C* and the input of the suppressor circuit are connected together and to an oscillator as shown in Fig. 6. As soon as the oscillator is connected to the input, the relay train begins operating and the shorting contacts of relay *C* in turn cut off the applied voltage. This short circuit is maintained across the input for a time by the slowness of release of relay *B* as previously explained. When it finally releases and in turn releases relay *C*, the suppressor again operates and the process is repeated over and over. At each repetition of the cycle the auxiliary contacts of relay *C* apply a ground to the test terminal which is connected to a counting device. With the aid of a stop-watch the number of cycles in any given time is readily determined and thus the time of a single cycle of operation. This time is the sum of the time needed for relays *A* and *C* to make and the time needed for relays *A*, *B* and *C* to release. By observing the uniformity and smoothness of operation with which this cycle is carried out the tester can check the adjustment of all the relays. If relays *A* and *C* are properly adjusted so that their operation is positive and uniform, the operating time will vary but slightly from the proper value of about 0·02 second. The test, therefore, gives a good measure of the longer release time which would normally be about 0·1 second.

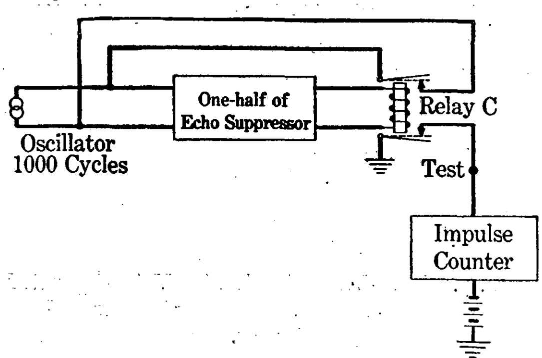


FIG. 6.—Circuit for Testing Time of Operation and Release.

Some General Considerations.

As was pointed out above, when an echo suppressor is applied to a telephone circuit, the telephone circuit remains operative in both directions when it is in the normal condition, *i.e.*, when no one is talking. It is only when talking is done over the circuit that the path for transmitting in the reverse direction, which is then useless so far as talking is concerned but which is harmful because it furnishes a path for the echoes, is blocked. The advantages gained by this arrangement are: (1) there is no possibility of cutting off the first part of words owing to the fact that the transmission path actually carrying the speech is unaffected by the switching operations; and (2) if the relays should fail to operate because the voice currents happen to be very weak, the listener at the distant end would still hear the speaker although both he and the talker might also hear some echoes. Weak speech does not, in general, give rise to such serious echoes as does strong speech. Therefore, when the voice currents happen to be so weak that they fail to operate the suppressor, the echoes produced may not be serious.

Now, in order to obtain these advantages it is necessary to face the possibility of "singing," since when no one is talking the paths for transmission in both directions remain in their normal operative condition. It is evident that if the repeater gains are raised high enough, singing will begin exactly as it would if the circuit contained no echo suppressor. If singing starts in a circuit containing an echo suppressor, the circulating currents will build up until they become strong enough to cause operation of the relay associated with one half or the other of the echo suppressor so that one of the transmission paths will be blocked.

This will temporarily stop the singing. It will commence again, however, as soon as the relay falls back to its normal condition. Thus, a chattering condition is produced which, in general, would not be tolerated.

In order to overcome the limitations which may be set on a circuit by the possibility of singing, it is necessary to go back to the old idea of a voice-controlled system in which the transmission is blocked when no one is talking. It is not necessary, however, to block both of the transmission paths since if one path only is blocked, singing evidently cannot occur.

Fig. 7 shows one of the possible arrangements of a voice-operated system in which singing is prevented. It will be seen that this arrangement includes an echo suppressor to which an additional relay D has been added, which keeps the upper transmission path blocked when the circuit is normal, *i.e.*, when no one is talking. Singing is, therefore, not possible when the circuit is normal.

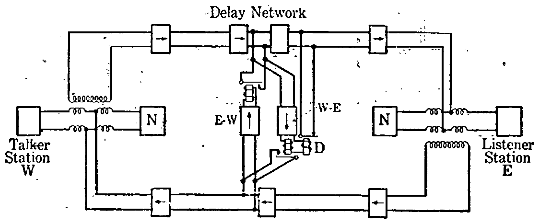


FIG. 7.—Four-Wire Circuit with Voice-Operated Device arranged to Suppress Echoes and Singing.

Now, when talking is done at Station W the voice current waves, on arrival at the middle of the circuit, cause operation of the two relays associated with the amplifier-detector W–E. An appreciable length of time is required, of course, to operate relay D. To avoid the possibility of cutting off the initial parts of words during the time before relay D operates, it is desirable to delay the main transmission. What has been called a " delay network " has, therefore, been included as shown in the figure. This delay network may, of course, assume various forms, one of which might be an artificial loaded line or low pass filter. By including such a delay network, the voice currents can be retarded long enough to give the contacts of relay D time to clear the path before the voice currents reach the point in the circuit where the transmission has been blocked.

In addition to clearing a path for the main transmission in the direction from W to E, the transmission path from E to W is blocked by the operation of the other relay associated with amplifier-detector W–E. The circuit, therefore, has no chance to sing when in the condition for talking from W to E.

When talking is done at Station E, the relay associated with amplifier-detector E–W is operated. This prevents the echo returning from Station W from operating the relays associated with amplifier-detector W–E. For talking in this direction, therefore, the upper transmission path remains blocked. There is, therefore, no chance for singing, as was also the case for the other conditions.

By adding the delay network, one of the disadvantages of voice-controlled relay systems which keep transmission normally blocked is overcome in large part. This is the clipping off of the first parts of words, the possibility of which was mentioned above.

There remains, however, an important disadvantage in the fact that it is necessary that the voice currents never fail to operate relay *D*. If they did fail to operate this relay, the listener at Station *E* would hear nothing. It is necessary, therefore, that the amplifier-detector-relay system *W–E* be sensitive enough so that the voice currents which traverse the upper path in the four-wire circuit will never fail to cause operation of its relays.

On the other hand, noise currents which traverse the upper path in the four-wire circuit must never cause operation of the relays associated with the amplifier detector *W–E*. Such false operation would, of course, prevent transmission over the lower pair of wires from Station *E* to *W* and would, therefore, render the four-wire circuit inoperative.

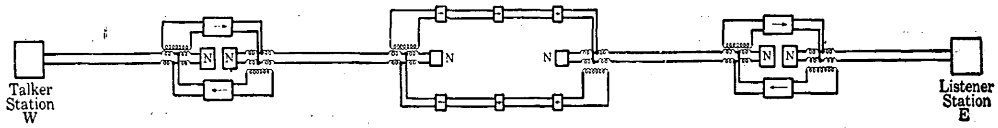
To overcome the singing limitation, it is thus seen that it has been necessary to produce a device which requires greater sensitivity and is, therefore, more seriously affected by noise currents than is a simple echo suppressor. This is in addition to the further complications involved.

Now, in applying simple echo suppressors to long telephone circuits, it is in general not the possibility of singing, but rather, the necessity of avoiding false operation of the relays by noise currents that constitutes the most serious limitation. This is discussed in more detail in what follows. For the present, it is sufficient to note that in the case of most long-distance telephone circuits the method of avoiding singing, which has been described, appears to offer possibilities of limited application only.

Echo Suppressors applied to other Types of Telephone Circuits.

It will, of course, be understood that in practice a normal commercial telephone circuit is always two-wire at the two ends where connection is made to the subscribers' instruments. The rest of the circuit may be entirely four-wire or it may be all two-wire, or a combination of both. The application of echo suppressors to circuits which are not all four-wire will now be considered.

One important practical case is that where a four-wire circuit is sandwiched in between two two-wire circuits. Such a case is illustrated in Figs. 8 and 9. Fig. 8 shows conditions without an echo suppressor while Fig. 9 shows conditions, with an echo suppressor. In both figures, a diagram of the circuit itself is shown in the upper part *b*, while in the lower part *b* are shown the paths of the direct transmission and echoes. These transmission paths illustrate the condition when talking is being done from Station *W* to Station *E*. In both figures, for simplicity, the first echoes affecting the talker and listener only are shown, echoes of these echoes being ordinarily of little importance.



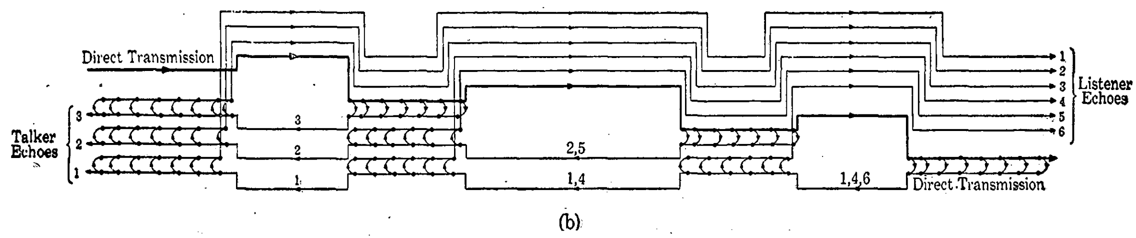


FIG. 8.—Echoes in Combination Two-Wire and Four-Wire Circuit.

It will be observed in Fig. 8*b*, which represents the condition of affairs when no echo suppressor is used, that the listener hears echoes coming from as many as six different paths. The talker hears echoes from three paths. Now compare this with Fig. 9*b* which represents the condition of affairs when an echo suppressor is employed. It will be observed that all of the echoes which return through the four-wire circuit have been suppressed. Echoes from only two paths now reach the listener, while echoes from only one path now reach the talker. Furthermore, the echoes affecting both talker and listener, which remain when the echo suppressor is employed, are those whose paths are comparatively short. The echoes whose paths are the longest have been cut off by the action of the echo suppressor. These echoes which travel over the long paths have the greatest lags and are usually most serious. Consequently, cutting these echoes off makes a material improvement possible even though the echoes whose paths are short remain.

In order that an echo suppressor may operate satisfactorily on a circuit, such as the one shown in Fig. 9*a*, it is necessary that the time required for operation of the relays be short enough so that, if there are any serious echoes returning over short paths, the relays will operate before these reach the suppressor. After operation, the suppressor relays must remain operated until the echoes whose paths are the longest have been suppressed.

In the case of telephone circuits worked entirely on a two-wire basis, echoes may also constitute an important limitation when the circuits are electrically long. On such circuits it is also generally true that the most serious echoes are those whose paths are the longest, namely, those which travel back and forth between points at or near the ends of the circuit. The application of an echo suppressor to one of the repeaters in a two-wire circuit, therefore, offers possible advantages.

If it is imagined that the four-wire circuit shown in Fig. 9*a* is shortened so that the whole four-wire circuit is located at one point, the two-wire condition would be represented. The time lags which were introduced by the lines comprising the four-wire circuit are now absent. It is possible, however, to introduce delay networks into the two sides of the two-wire repeater

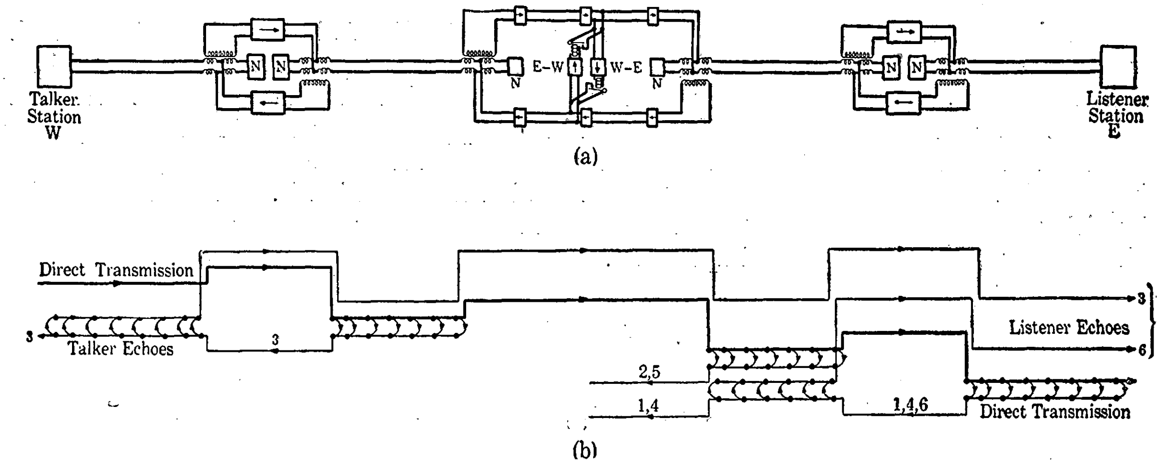


Fig. 9.—Echo Suppressor Cutting off Echoes in Combination Two-Wire and Four-Wire Circuit.
(*a*) Combination two-wire and four-wire circuit with echo suppressors.
(*b*) Paths of direct transmission and echoes.

to which the echo suppressor has been applied, so as to make it effectively a four-wire circuit, although the two ends are not geographically separated. This would evidently allow the four-wire echo suppressor which has already been described to be applied without modification.

By using somewhat higher speed relays and switching systems, however, it has been found possible in tests which have been made, to obtain satisfactory operation on an all two-wire without introducing devices to produce time lags. This is possible because the important echoes in a two-wire circuit generally lag enough to allow time for relays to operate. Only a few of the echoes return to the suppressor with very small time lags. Some of these can be allowed to pass without causing appreciable impairment provided they are not strong enough to cause false operation of the relays which block the main transmission path.

Possibilities and Limitations of Echo Suppressors.

The curves in Fig. 10 show how, when no echo suppressors are employed, the echo effects limit the extent to which the overall loss of a circuit may be lowered by the application of repeaters.* The curves in this figure apply to four-wire circuits of various lengths (without

* The ordinates on this figure are in terms of the new "transmission unit" abbreviated "TU," which is defined in a paper entitled "The Transmission Unit, etc.," by W. H. Martin, *Journal of the A.I.E.E.*, June, 1924. Also in the article entitled "The Transmission Unit," by R. V. L. Hartley, in *Electrical Communication*, July, 1924.

· echo suppressors) used to handle terminal business, *i.e.*, connections to subscribers not involving the use of other toll lines in tandem with the four-wire circuit. It is assumed that simple compromise networks giving only a rough degree of simulation of the impedances of the terminal circuits are used. The curves, which are based on experimental data, indicate roughly how the overall volume efficiency must be limited to keep echo effects small enough so that they are not considered disturbing when ordinary telephone conversations are carried on.

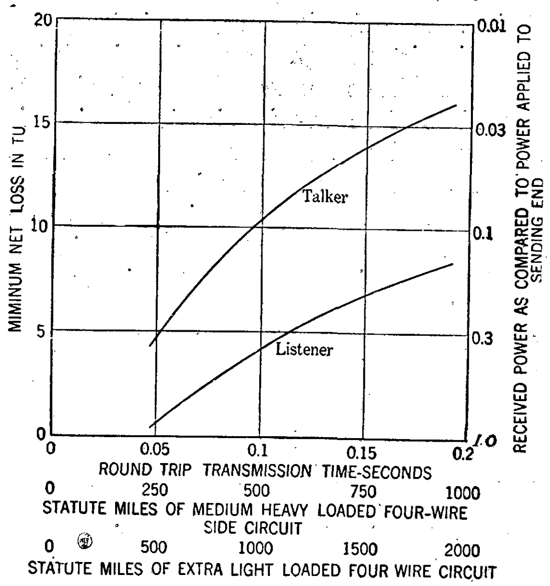


FIG. 10.—Echo Limitations on Loss of a Four-Wire Circuit.

Consider, for example, what are the limitations for a circuit 1,500 miles (2,400 km.) long, with extra light loading. One of the curves which is marked " Talker " shows that in order to keep the echoes which affect the talker sufficiently low, requires that the overall loss in the circuit be made no lower than about 14 TU*. The other curve marked " Listener " shows that keeping the echoes which affect the listener within proper limits is a less severe limitation, requiring only that the net loss be made no less than about 7 TU. Singing of a circuit such as this would not ordinarily begin until the loss was reduced to zero or even, perhaps, made less than zero, *i.e.*, an overall gain.

If an echo suppressor were applied to a circuit such as the above, a maximum improvement of the order of 14 TU might be looked for. As a matter of fact, results as good as this have been obtained in tests.

In order to obtain a result as good as this requires, of course, that the echo suppressor be given a sensitive enough adjustment so as to cut off substantially all of the echoes, even when the voice currents are weak. When given such a sensitive adjustment, there will, of course, be a tendency for noise currents to produce false operation. In certain cases, avoiding such false operation may require that the sensitivity of the echo suppressor be reduced to the point where weak voice currents fail to operate the relays. In such cases, results as good as the above will not be obtainable.

In practice, little or no trouble from false operation due to noise within the cable facilities comprising a four-wire circuit is experienced. When the connections to the terminals of the four-wire circuit are short, therefore, so that, on these terminal connections, the noise currents are comparatively weak and the voice currents large, it is possible to realise in practice the full theoretical possibilities from an echo suppressor. In other words, it is possible to work a four-wire circuit under these conditions at a very low loss, or even an overall gain.

When the lines connecting the subscribers with the terminals of the four-wire circuit are long, so that the voice currents may be weaker and, perhaps, the noise currents may also be stronger, results as good as this may not be obtainable. However, even in this case, a material improvement can usually be effected by the echo suppressor.

* Due to transmission variations of the different parts comprising long telephone circuits such as these, the overall loss varies to a certain extent with time. In practice, adjustments of circuits in the Bell System Plant are made often enough to keep the variations within about ± 2 or 3 TU. The working net loss must, of course, be made high enough so that echo difficulties will not be encountered when the variations combine in such a way as to give the overall, or net loss, its minimum value. For example, in the case of the 1,500-mile (2,400 km.) circuit above, if it is assumed that the circuit is limited by echoes to a 14 TU minimum net loss and that it is maintained within limits of variation of ± 3 TU, the working net loss would be 17 ± 3 TU.

For the condition in which a four-wire circuit is switched to a variety of different circuits at the terminals, it was shown in Fig. 10 that the requirement that echoes should not disturb the talker is more severe, so far as limiting the minimum loss is concerned, than the requirement that echoes should not affect the listener's transmission. It will, of course, be obvious that talkers connected to either terminal of the four-wire circuit through connections involving small transmission losses will hear louder echoes than will talkers connected through circuits having larger losses. In other words, the minimum net loss of a four-wire circuit used in this way is limited by the requirement that the talkers connected through low losses should not receive too much echo. Now, of course, the relays in the echo suppressor will respond most readily to these talkers. Satisfactory operation of the relays for these talkers will, therefore, be secured even though the echo suppressors be given such an adjustment that the relays will not respond to the voice currents from talkers connected to the circuit through a higher loss. Cutting off the talker echoes in the case of the connections involving low losses, therefore, makes it possible to materially lower the loss introduced by the four-wire circuit even though other echoes are not cut off.

In the curves of Fig. 10 it is seen that for a 1,500 mile (2,400 km.) extra light loaded circuit the possible improvement which may be secured by cutting off the talker echoes from low loss connections may be as much as 7 TU even though echoes from other connections are not cut off.

In general, for combinations of four-wire and two-wire circuits and for circuits which are all two wire as well, talker echoes are also more serious than listener echoes provided that the impedance irregularities at intermediate points in the circuit are small, as is usually the case with high grade circuits. Consequently, echo suppressors make it possible to effect improvement in many cases even if the line noise which is present requires reduction of the sensitivity of the echo suppressors to the point where weak voice currents fail to operate the relays. If the line noise requirement does not enter as a limitation, a greater improvement is, of course, possible as is also the case with all four-wire circuits.

Conclusion.

The echo suppressor which has been described offers attractive possibilities in supplementing other methods for obtaining satisfactory transmission over long two-way telephone circuits.

The application of an echo suppressor to a telephone circuit requires no changes in the circuit itself, the echo suppressor being merely attached to the circuit at some convenient point.

For any particular type of circuit, the advantages to be gained by using echo suppressors increase with length. For a given circuit length the advantages to be gained are greater with low speed than with higher speed circuits.

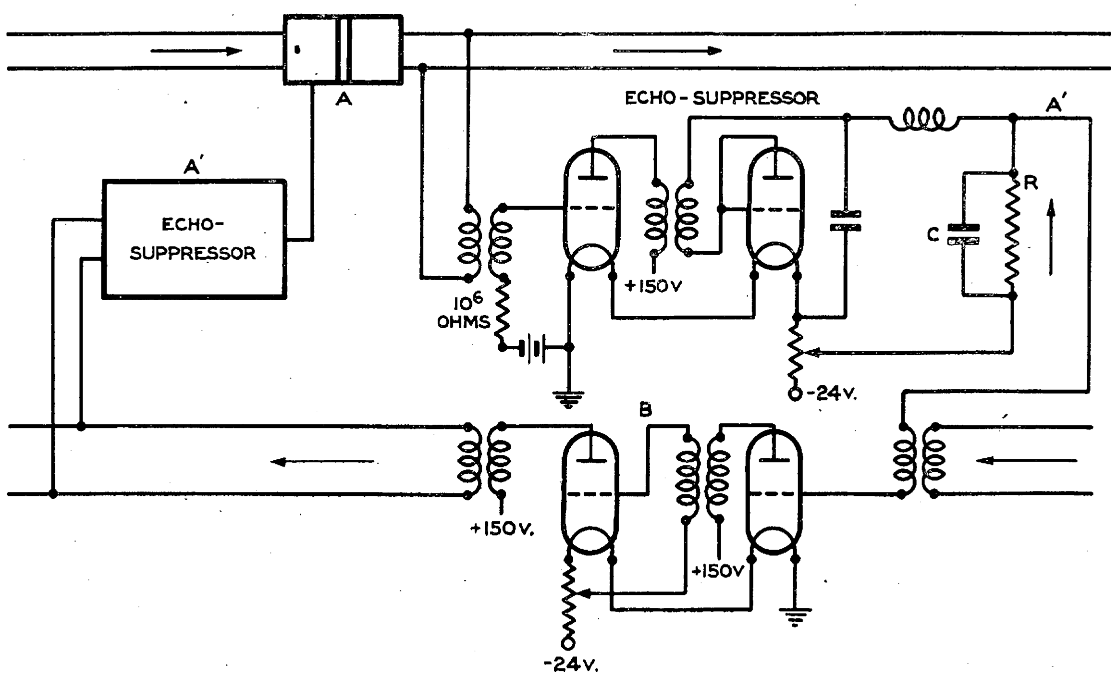
Echo suppressors offer the greatest possibility of usefulness on cable circuits owing to the inherent low speed and quietness of such circuits. Generally speaking, the application of echo suppressors to cable circuits offers possibilities of effecting savings by allowing the use of heavier weight, lower speed loadings in place of lighter weight, higher speed loadings, as well as the imposition of less severe requirements as to impedance uniformity of the circuits.

ECHO SUPPRESSOR.

(British Post Office System.)

A long telephone line having high amplification and being therefore electrically a short line, is liable to be disturbed by echo effects arising from reflections. The action of an echo suppressor is to reduce the efficiency of the return path while conversation is proceeding, so that the circulation of echo currents is prevented.

The suppressor (see Fig. 1) consists essentially of an amplifier-rectifier, actuated by a repeater in the "go" line. The anode circuit of the rectifier contains a resistance shunted



A —Two-Stage Repeater.
A′—Amplifier-Rectifier, of which the Rectifier produces a voltage across resistance R, which joins the first stage of B.
B —Repeater on opposite channel.
C —Condenser } Hang-over Circuit.
R —High-Resistance } Hang-over Circuit.

NEW TYPE ECHO-SUPPRESSOR.
REPEATER STATION ON 4-WIRE CIRCUIT.

FIG. 1.

by a condenser, in combination with a filter device to prevent circulation of A.C. in the resistance.

This resistance is in series with the first stage grid of the repeater in the " return " line so that the unidirectional voltage produced across the resistance greatly reduces the amplification of the " return " repeater. In this way the attenuation of the return line is made extremely high so that the reflected (echo) currents are practically stopped.

Similarly, the repeater in the " return " line is provided with a suppressor, precisely similar to the one in the " go " line, which paralyses this line during conversation on the " return " line.

The time necessary for the restoration of normal conditions after the cessation of speech can be adjusted by varying the resistance and condenser values according to the propagation time of the circuit.

APPENDIX C.d., No. 2.

REPORT OF THE GERMAN ADMINISTRATION WITH REFERENCE TO LONG DISTANCE COMMUNICATIONS ON EXTRA LIGHT LOADED TOLL CABLES.

Precautions to be taken when Transient Phenomena become troublesome.

Summary.

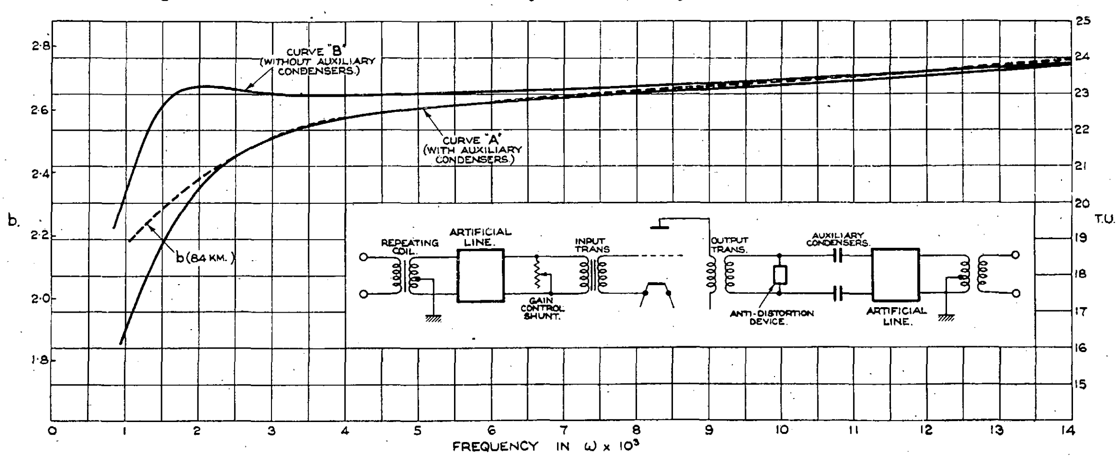
PROBLEM: To set up very long circuit.

RESULTS: By making use of all extra light loaded circuits in the Berlin–Stettin Toll Cable a 4-wire circuit 1,800 km. long (or one-way circuit 3,600 km. long) has been set up, using 25 repeaters and transmitting, without distortion, a band of frequencies between 300 and 3,500 p.p.s. Speech tests made on the two kinds of circuit have shown that the transmission was good (tone natural, good reproduction of consonants, vowels clear).

In order to make tests on a long extra light loaded circuit, all the 0·9 mm. extra light loaded pairs ($L = 0{\cdot}05\ H.$, $s = 2$ km., $C_{km} = 0{\cdot}0335$ mf., $w_0 = 34{,}000$ or 5,400 p.p.s.) of the Berlin–Stettin Toll Cable were connected together to form a 4-wire circuit as indicated on Fig. 1. Pairs 43 to 54 and 71 to 82 were connected together in the order indicated, to avoid, as far as possible, crosstalk between adjacent pairs caused by the large differences in the levels of the speech currents, and in order to approximate the conditions of an actual circuit. The length thus obtained for each direction is 1,808·86 km. and the total attenuation of the cable for one direction is $b = 58{\cdot}2$ or 505 TU for $w = 10{,}000$ (1,590 p.p.s.).

Siemens and Halske repeaters of the 4 Sl type were installed in the three repeater stations at Berlin, Angermünde and Stettin; they were supplied with current from the plate-and-filament supplies of these stations; special grid voltage batteries were provided for each repeater.

The repeaters were provided with anti-distortion devices, connected in parallel with the output transformer and constructed in such a way as to be correct when the cable terminates with a half loading section. In order to take account of the large imaginary component of the impedance of the cable circuits at low frequencies, two 1-mf. condensers in series with the output transformer were added to the existing anti-distortion device; in this way amplification curve A of Fig. 2, which coincides in a very satisfactory manner with the attenuation curve



GAIN OF A SIEMENS & HALSKE 4 SL TYPE REPEATER IN A CABLE CIRCUIT WITH AND WITHOUT AUXILIARY CONDENSERS ON THE OUTPUT TRANSFORMER,

b(84KM.) IS THE CURVE FOR THE LOSS FOR AN 84 KM REPEATER SECTION

FIG. 2.

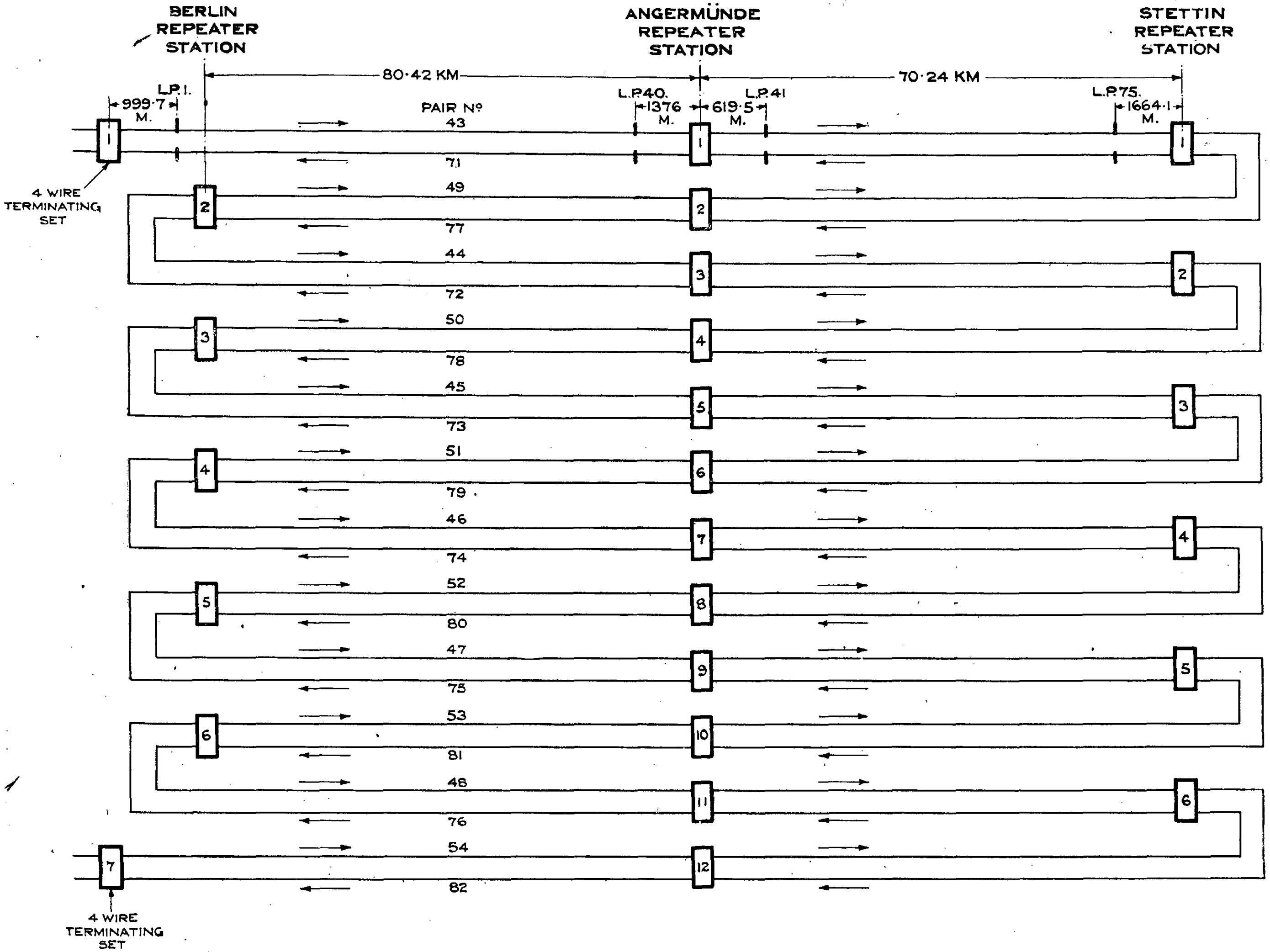


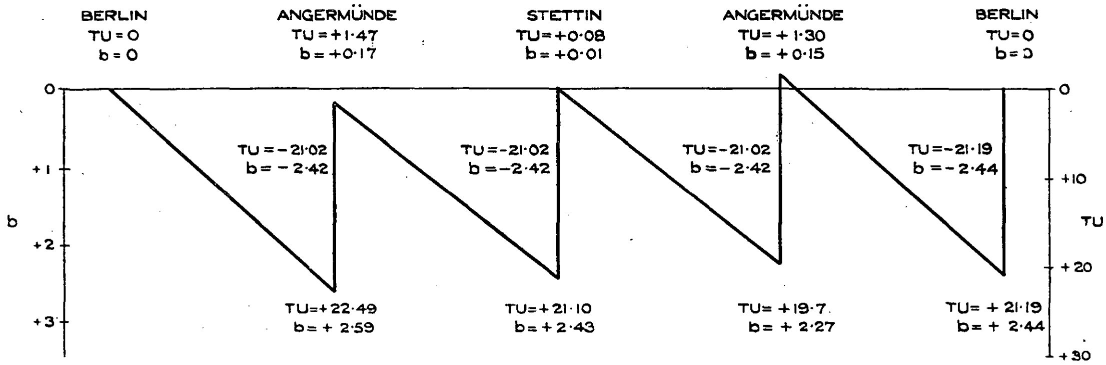
Fig. 1.

TESTS ON BERLIN - STETTIN TOLL CABLE

TOTAL LENGTH OF CABLE = 1808·86 KM.

of the cable, was obtained. The discrepancy between the two curves should be as small as possible on account of the large number of repeaters, particularly if this discrepancy is systematic (that is to say, if it is always in the same direction). A 10-step regulating resistance, connected in parallel with the input transformer, enables the gain of each repeater to be adjusted so that it compensates for the attenuation of the corresponding repeater section. One step varies the gain s by $b = 0 \cdot 05$ or $0 \cdot 43$ TU; it is possible to vary s from $b = 2 \cdot 1$ or $18 \cdot 2$ TU to $b = 2 \cdot 6$ or $22 \cdot 5$ TU. The lengths of the sections are alternately $80 \cdot 4$ and $70 \cdot 2$ km.; all the repeaters are arranged to give the same "average" amplification, chosen in such a way that the attenuation of a loop Berlin–Stettin–Berlin is exactly compensated.

Fig. 3 gives the transmission level diagram. Difficulties were encountered when an attempt was made to carry out the first tests on the entire circuit; the overall equivalent for



TRANSMISSION LEVEL DIAGRAM
BERLIN-STETTIN LOOP TESTS
(ONE SIXTH OF THE COMPLETE SET UP IS SHOWN).

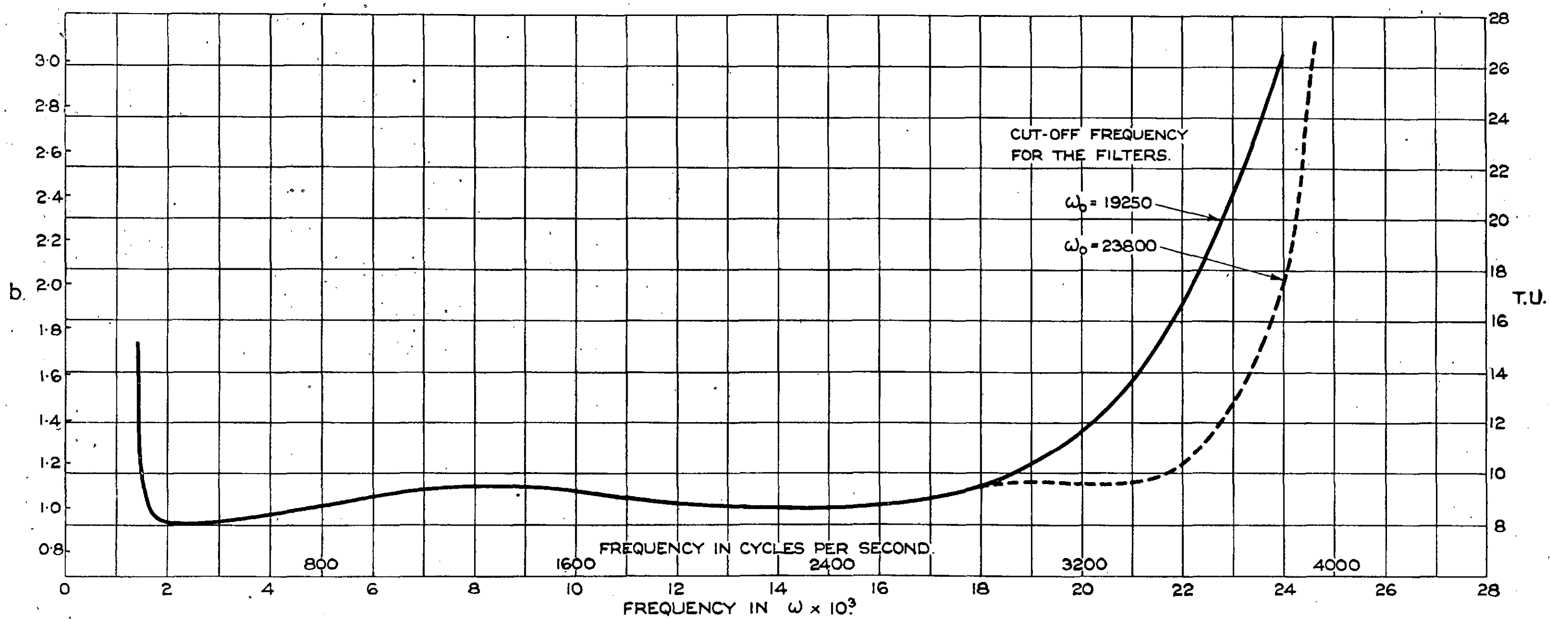
FIG. 3.

the low frequencies (635 p.p.s.) was found to be a large gain due to systematic discrepancies between the gains and attenuations for these frequencies (see above and curve B of Fig. 2), but after the 1-m.f. condensers were connected to the output transformer, an overall equivalent represented by Fig. 4, resulted. In this way, distortionless transmission of the frequencies between 300 and 3,500 p.p.s. was obtained; the upper limit is determined arbitrarily by the natural frequency (3,800 p.p.s.) of the low pass filters introduced in the 4-wire terminating sets.

The advance made in the precision of the anti-distortion device in each repeater has rendered the use of an auxiliary anti-distortion device for the whole circuit superfluous for the moment. It is always desirable to dispense with this kind of device in order to obtain simplified engineering practices, and in order to avoid the effects of crosstalk.

The overall transmission equivalent, shown on Fig. 4 of $b = 1$ or $8 \cdot 7$ TU to $b = 1 \cdot 1$ or $9 \cdot 5$ TU, represents the overall attenuation obtained in practice; that is to say, the attenuation which exists between the two terminals to which the two subscribers would be connected. These two terminals are connected to the 4-wire terminating sets by artificial lines of $b = 1 \cdot 2$ or $10 \cdot 4$ TU. These artificial lines must be balanced as accurately as possible at the terminals of the 4-wire circuits in order that the echo may be reduced as far as possible. Echo-suppressors of well known construction (S. & H., $R_R I$) were connected to the middle of the circuit in order to eliminate echo effects entirely.

In this manner, a very good transmission of speech was obtained. The intelligibility of the words was much better than on a medium heavy circuit of the same length (see Fig. 5). The 2-wire circuit was then converted to one-way circuit of 3,600 km. with 50 repeaters, and an attenuation of $b = 116 \cdot 5$ or 1011 TU (1,590 p.p.s.); the speech transmitted by this circuit remained intelligible.



OVERALL NET LOSS OF 1800 KM 4 WIRE CIRCUIT.

(0·9 m/m DIAM. CONDUCTORS EXTRA LIGHT LOADING.)

FIG. 4.

Finally a 4-wire medium heavy circuit 800 km. long (Berlin–Wesel) was connected to the above circuit; the intelligibility of this circuit 4,400 km. long was still commercial. In these transmission tests it was found that, in the first place, transient phenomena, which increased with the length of the circuit, diminished the intelligibility. In order that these phenomena should not exceed a certain magnitude, determined by systematic speech tests, the highest frequency to be transmitted should be limited for a circuit of any given length. This may be achieved, for example, by inserting filters at the terminals of the 4-wire circuits.

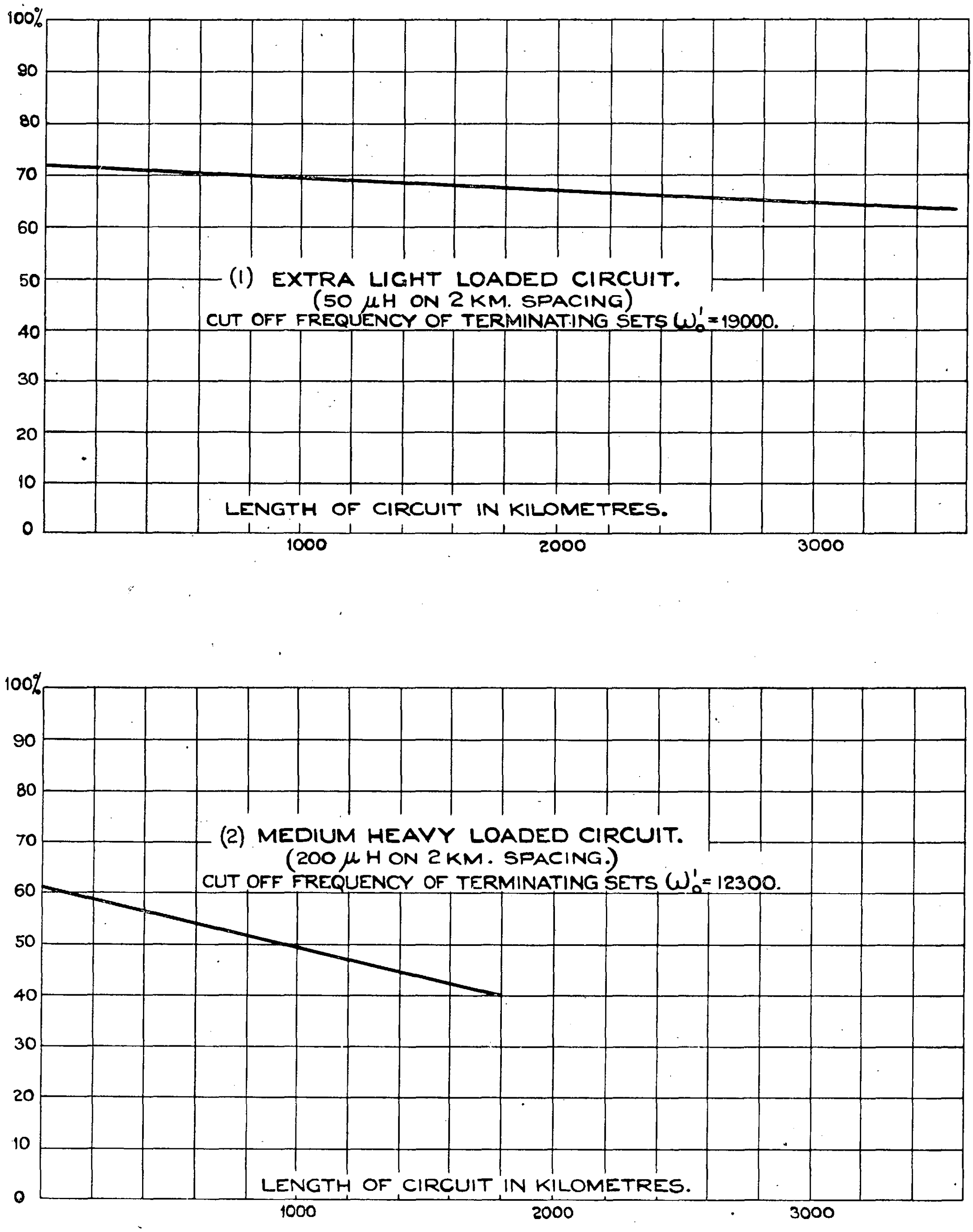
The numerical relation between the length of circuit, the duration of transient phenomena, and the "artificial" cut-off frequency, is given by the figures 6 and 7 for an 0·9 mm. extra light loaded circuit; the well-known formula :—

$$T = t\left[\frac{1}{\sqrt{1 - n^2}} - 1\right]$$

has been used as a basis for these curves; $T =$ the duration of transient phenomena, t (time of direct transmission) $= l\sqrt{LC}$, $n = \frac{w}{w_0}$ and $\frac{w}{w_0}$ = cut-off frequency of the line.

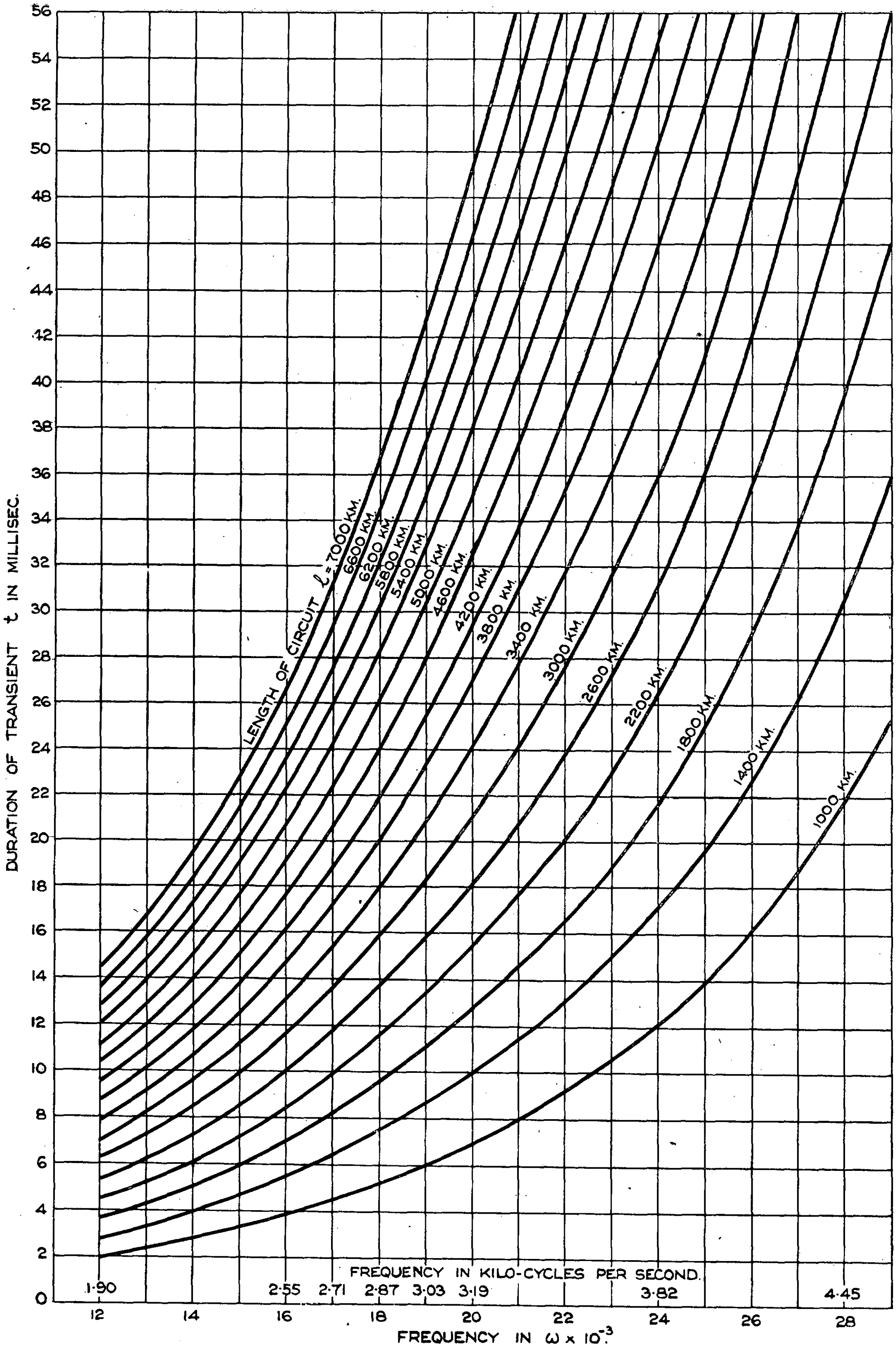
On Figs. 6 and 7 the duration of transient phenomena has been plotted as a function of the frequency for different lengths of lines. From it Figs. 8 and 9 have been deduced, which are more applicable to the present discussion; in these figures the highest frequency transmitted has been shown as a function of the length of the line, the duration of transient phenomena being taken as a parameter. From Fig. 8 it is clear that if a duration of transient phenomena of 25 milli-seconds is permissible, a limit of 3,820 p.p.s. for a circuit 2,000 km. long and of 3,185 p.p.s. for a circuit 3,600 km. long should be adopted.

These figures are given because they are applicable to the circuits described above; it has been calculated that the duration of transient phenomena did not exceed 25 milli-seconds throughout our tests, and that this order of magnitude is fairly consistent with commercial transmission.



PERCENTAGE INTELLIGIBILITY.

FIG. 5.



DURATION OF TRANSIENT t IN MILLISEC.
LENGTH OF CIRCUIT l = 7000 KM.
6600 KM.
6200 KM.
5800 KM.
5400 KM.
5000 KM.
4600 KM.
4200 KM.
3800 KM.
3400 KM.
3000 KM.
2600 KM.
2200 KM.
1800 KM.
1400 KM.
1000 KM.
FREQUENCY IN KILO-CYCLES PER SECOND.
1·90
2·55
2·71
2·87
3·03
3·19
3·82
4·45
FREQUENCY IN ω × 10⁻³

Fig. 6.

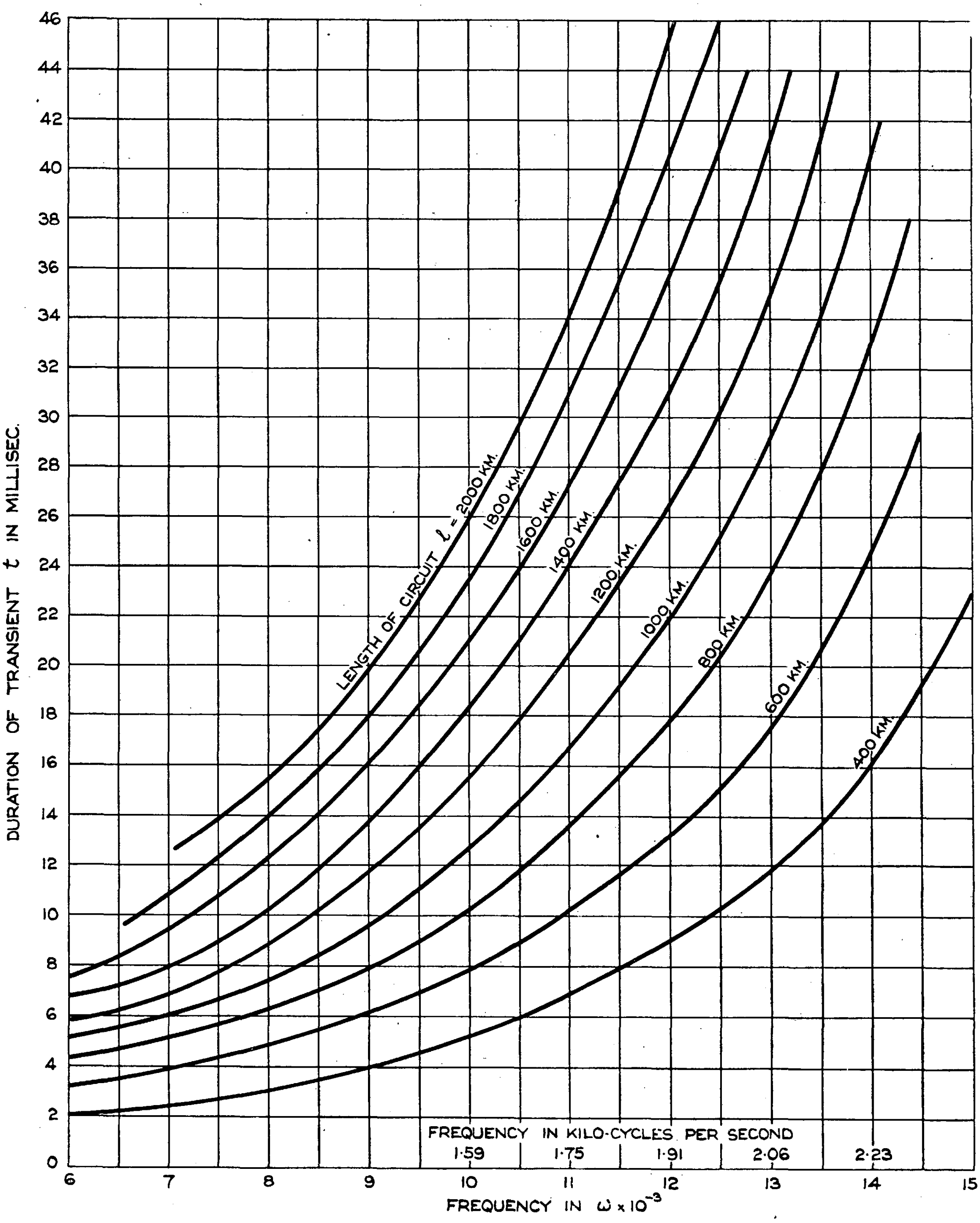
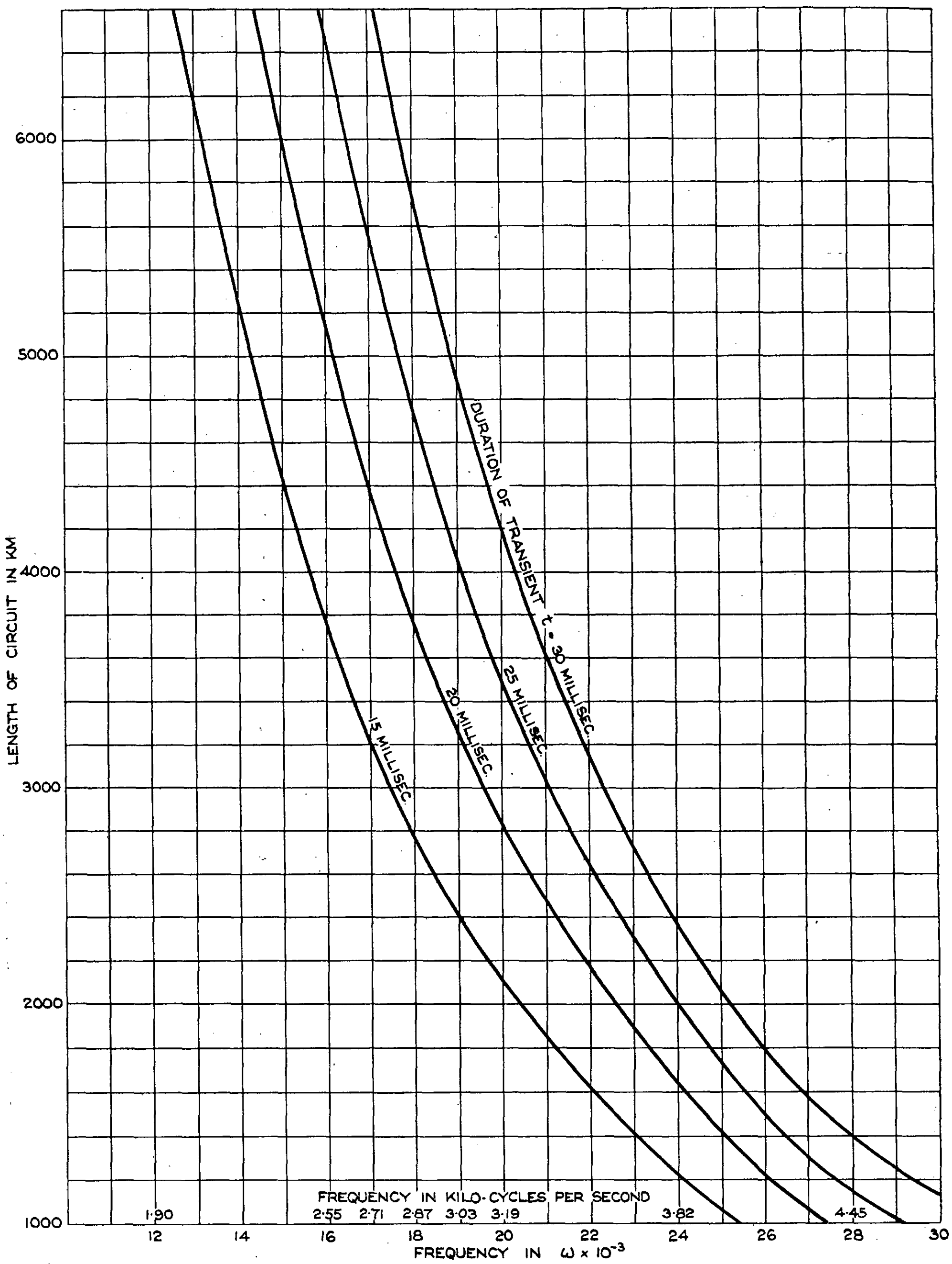

DURATION OF TRANSIENT t IN MILLISEC.
LENGTH OF CIRCUIT l = 2000 KM.
1800 KM.
1600 KM.
1400 KM.
1200 KM.
1000 KM.
800 KM.
600 KM.
400 KM.
FREQUENCY IN KILO-CYCLES PER SECOND
1·59
1·75
1·91
2·06
2·23
FREQUENCY IN ω × 10^-3

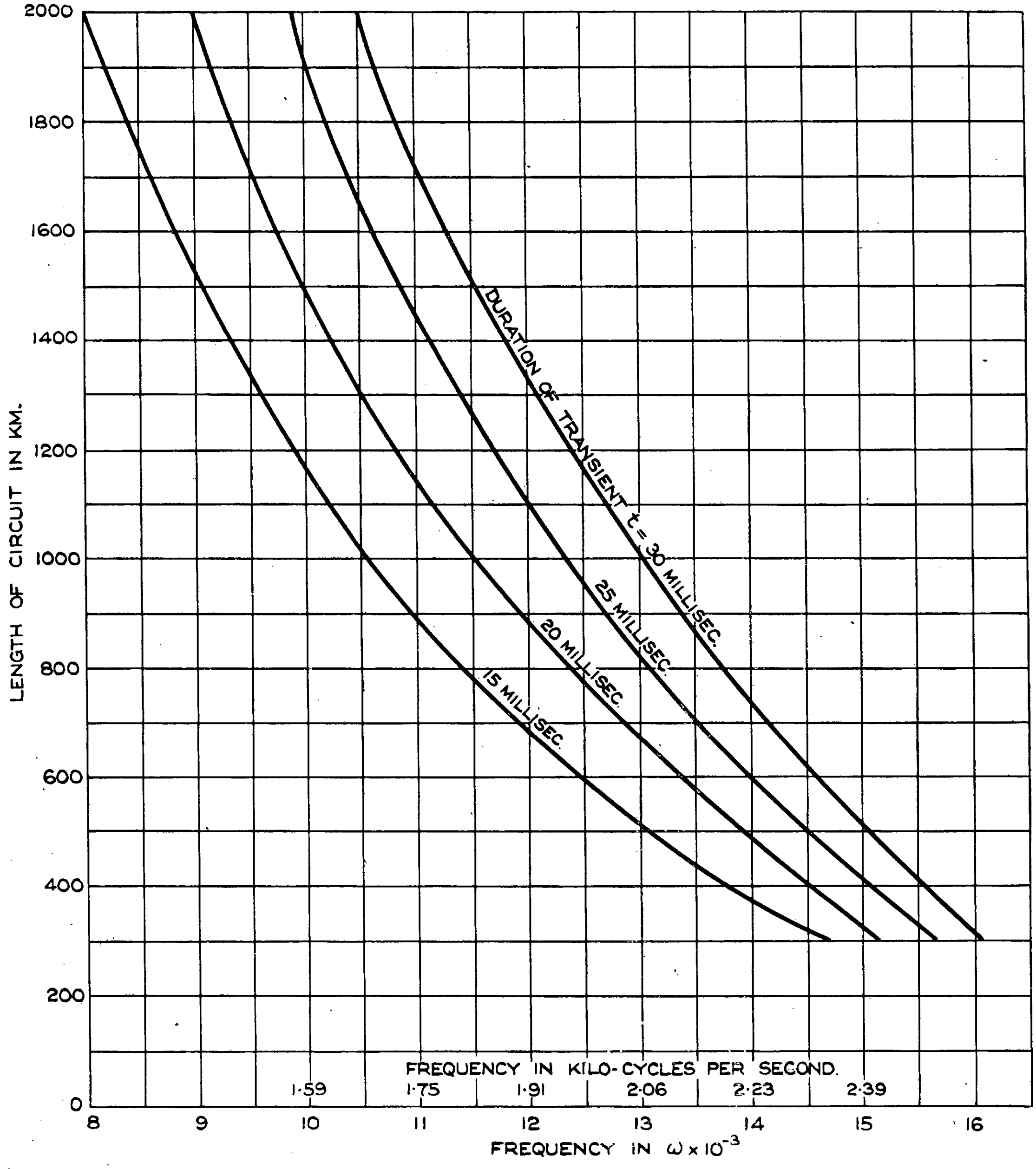
FIG. 7.



DURATION OF TRANSIENTS OF THE HIGHEST FREQUENCY TRANSMITTED AS A FUNCTION OF THE LENGTH OF CIRCUIT AND THE CUT-OFF FREQUENCY OF THE TERMINATING SETS.

(APPLICABLE TO THE EXTRA LIGHT LOADED 0·9 mm. SIDE CIRCUITS OF GERMAN STANDARD CABLE.)

FIG. 8.



LENGTH OF CIRCUIT AS FUNCTION OF THE HIGHEST FREQUENCY PASSED BY THE TERMINATING SETS FOR DIFFERENT DURATIONS OF TRANSIENTS.

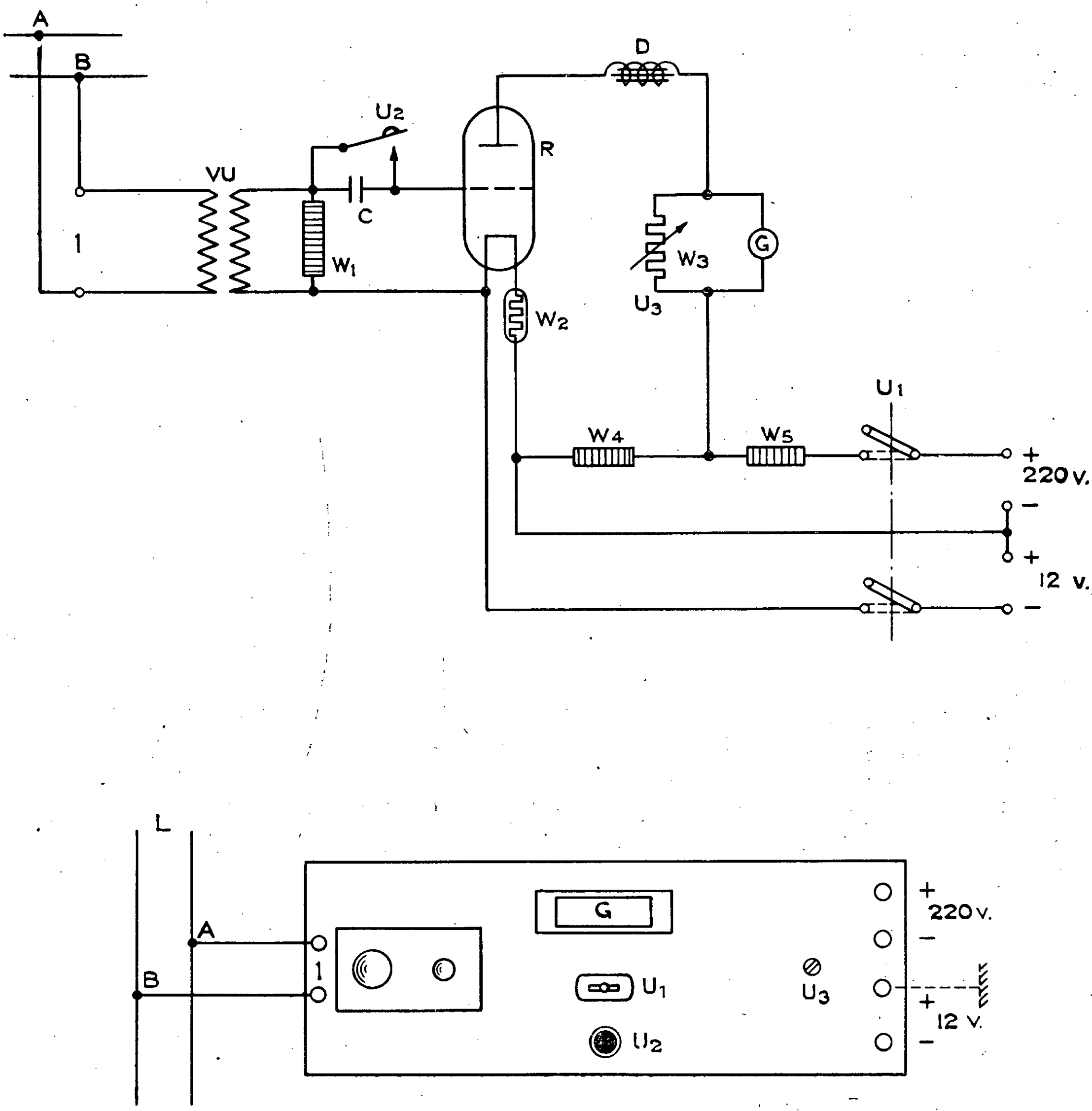
(0·9 mm. SIDE CIRCUIT MEDIUM HEAVY LOADED GERMAN STANDARD TOLL CABLE.)

FIG. 9.

THE SIEMENS IMPULSE METER.

A.—Application and Design of the Set.

The impulse meter serves for testing the maximum voltages in transmission systems. The wiring diagram is shown by Fig. 1. Part of the telephone currents flowing through the line L is branched at the points A and B and, across an input transformer VU, supplied to the grid of an amplifier valve R. The section grid-filament of the amplifier valve acts here as valve which is in series with the alternating current source and a condenser C that may be bridged by key U_2. The incoming alternating currents are rectified in the grid-circuit; they apply a negative continuous voltage to the condenser and consequently to



WIRING DIAGRAM OF THE IMPULSE METER.

Fig. 1.

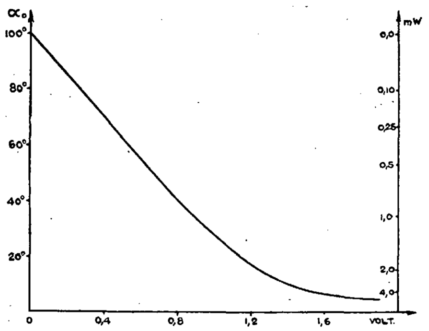
the grid. The order of magnitude of this voltage depends on the amplitude and the duration of the alternating voltage under test. In order to increase the rectifying action, use is made in the plate circuit of a choke D and the resistances W_4 and W_5, furthermore of a calibrated galvanometer G having a shunt resistance W_3, which can be adjusted by U_3 to the zero point of the power scale. The iron resistance W_2 controls the heating current intensity. Key U_1 realises the interruption of the filament and plate circuit.

B. Operation.

Fig. 2 shows the deflection α_0 of the ammeter G in dependency of an alternating voltage applied to the input terminals 1. It will be seen that the plate current of the valve decreases as the alternating voltage or negative charge of the grid decreases. The instrument G is calibrated in such a way that it indicates the power transmitted over the line in mV in case of a line resistance of 800 ohms.

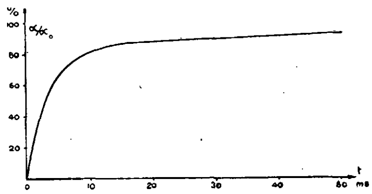
If a suddenly arising alternating voltage of a certain duration t is effective at the input of the impulse meter, the condenser C is charged to a negative continuous voltage, whose magnitude is given by the effective line constant of the rectifier circuit.

Fig. 3 illustrates the deflection α corresponding to the time t in percentages of the permanent deflection α_0 corresponding to the same voltage amplitude. As will be seen, an



DEFLECTION α_0 OF THE AMMETER G IN DEPENDENCY OF AN ALTERNATING VOLTAGE APPLIED TO THE INPUT TERMINALS.

FIG. 2.



DEFLECTION α CORRESPONDING TO THE TIME t IN PERCENTAGES OF THE PERMANENT DEFLECTION α_0 CORRESPONDING TO THE SAME VOLTAGE AMPLITUDE.

FIG. 3.

alternating voltage of 30 ms. applied to the input results in a charge of the grid which corresponds to 90 per cent. of the permanent charge. Since the instrument, on account of its inertia, does not immediately respond to the grid charge, this charge should be always maintained until the instrument indicates its correct value. This is achieved by means of the special arrangement of the rectifier circuit (see Fig. 1), in which the grid can only lose its negative charge across the insulation resistances. The time of after-effect thus obtained amounts to a few seconds; special measures in order to increase the insulation are thereby not required. The instrument thus approximately indicates the maximum values of the voltage integrated during a time of 10 to 30 ms., for any process of the alternating voltage at the points A and B in terms of time.

Fig. 4 shows the process of the voltage V at the input terminals 1 in terms of time. If this process is integrated during intervals of 20 ms., we obtain the curve plotted in Fig. 5.

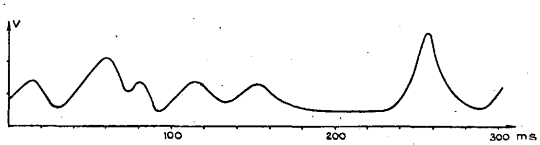


DIAGRAM OF VOLTAGE PROCESS AT THE INPUT TERMINALS 1.

FIG. 4.

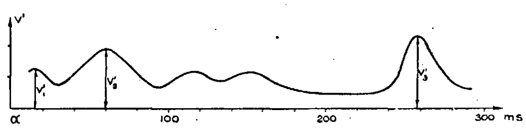


DIAGRAM OF VOLTAGE PROCESS INTEGRATED DURING INTERVALS OF 20 ms.

FIG. 5.

The deflections of the instrument correspond to the maximum voltages designated by V'_1, V'_2 and V'_3 as is shown by Fig. 6.

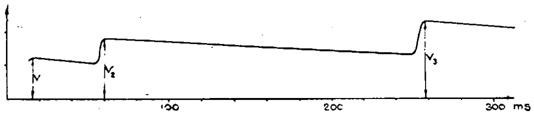


DIAGRAM OF MAXIMUM VOLTAGES.

FIG. 6.

C.—Preparations for the Measurement.

1. Apply plate voltage of 220 volts and filament voltage of 12 volts to the correspondingly designated terminals.

2. Set switching key U_1 to "Ein" (on).

3. Let the valve R burn 5 minutes before beginning the measurement.

4. Short-circuit terminals 1 and adjust the needle of the galvanometer to zero by varying U_3 or

4a. apply an alternating voltage of $\sqrt{\frac{10^{-3}\ W}{800\ \Omega}} = 0{\cdot}895\ V$ whose frequency is $f = 800°$ cycles per sec. to the terminals 1 and adjust the needle of G to the red line ($= 10^{-3}\ W$) by varying U_3.

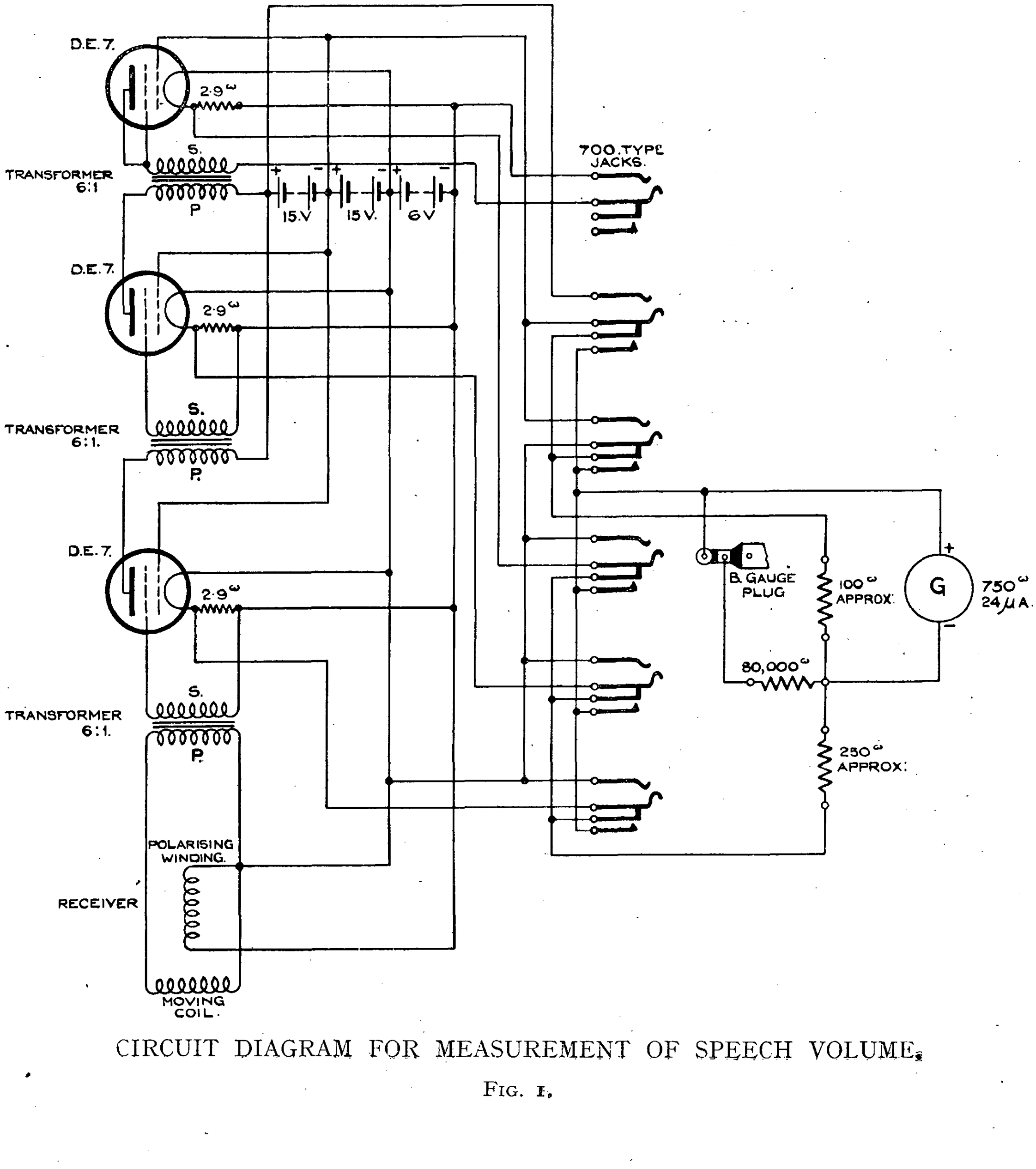
4b. Short-circuit terminals 1; if the valve is serviceable, the needle deflection should be within the auxiliary scale surrounding the zero point. In the contrary case the valve must be exchanged.

D.—Measurement.

1. Connect terminals 1 to the transmission system under test having an impedance of $Z = 800$ ohms.

2. The galvanometer G then indicates the corresponding maximum mean value of the transmitted power, in terms of an integration interval of about 10 to 20 ms.

3. Key U_2 is utilised to accelerate the discharge process so as to enable us to ascertain by checking if the needle deflection corresponds to the actually existing voltage. The deflection of G should only be read if key U_2 is not depressed.



CIRCUIT DIAGRAM FOR MEASUREMENT OF SPEECH VOLUME.

FIG. 1.

APPENDIX C.e., No. 2.

APPARATUS FOR THE MEASUREMENT OF SPEECH VOLUME.

(British Post Office System.)

This apparatus is intended for the use of observers making transmission tests to ensure that the volume of speech used is of the required standard. This is a matter of considerable importance when comparing instruments of different types, and particularly a commercial instrument against a reference standard. It will also be required to compare the volumes of speech used in testing by different Administrations.

The instrument consists essentially of a special moving coil transmitter with a flat output-frequency characteristic. This is spoken into from a fixed distance and the resulting voltage amplified, rectified and then read upon a needle instrument. The instrument is calibrated by recording the voltage outputs of a large number of speakers, neglecting any of a freak order and averaging the rest.

The transmitter used is an electro-magnetic apparatus with a moving coil suspended by means of three wires. No diaphragm is used, but the sound waves are collected by a small aluminium piston. The magnetic system is stout and compact.

To reduce the H.T. battery four electrode valves are used. These are somewhat sensitive to filament current so that means are provided for measuring the various voltages.

A fairly dead beat needle instrument is used and it is found that readings can be obtained during speaking sufficiently stationary for use.

The sensitivity of the set is such that normal speech into the transmitter with the mouth close to the spacing guard, that is, about 0·7 micro-volt per sq. cm. acoustic force, gives a deflection of 40 divisions.

Fig. 1 shows the circuit.

Fig. 2—a general view of the apparatus.

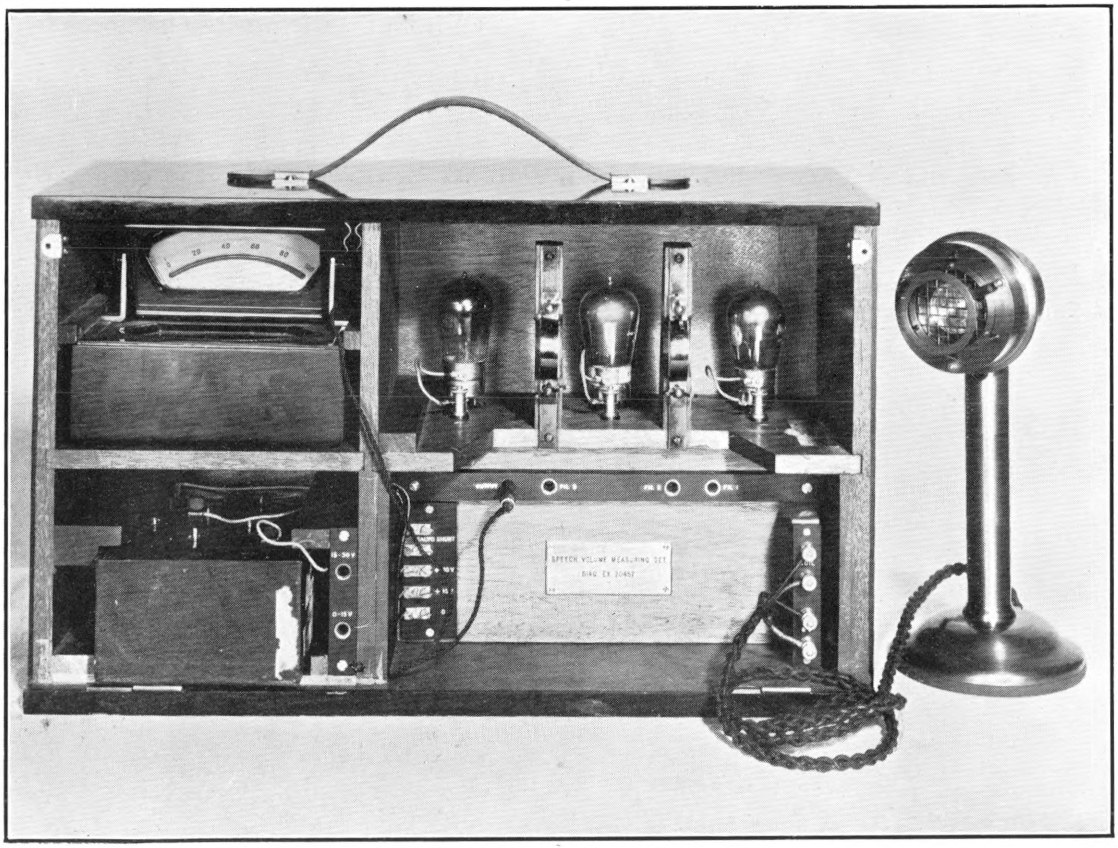


Fig. 2.

APPENDIX C.f., No. 1.

VOICE-FREQUENCY CARRIER TELEGRAPH SYSTEM* FOR CABLES.

By B. P. HAMILTON,† Associate A.I.E.E.; H. NYQUIST,† Member A.I.E.E.; M. B. LONG,‡ Associate A.I.E.E.; and W. A. PHELPS,‡ Associate A.I.E.E.

Synopsis.—Carrier telegraph systems using frequencies above the voice range have been in use for a number of years on open-wire lines. These systems, however, are not suitable for long toll cable operation because cable circuits greatly attenuate currents of high frequencies. The system described in this paper uses frequencies in the voice range and is specially adapted for operation on long four-wire cable circuits, ten or more telegraph circuits being obtainable from one four-wire circuit. The same carrier frequencies are used in both directions and are spaced 170 cycles apart. The carrier currents are supplied at each terminal station by means of a single multifrequency generator.

A telegraph system has recently been developed which utilises the range of frequencies ordinarily confined to telephonic communication. It represents a special application of the carrier method of multiplexing telephone and telegraph circuits, which has already been described.§

The new system has been designed particularly for application to four-wire telephone circuits. Installations have been made at New York and Pittsburgh, by means of which ten telegraph circuits are derived from one four-wire telephone circuit extending between these cities. Additional installations are planned and under way in which it is expected that a greater number of telegraph circuits will be obtained from each four-wire telephone circuit.

Experience in commercial service extending over a considerable period has fully demonstrated the effectiveness of this system.

* Presented at the Midwinter Convention of the A.I.E.E., New York, N.Y., February 9–12, 1925. Published in the *Journal of the A.I.E.E.*, March, 1925.

† American Telephone & Telegraph Co., New York, N.Y.

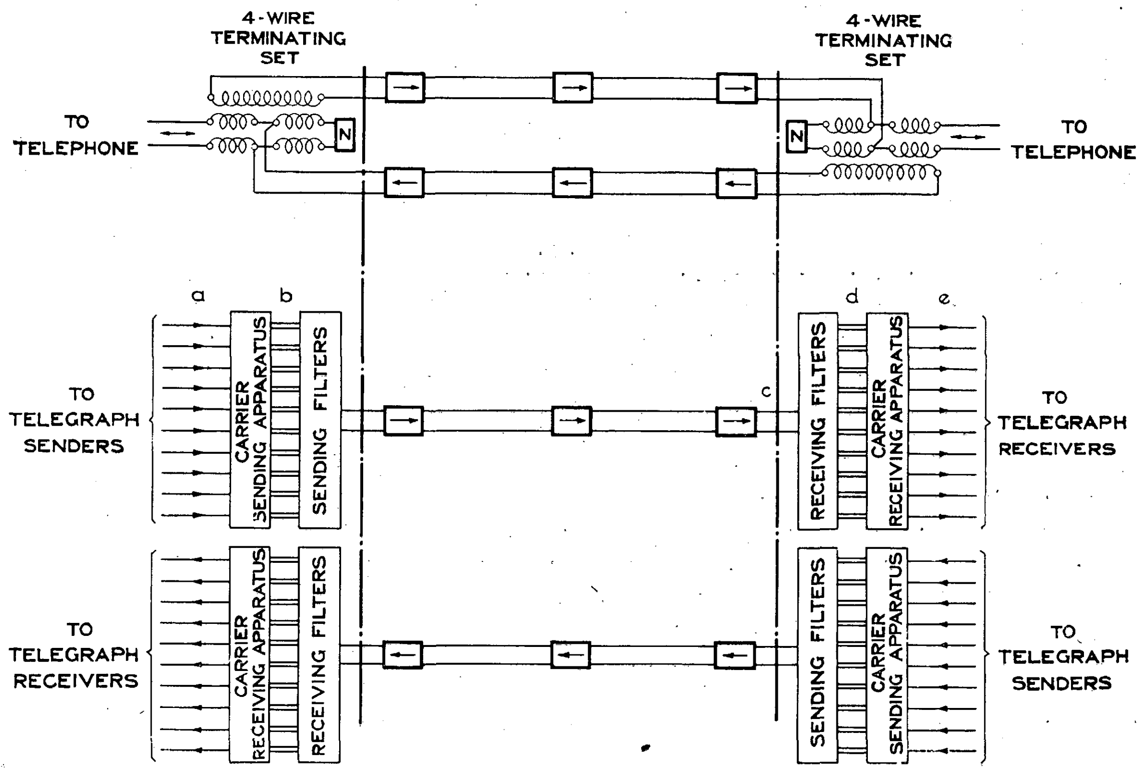
‡ Bell Telephone Laboratories, Inc., New York, N.Y.

§ "Carrier-Current Telephony and Telegraphy," E. H. Colpitts and O. B. Blackwell, *Transactions A.I.E.E.*, 1921, page 205.

General Features.

In a general way, the voice-frequency system resembles the high-frequency carrier system for open-wire lines, which has been described in the paper referred to above. The most important differences are that the voice-frequency system uses (1) a four-wire cable circuit instead of a two-wire open-wire circuit, (2) the same frequencies for transmission in both directions, (3) frequencies of the voice range rather than the higher frequencies used in open-wire carrier telegraph systems, (4) a multifrequency generator instead of vacuum tube oscillators to supply the carrier currents and (5) fixed band pass filters, instead of adjustable tuned circuits for segregating the several telegraph circuits.

Fig. 2 shows in a simplified manner the essentials of the telegraph system under discussion. Reference to Fig. 1, which shows a four-wire telephone circuit,* will make clear how the line portion of the telegraph system is derived from such a telephone circuit. As indicated in Fig. 1, the four-wire cable circuit uses two pairs of wires, one pair for transmission in each



FIGS. 1 AND 2.

direction. When a voice-frequency telegraph system is applied to a telephone circuit the four-wire terminating sets, which normally terminate the circuit when used for telephone purposes, are removed and voice-frequency carrier telegraph equipment is substituted.

Signal Traced Through System.—A general layout of the system is shown in Fig. 3, and in describing the operation, reference is made to this Figure. The path of a signal from the sending operator to the receiving operator, on one of the ten two-way circuits will be considered.

* "Telephone Transmission over Long Cable Circuits," A. B. Clark, *Transactions A.I.E.E.*, Vol. XLII, 1923, page 86.

To produce a spacing signal the sender opens his key (shown at the left of the Figure) which causes the sending relay to operate so as to short-circuit the source of alternating current.

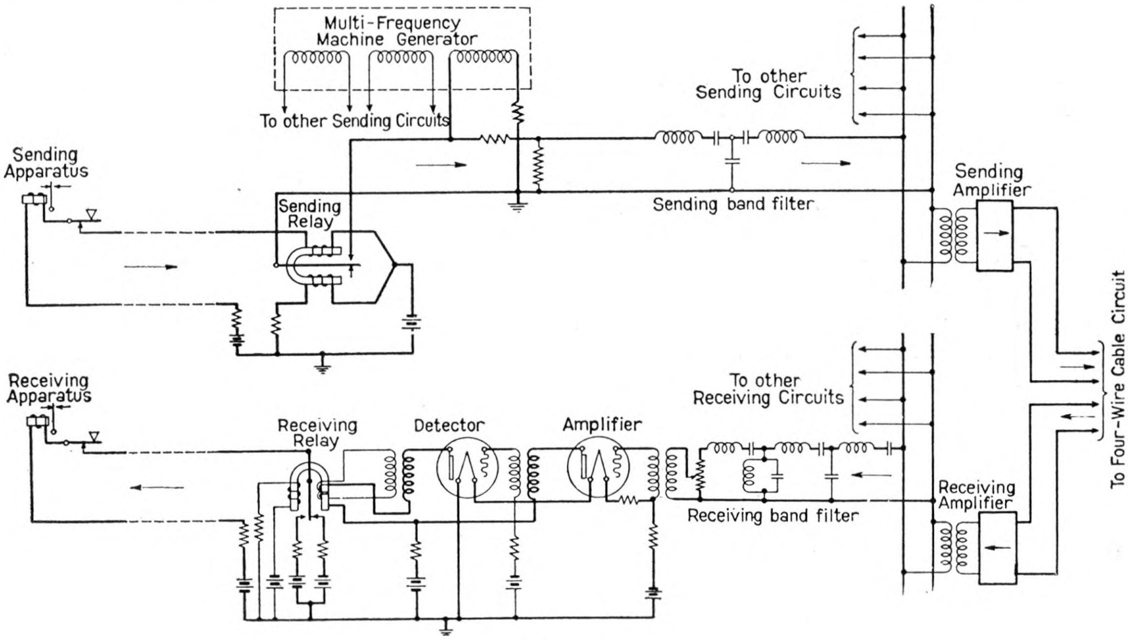


FIG. 3.

To produce a marking signal the key is closed, which causes the sending relay to operate and to remove the short circuit. This permits the alternating current from the generator to flow freely into the filter. This sending filter is so constructed as to permit relatively free passage of current of frequency near the particular carrier frequency for which it is designed. For other frequencies the filter practically shuts off the current.

After passing through the filter, the current mingles with currents from other channels and all are transmitted over the line as a resultant composite current. After flowing through the line in this mixed-up condition, the currents encounter the receiving filters which resemble the sending filters in that each transmits a relatively narrow range of frequencies in the neighbourhood of the carrier frequency for which it is designed, and in that it acts substantially as an open circuit to other frequencies. By means of these receiving filters the currents are separated and each flows freely into its own channel. After passing through the receiving filter the current enters the detector, whose function is to convert the alternating current signals into direct-current signals which are capable of actuating the receiving relay. The receiving relay in turn transmits direct-current signals to the receiving operator's sounder or local relay.

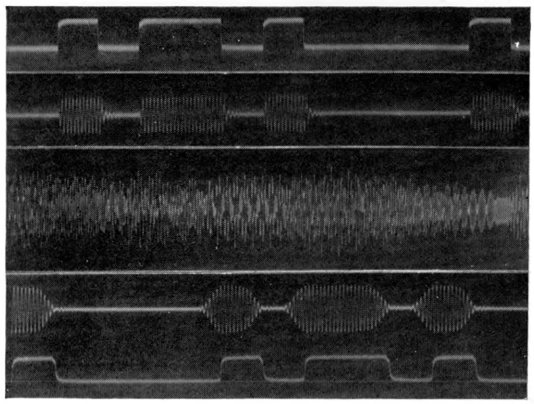


FIG. 4.

This sequence of events is illustrated in the series of oscillograms of Fig. 4, which shows the different forms of a group of telegraph signals in the 425-cycle channel from the time when, as d.-c. impulses, they flow through the sending relay windings, to the time when again, as d.-c. impulses, they flow through the receiving relay and sounder circuit. It shows (*a*) their form in the sending relay and telegraph key circuit, (*b*) their translation into alternating current prior to passing into the sending filter, (*c*) their mingling with other similar impulses of different carrier frequencies after passing through the sending filter and on to the line as a single resulting wave flowing through the four-wire circuit, (*d*) their form after separation from the other channels by the receiving filter, and (*e*) their final form in the receiving sounder circuit. The points where the oscillograms were taken are shown in Fig. 2 at *a*, *b*, *c*, *d*, and *e*, the cases being correspondingly denoted on the oscillograms.

Carrier Frequencies.—The carrier frequencies are so chosen as to be odd multiples of a basic frequency of 85 cycles per second. The lowest frequency used is the fifth multiple of 85 cycles, that is, 425 cycles per second. Starting with this frequency, the carriers are spaced at 170-cycle intervals from their nearest neighbours, so that in the ten-channel system the uppermost frequency is 1955 cycles per second. Each channel has assigned to it a range of frequencies 85 cycles above and below its own frequency. For example, the channel using a carrier frequency of 1105 cycles has assigned to it the range between 1020 and 1190 cycles. Choosing the carrier frequencies in this manner and placing each carrier midway in the band of frequencies assigned to it has the effect of giving maximum discrimination against interfering frequencies generated in the various vacuum tube repeaters. As is well known, when a number of frequencies are transmitted simultaneously through a vacuum tube, currents which cause interference are generated due to small departures from linearity on the part of the tube characteristic. Some of the most important of these currents have frequencies equal to the sum and difference of the frequencies of the transmitting currents taken in pairs. Since the carrier frequencies are all odd multiples of the common frequency, 85 cycles, it follows that the sum and difference of the frequencies are even multiples of 85 cycles and therefore are located midway between the carrier frequencies. This permits obtaining the maximum discrimination against these interfering frequencies by means of the filters, of which the characteristics are set forth below.

The number of carrier telegraph circuits which can be derived from a single four-wire cable circuit depends on the type of loading and, to a less extent, on the length of the circuit. It has been mentioned above that at the present time ten two-way carrier telegraph circuits are operated simultaneously over a four-wire circuit between New York and Pittsburgh, a distance of about 400 miles (644 km.). This is not, however, the maximum possible number of telegraph circuits which can be derived from the type of circuit used with this installation. Four-wire circuits which are loaded with coils of small inductance transmit a wider range of frequencies and are already in use for telephone purposes. If such circuits were used instead of the type employed with the present installation, at least fifteen two-way carrier telegraph circuits could be obtained.

Description of Apparatus.

Carrier Current Generator.—Vacuum-tube oscillators are the source of the carrier current in carrier systems previously developed. In this system, however, all the carrier currents for the ten channels are obtained from a compact multifrequency generator driven by a motor built into the same housing with the generator.

The generator is an inductor-alternator, designed to generate currents of ten different frequencies in ten different magnetic circuits electrically independent of each other. The machine has two field coils common to all the stators. The exciting current for these two windings is supplied by a storage battery. On the pole arc of each stator opposite each of the narrow disk-like rotors, mounted in a row on the shaft, are cut a number of slots, the number per unit length depending on the frequency to be generated. The stator windings for each circuit are placed in these slots. The rotor belonging with each stator has a corresponding group of slots cut in it, but no windings are placed in these rotor slots. The result is equivalent to ten separate alternators, except that the field excitation is common to all. The flux in any stator tooth is greatest when a rotor tooth is opposite it and least when a rotor slot is opposite it. This variation in flux in the stator teeth as the rotor moves induces the voltage in the windings on these teeth. All the windings of a given stator are connected in series, so the total voltage generated in each stator is the sum of the separate voltages in the several windings.

A comparatively small generator is able to supply carrier currents to several ten-channel systems because, by using terminal repeaters or amplifiers (Fig. 3), the amount of energy required to operate each telegraph channel is very small, and no channel produces any noticeable interference in another drawing current from the same stator winding. The terminal voltage of each stator is 0·7 volt and a current of 40 m.a. may be drawn from it without producing a change in terminal voltage sufficient to cause interference in any telegraph circuit drawing current from the same set of windings.

The driving motor is a small shunt-wound machine which receives its energy from a 24-volt storage battery. The speed of the motor is maintained accurately at 1,700 revs. per min. by means of a centrifugal type of governor which controls the amount of current flowing through the shunt field winding. As the stability of the carrier frequencies depends on the constancy of the motor speed, it is necessary that the governor control the speed within narrow limits.

As a means of checking the speed of the generator an electrical frequency indicator is provided. This device is connected to and indicates the frequency of one of the generator circuits. As the frequency of an alternator is directly proportional to the speed it gives an indication of the correctness of the speed and also of all frequencies produced by the generator.

Filters.—Fig. 5 shows the transmission characteristics of the transmitting and receiving filters. These filters are designed to transmit as wide a range in the neighbourhood of the carrier frequencies as is necessary to secure the desired quality of transmission and at the same time exclude interfering currents, whether they be caused by foreign interference, direct transmission from other channels, or distortion in the repeater tubes. The principal interfering currents due to the latter are located 85 cycles on either side of the carrier frequencies. The receiving filters have been designed to reduce these interfering currents to about 10 per cent. of their original value.

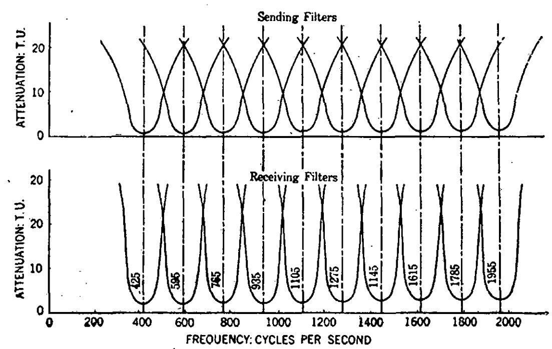


FIG. 5.—Characteristics of Filters.

In addition to screening out any undesired frequencies produced in the generator windings, the sending filters have the following more important functions. Each sending filter presents a high and comparatively non-dissipative impedance to the currents issuing from the other sending filters and also "rounds off" the impulses of the modulated carrier wave passing through it. The modulation of the carrier current by the sender's key produces what is called a "square" wave, that is, a wave containing not only the carrier plus and minus the frequency at which the key is operated but also the carrier plus and minus a large number of multiples of the frequency. Some of the component frequencies of this transmitted wave not only are found unnecessary in reproducing the transmitted signal at the receiving end but also lie within the range of adjacent channels and produce interference in them unless screened out by the sending filter in the channel in question.

The effect of the sending and receiving filters in "rounding off" the modulated carrier wave, that is, in screening out the objectionable components of the signal wave, is shown by the oscillograms of Fig. 4. The combined effect of the two filters on the shape of the modulated carrier may be seen by comparing oscillograms (*b*) and (*d*) of this figure, which show respectively the appearance of the modulated wave before it enters the sending filter and after passing through the sending filter, over the line and through the receiving filter. Another interesting point in connection with these oscillograms is the time lag due to the circuit which is shown by the relative differences in position of the two waves referred to above. Owing to the limitations imposed by the ordinary oscillograph all of the traces shown in Fig. 4 were not taken simultaneously. This accounts for minor inconsistencies which are revealed by a careful inspection.

Detector.—The detector receives alternating current signals from the line after the signals belonging to that particular channel have been selected by the receiving filter, It consists of two vacuum tubes in tandem, the first tube (Fig. 3) amplifying the received signals, and the second converting them into direct-current pulses which operate the receiving relay. The receiving relay then repeats these telegraph signals into the receiving direct-current circuit which contains the receiving sounder.

To improve the operation of the receiving relay a device called an accelerating circuit or " kick " circuit, such as is used in open-wire carrier-telegraph systems, is interposed between the detector tube and the receiving relay. This circuit is obtained by introducing a transformer whose high-voltage side is connected in series with the detector tube and a winding of the receiving relay and whose low-voltage side is connected to another winding of the relay. When the current in the high-voltage side is constant, there is no current in the low-voltage side, but if the former current suddenly changes, as at the beginning or end of a marking signal, there is a sudden rush of current in the low-voltage circuit which has the effect of causing the relay to operate promptly and positively.

Relays.—As shown in Fig. 3, the sending and receiving relays are of the polar type. These relays are identical and interchangeable with those used in the metallic and open-wire carrier-telegraph systems. They are described in the paper on telegraph relays which has been prepared for presentation at this meeting.

Power and Testing Equipment.—In the development of the voice-frequency carrier telegraph system, the central thought was the desirability of designing a system which would fit into the existing cable telephone and telegraph plant. It has been possible to use the standard voltages obtainable from the storage batteries in such plants without exception.

In line with the policy of simplifying this new system as far as possible, the amount of auxiliary testing apparatus was reduced to a minimum. This policy has been assisted by the stability of the cable circuits and the use of a multi-frequency generator as a source of carrier currents. Only two pieces of special testing apparatus are used at each station, namely, the frequency indicator, and a thermocouple voltmeter for checking the alternating voltage in each generator circuit.

Line and Repeaters.

As has been pointed out elsewhere in this paper, the voice-frequency carrier telegraph system was designed primarily for use on small-gauge, four-wire cable circuits. These circuits are loaded and provided with vacuum tube repeaters at 50 to 100-mile (80·5 to 161 km.) intervals, depending on the weight of loading used. The repeaters used in long toll circuits are similar to those described at an earlier date.* The characteristics of the long cable circuits used in voice-frequency carrier telegraph transmission have also been described in a more recent paper.†

Equipment Features and Arrangements for giving Service.

The apparatus which is associated with each of the ten two-way circuits in this system has been segregated according to function, and each group of apparatus performing the same function, such as the detector, has been mounted on a separate steel panel. Each one of these panels forms a unit in itself. This type of construction allows the substitution of new apparatus performing some particular function in the system without an expensive redesign. Thus, it is possible to install future improvements in the several circuits of the system in an economical manner.

These unit panels are mounted on pairs of vertical I-beams and the combination is termed a " bay." The bays are of different heights, depending on the requirements of the office in which they are installed. Fig. 6 shows a line-up of so-called low-type bays (about five feet high) in the Pittsburgh office. Each bay in this line-up contains sufficient equipment

* " Telephone Repeaters," by Bancroft Gherardi and Frank B. Jewett. *Transactions A.I.E.E.*, 1919, page 1287.

† Clark, *loc. cit.*

to provide for the transmission and reception of signals at the Pittsburgh terminal of one of the ten two-way telegraph circuits. Fig. 7 shows a line-up of similar equipment in the New York office, this layout differing from the one in Pittsburgh in that it uses high instead of low-bays. Each bay in this line-up contains sufficient terminal equipment for two of the ten two-way telegraph circuits.

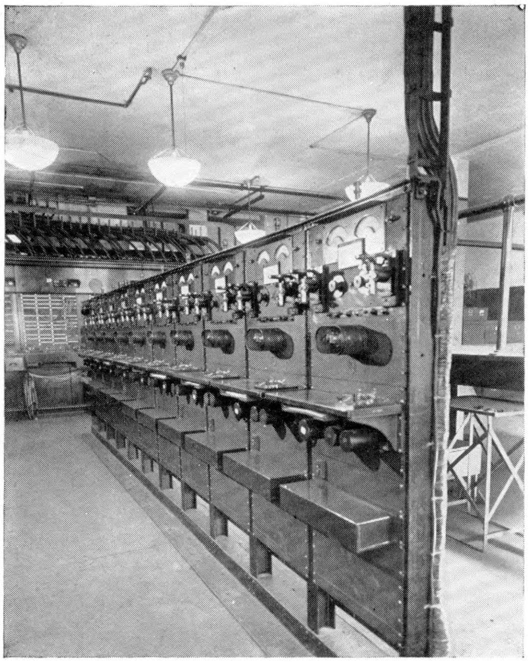


Fig. 6.

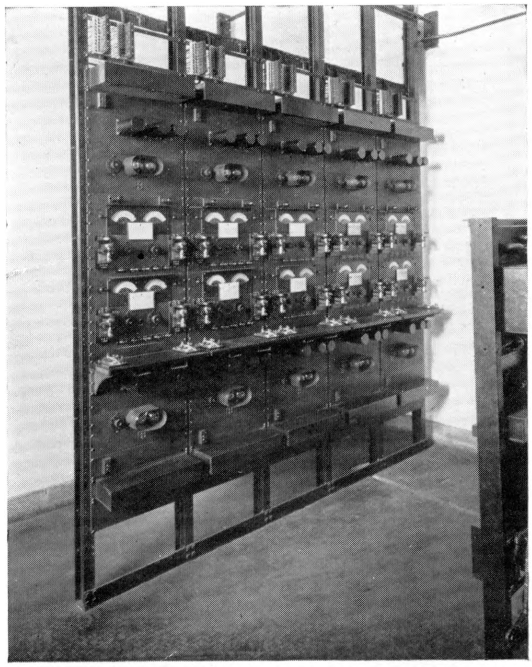


Fig. 7.

In addition to the bays described above there are three bays carrying auxiliary equipment. This auxiliary equipment consists primarily of control and testing apparatus for batteries and carrier supply. Two of these bays, namely, the generator and carrier supply bays, are shown in Fig. 8. This figure shows two of the multi-frequency generators (one a spare machine) described above, and the carrier testing equipment. The control equipment associated with these machines is mounted on the panels above the generator and the frequency indicator is mounted on the panel to the right of this control apparatus.

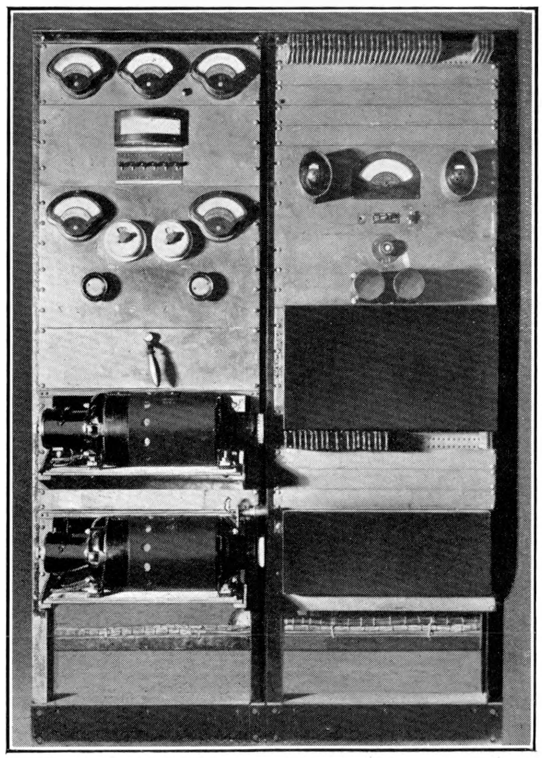


Fig. 8.

Switching and Monitoring Arrangements.

The monitoring arrangements, which enable the attendant to check the quality of signals passing over a circuit or to trace trouble quickly and easily, are similar to those now in use in the open-wire carrier and metallic telegraph systems. These arrangements are described in the paper on the metallic telegraph system which has been prepared for presentation at this meeting and, therefore, will not be given in detail here. In a general way it may be said that switches and meters are provided to connect the telegraph batteries to local apparatus, to provide either one-way or two-way service and to facilitate repeating to other telegraph systems.

Capabilities of System.

Field tests over the New York–Pittsburgh system have shown that each telegraph circuit derived therefrom is of high grade, allowing signal speeds of 35 to 40 cycles per second. That is, with machine sending, it is possible to transmit 140 to 160 words per minute (five letters and a space per word) each way over each telegraph circuit. Considerably higher speeds may, of course, be obtained by widening the frequency range assigned to each telegraph circuit.

The New York–Pittsburgh system may be used in connection with a multiplex printing telegraph system and three printer messages may then be sent simultaneously in either direction on each carrier circuit. Assuming 50 words per minute as the working speed for each of the three printers a total of 1,500 words per minute could be transmitted simultaneously in either direction over the ten circuits.

A simple numerical example will indicate what is technically possible by the application of this type of telegraph system to toll cables. A toll cable 2⅝ inches (6·7 cm.) in diameter contains about 300 pairs of No. 19 B. & S. gauge (0·91 mm.) conductors. Utilising the phantom circuits this gives a total of 225 four-wire circuits. Counting 30 messages in each direction per four-wire circuit it is evident that it is technically possible to transmit 6,750 messages in each direction simultaneously.

The "break" feature of this system is satisfactory. It functions in a manner similar to that used with the metallic telegraph system. It takes about 0·1 second to transmit a "break" signal over a 1,000-mile (1,610 km.) circuit.

Fields of Application.

It will be evident that while the foregoing description assumes that this system is applied to four-wire circuits, it could be readily applied to two-wire circuits by transmitting half of the carrier frequencies in one direction and the other half in the opposite direction. Furthermore, if the impedance characteristic of the line could be reproduced with sufficient accuracy in networks to balance the line at the repeaters, the same frequencies could be transmitted in both directions and as many of them could be so transmitted as the natural "cut-off" of the line would permit.

While the voice-frequency carrier telegraph system has been designed primarily for use on an ordinary telephone circuit, the system may be applied to carrier telephone or radio telephone channels without involving radical changes in either the telegraph system or the telephone circuit to which it is applied.

APPENDIX C.f., No. 2.

METALLIC POLAR-DUPLEX TELEGRAPH SYSTEM FOR LONG SMALL-GAUGE CABLES.*

By JOHN H. BELL,† Associate A.I.E.E.; R. B. SHANCK,‡ Associate A.I.E.E., and D. E. BRANSON,‡ Associate A.I.E.E.

Synopsis.—In connection with carrying out the toll-cable program of the Bell System, a metallic-circuit polar-duplex telegraph system was developed. The metallic-return type of circuit lends itself readily to the cable conditions, its freedom from interference allowing the use of low potentials and currents so that the telegraph may be superposed on telephone circuits. The new system represents an unusual refinement in d.-c. telegraph circuits, the operating current being of the same order of magnitude as that of the telephone circuits on which the telegraph is superposed.

The metallic system is suitable for providing circuits up to 1,000 miles or more in length, the grade of service being better than that usually obtained from ground-return circuits on open-wire lines for such distances. About 55,000 miles of this type of telegraph circuit are in service at present.

There has been developed recently by the Bell System a low-current metallic telegraph system, of the polar-duplex type, which is suitable for superposition on telephone circuits in long small-gauge cables. In certain sections where long-distance toll traffic is heavy, it becomes desirable, from the standpoints of economy and continuity of service, to employ such cables to replace existing open-wire lines and to provide for future growth. The new telegraph system is being applied on a considerable scale in connection with the toll cable system, the general features and telephone arrangements of which have been described in previous papers.§ The present paper outlines the general features of the metallic telegraph system and the method of superposing telegraph circuits of this type upon "two-wire" and "four-wire" telephone circuits in small gauge cables.

The metallic-return or two-wire type of telegraph circuit was chosen in preference to the ground-return type because it appeared to offer a more straightforward solution of the technical problem and to be more economical, sufficient cable conductors being available as a result of the telephone requirements. On a long telephone circuit in a small-gauge cable it is necessary to employ a number of repeaters with comparatively large amplification and also to insert loading coils in the line at short intervals. As a result, the interference from superposed telegraph would be excessive unless the telegraph voltages and currents were kept far below the values ordinarily employed for ground-return telegraph. To allow the use of small currents and potentials with ground-return telegraph would require the development of arrangements for neutralising difference in earth potential and inductive interference from telegraph circuits in the same cable as well as from power circuits. It will be evident that a metallic telegraph circuit possesses certain transmission advantages over a ground-return telegraph circuit in the same way that a metallic telephone circuit possesses advantages over a ground-return telephone circuit.

This development resulted in a telegraph system which in some ways is unique in its refinement. The telegraph line currents are of the same order of magnitude as those of the telephone circuits which use the same wires. Although cable is fundamentally much less favourable to telegraph transmission than open wire, one mile of small-gauge cable having

* Published in the *Journal of the A.I.E.E.*, April, 1925.

† Bell Telephone Laboratories, Inc.

‡ American Telephone and Telegraph Co. Presented at the Midwinter Convention of the A.I.E.E., New York, N.Y., February 9–12, 1925.

§ "Philadelphia–Pittsburgh Section of the New York–Chicago Cable," J. J. Pilliod, *Journal A.I.E.E.*, Aug., 1922, p. 446. "Telephone Transmission over Long Cable Circuits," A. B. Clark, *Journal A.I.E.E.*, Jan. 1923, p. 1. "Telephone Equipment for Long Cable Circuits," C. S. Demarest, *Journal A.I.E.E.*, Nov. 1923, p. 1159.

as much effect as many miles of open wire, the present system affords satisfactory operation on each pair of the cable for distances up to 1,000 miles (1,600 km.) or more.

Two improved forms of mounting are employed; in one of these a repeater is built as a single self-contained unit and in the other a repeater consists of several units mounted on upright I-beams. The relays are quiet in operation and sounders are normally made inoperative mechanically, as they are seldom used. Altogether a metallic repeater office bears little resemblance to the older type of office with apparatus mounted on tables and hundreds of sounders in operation.

Principles of Operation.

In describing the general principles upon which the present telegraph system operates, it will be convenient to evolve it from the familiar ground-return polar-duplex system, the essential features of which are illustrated in Fig. 1. It will be seen that at each end of the line circuit there are provided a transmitter and a receiving relay. The operation of the transmitter sends current into the line and the artificial line, one polarity being used for "marking" and the other for "spacing." If the artificial line has the same impedance as the real line, there will be no effect upon the receiving relay, since the latter is connected differentially. Currents received from the transmitter at the distant station will, however, cause the receiving relay to operate. The arrangement, therefore, makes it possible to send telegraph signals in either direction, or in both directions simultaneously.

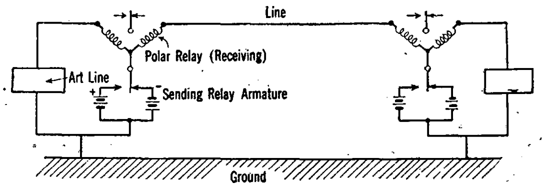


FIG. 1.—Differential Duplex on Grounded Circuit.

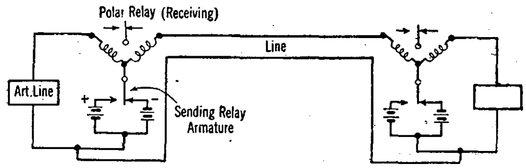


FIG. 2.—Differential Duplex on Metallic Circuit.

In Fig. 2 the ground-return is replaced by a second line wire so that the circuit is now a metallic circuit.

Fig. 3 differs from Fig. 2 only in that each receiving relay has its windings divided into four parts instead of two, making the circuit symmetrical.

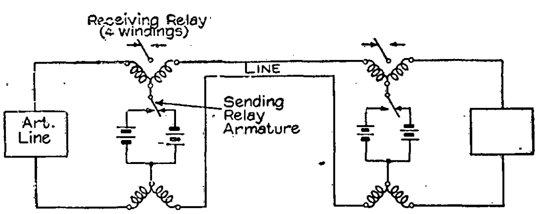


FIG. 3.—Symmetrical Differential Duplex on Metallic Circuit.

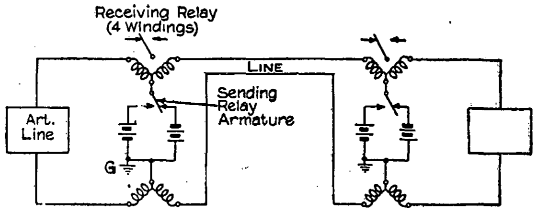


FIG. 4.—Metallic Duplex Circuit—Single Commutation.

For actual operation involving the working of a number of circuits in a given office from the same set of batteries, it is desirable to make a connection to ground at each station at the point *G* as shown in Fig. 4. These connections stabilise the system and facilitate the clearing of accidental grounds. Although this results in unbalancing the currents in the circuit, there is substantially no effective change in the metallic or two-wire operating currents if the line and apparatus are well balanced, and this arrangement has the essential characteristics of an actual metallic telegraph circuit. It may be helpful, however, to consider that the upper wire is employed for the transmission of signals and the lower wire is used to carry only neutralising current to offset the effect of currents in the upper wire which are due to earth-potential differences and voltages to ground caused by induction from power or telegraph circuits. Since each pair in the cable is closely balanced, encloses a small loop, and is frequently transposed by twisting, it will be apparent that the currents due to interference are practically equal in the two wires, flowing in the same geographical direction and therefore do not affect the balanced relays.

Fig. 5 shows another arrangement of a metallic telegraph circuit in which the transmitter comprises two tongues, reversing the connections to a single battery, instead of switching between two different batteries as in the case of Fig. 4. The ground connection at the mid-point of the battery at each station is for the purpose of stabilising the system and facilitating the clearing of trouble.

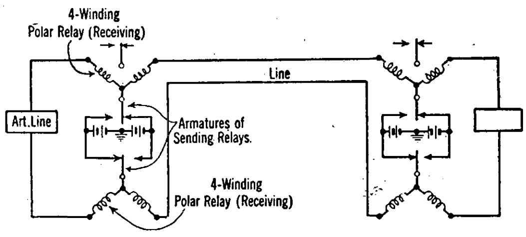


FIG. 5.—Metallic Duplex Circuit—Double Commutation.

Circuits of the type shown in Fig. 5 were first developed and put into extensive use in preference to the type shown in Fig. 4, largely for the reason that it was not at first practicable to obtain sufficiently close balance of relay windings. With improved relays, telegraph repeaters have been designed to operate on the basis of Fig. 4, effecting certain economies. These two arrangements, which are known respectively, as " double commutation " and " single commutation," may be operated one against the other in a telegraph repeater section.

The local circuits of the repeaters are arranged so that they may be conveniently set up either for simultaneous operation in both directions (known as full-duplex) or for operation in only one direction at a time (called half-duplex), the latter giving the same communication facilities as a simple open-and-close Morse telegraph circuit.

General Features.

As in the case of other telegraph systems it is necessary to subdivide a long circuit into sections by means of repeaters to avoid the use of excessive potentials and to limit the distortion of signals. For repetition between two metallic cable circuits a simple arrangement called a " through repeater " is employed. The equipment used at the end of a metallic telegraph circuit is known as a " terminal repeater."

The metallic polar-duplex system operates with a potential of 34 volts, requiring one 34-volt battery for double commutation and two such batteries for single-commutation. Where both are used in the same office, one of the single-commutation batteries may be used for double-commutation, this being equivalent to the regular arrangement with a ground potential of 17 volts in addition. The batteries are ordinarily " floated." Tungar rectifiers are generally used, without causing any noise in the telephone circuits.

The telegraph current in the cable circuit, with the batteries at the two ends aiding, is from about 3 to 15 milliamperes depending on the resistance of the line circuits. With the batteries opposing, the current is, of course, practically zero.

The small-gauge cables are made up of No. 16 and No. 19 B. & S. gauge (1·29 and 0·91 mm. respectively) copper conductors, and the metallic telegraph system may be operated over conductors of either gauge, or over the derived phantom circuits when the latter are not in use for telephone service. The maximum distance between two consecutive repeaters is about 120 miles (195 km.) on 19-gauge, composited pairs, or 160 miles (260 km.) on 16-gauge. For non-composited circuits the corresponding distances are about 140 miles (225 km.) and 190 miles (305 km.) respectively. The average telegraph repeater section is about 100 miles (160 km.) in length as a result of the telephone requirements in connection with locating repeater stations. In some cases the telegraph is operated over non-loaded circuits, such conductors being available before loading coils have been applied to all wires of the cable. The telegraph transmission is practically the same on non-loaded and loaded circuits.

Curves of resistance and reactance versus frequency are shown in Fig. 8, for a representative metallic line section and the corresponding artificial line. It will be noted that there are large variations in these impedance components in the frequency range from zero to about

30 cycles per second, and they tend to become constant as the frequency is further increased. At the lower frequencies the effect of the distant terminal apparatus is, of course, large. Curves for non-loaded lines are similar except that at the higher frequencies the resistance is lower and the reactance higher.

A feature which has an important effect on the quality of the received telegraph signals is the "vibrating circuit" which was devised originally by Gulstad. This circuit comprises two auxiliary windings on the receiving relay, a condenser and two resistances as illustrated in Fig. 9. A current through the resistance branch of the vibrating circuit moves the relay armature to the opposite contact when the effective operating current, in reversing, approaches zero value. While the armature is passing between contacts, the condenser in the other branch partially discharges through both windings in series, the discharge current accelerating the armature. As soon as the armature touches the other contact, a transient current completing the discharge of the condenser and charging it in the opposite direction holds the armature firmly against this contact until the operating current has had time to become large enough to assume control. The vibrating circuit, therefore, increases the

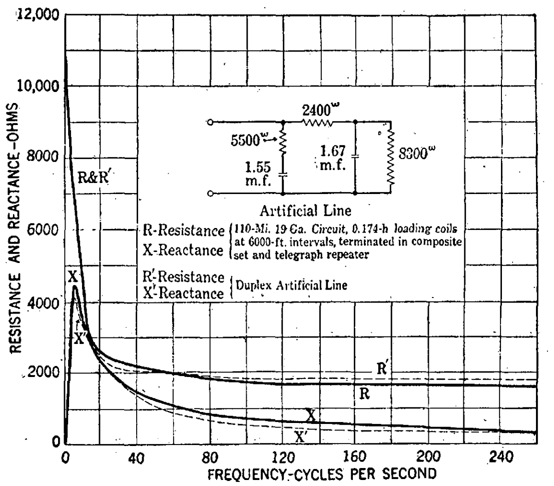


FIG. 8.—Impedance of Line and Artificial Line.

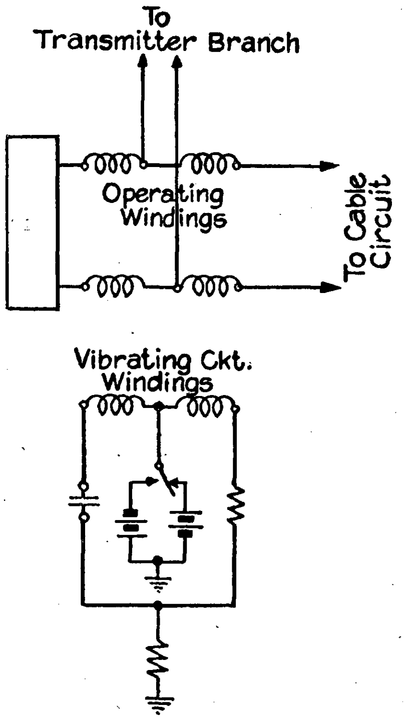


FIG. 9.—Vibrating Circuit.

sensitivity, reduces the time of armature travel, lessens chatter of the armature contacts and makes the operation of the relay more positive. Furthermore, the constants of the vibrating circuit are so proportioned as to minimise distortion of signals, the relay being caused to operate near the steepest part of the received current wave.

The receiving and transmitting relays used in metallic telegraph repeaters are the 209-*F A* and 215-*A* relays, respectively, which are being described in a separate paper. The former is a highly sensitive polarised relay, furnished with vibrating windings, whereas the latter is of the same general construction but less sensitive and has no vibrating windings. The 215-*A* relay is also used in the arrangements provided for facilitating "breaking." In cases where a terminal repeater is operated between a ground-return circuit and a metallic circuit, relays of this type function as receiving relays for the ground return section.

The through-type repeater is a direct-point repeater; the armatures of sensitive polar relays, operated by the line current from one direction, repeat the signal (differentially through the windings of the opposite receiving relays) into the other line in the opposite direction. A simplified diagram of this repeater is shown in Fig. 10. This repeater is a full-duplex repeater but is used on half-duplex circuits without change. As shown, two

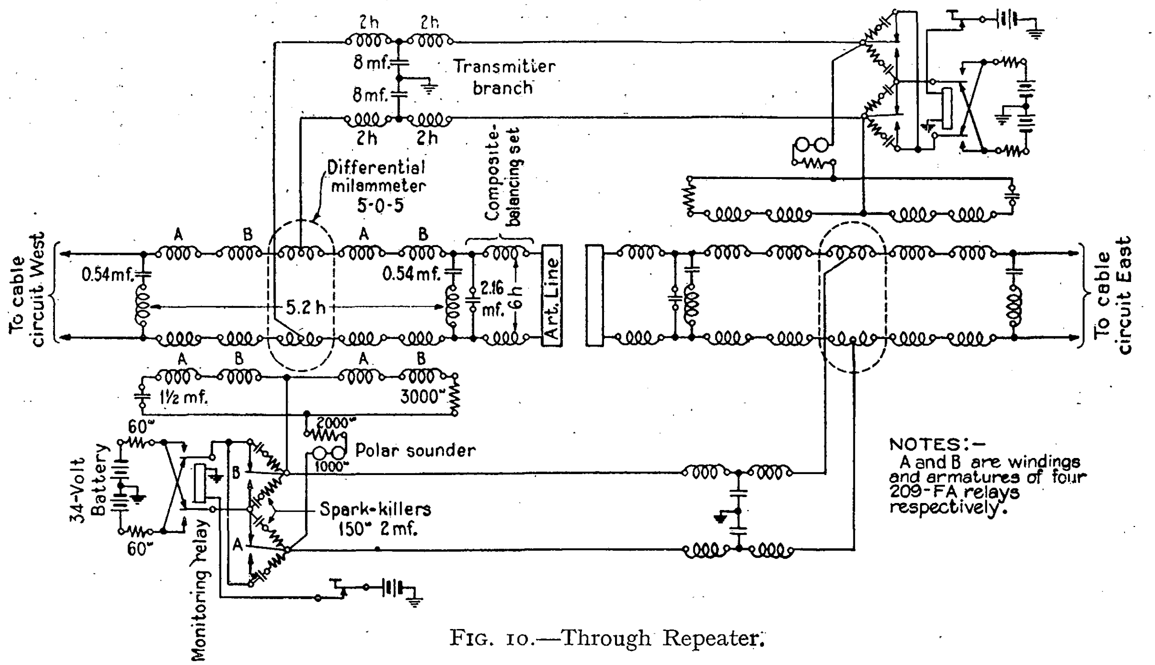


FIG. 10.—Through Repeater.

polarised sounders are provided for reading signals, and a telegraph key controls the operation of local neutral relays, designated monitoring relays, making it possible to send into either line independently, or in both directions at once.

The terminal-type repeater is also a direct-point repeater and is used to repeat signals between a metallic cable section and either a ground-return circuit or a local circuit. Polarised sounders and other monitoring features similar to those in the through-type sets are provided. The local circuit arrangements are described in detail in the next section.

Local Circuits.

To avoid supplying battery at outlying points and to facilitate setting up and changing circuits which have a number of stations in the same locality or have branches, a two-wire circuit or "loop" is extended from the repeater office to each operator's station. For the marking or closed condition the current is approximately 60 milliamperes and for spacing it is zero.

For full-duplex service the arrangement is simple, involving the use of a receiving loop and a sending loop as shown in Fig. 11. In the receiving loop the batteries are aiding when the line relay tongue is on marking, and opposing when it is on spacing. Signals may, therefore, be received by the operator by means of an ordinary Morse (neutral) relay or main-line sounder. The sending loop is opened and closed by the operator's key in sending out signals. The sending relays are of the polar type and may be considered to have a biasing circuit which includes the battery connected to the apex point, the lower windings and the artificial line. When the key is closed the effect of the biasing current is overpowered by the loop current, as the latter is twice as great. When the key is opened the biasing current moves the relay armatures from marking to spacing.

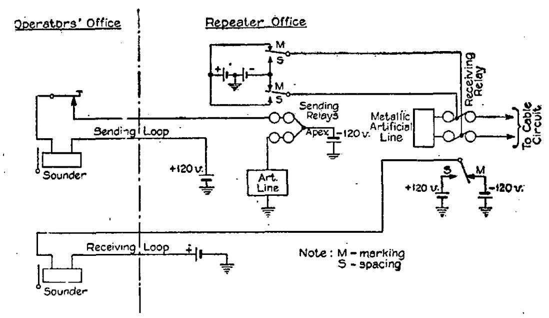


FIG. 11.—Terminal Repeater—Full-Duplex Local Circuits.

For half-duplex service, a single loop is used for both sending and receiving as depicted in Fig. 12. Signals are sent out in precisely the same manner as in full-duplex and do not affect the metallic line relay on account of the balanced duplex connection. The sending relays, although connected in the loop, are unaffected by received signals as they are differential as regards current from the receiving relay tongue. This is in fact a duplex connection, and it allows the working of the grounded side of the terminal repeater directly into a long circuit having a standard ground-return polar-duplex repeater at the distant station. A suitable artificial line is provided for this purpose.

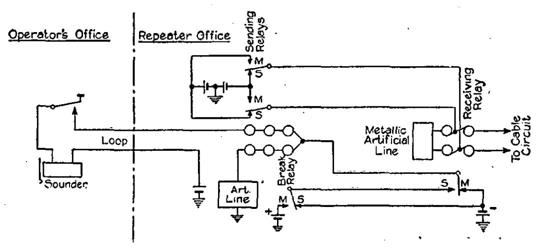
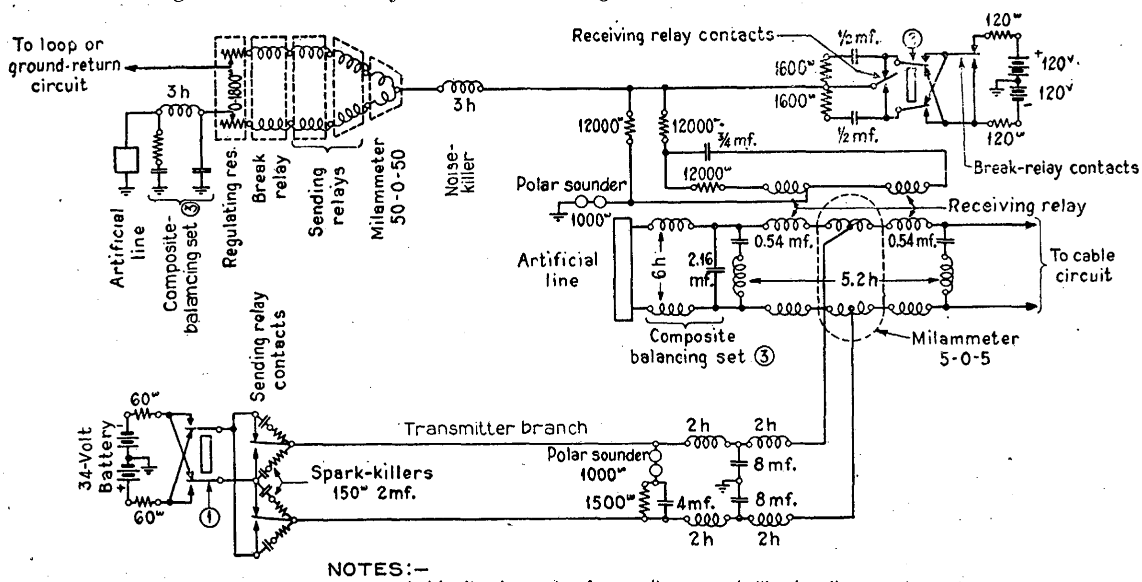


FIG. 12.—Terminal Repeater—Half-Duplex Local Circuits.

To facilitate interruption of the sending operator by the receiving operator a "break relay" is also provided, operating simultaneously with the sending relays. To understand its function, assume the key in the loop to be opened; as soon as a marking signal is received from the line, the sending relay armatures will be moved to spacing due to the current in the biasing windings and the absence of current in the loop. The break relay at the same time connects marking battery to the spacing contact of the receiving relay so that no matter what signal impulses are subsequently received from the line the sending relays will be unaffected. If the break relay were not used, incoming signals would operate the sending relays and be repeated back into the line, reversed. This would result in a slow and uncertain break.

In using two terminal repeaters to connect an operator's office at an intermediate point to a metallic circuit, the loop or loops are connected in tandem between the two repeaters. In full-duplex the sending leg of one repeater is connected to the receiving leg of the other, and vice versa, with a loop in series with each connection. In half-duplex the two local circuits are connected together with the loop in series, and at one repeater, batteries on the receiving relay contacts are reversed and the connections to the loop and biasing windings of the sending and break relays are interchanged.



NOTES:—
1. Monitoring relay for sending on metallic circuit, controlled by a telegraph key.
2. Monitoring relay for sending on ground-return circuit, controlled by a telegraph key.
3. Composite-balancing set removed by key for loop or non-composited operation.

FIG. 13.—Terminal Repeater.

Local circuit arrangements of the type just described make the metallic repeaters suitable for use in combination with the carrier-current and ground-return polar-duplex repeaters used in the plant. This flexibility has been secured by designing the loop circuits to operate with 60 milliamperes current for marking and zero for spacing. Briefly, the flexibility necessary to permit of setting up long circuits with branches is in no wise sacrificed by the use of the several systems.

The essential features of the circuit of the terminal-repeaters are shown schematically in Fig. 13.

Superposition on Telephone Circuits by Compositing.

In superposing the metallic telegraph on telephone circuits, the well-known "compositing" method is used. This is based on frequency discrimination, the telegraph occupying the range below that of the telephone. For satisfactory results, the telegraph and the telephone arrangements, including signalling, as well as the composite sets, must be designed in conjunction with the line circuits so as to avoid serious interference between telegraph and telephone. Furthermore, the compositing means employed should have but little detrimental effect on the transmission of the three forms of communication operating separately, and must not upset the symmetrical circuit arrangement upon which freedom from external interference depends.

Interference from telegraph and telephone manifests itself in two ways. The first of these is telegraph "thump" which is the name given to a low pitched noise in the telephone due to a small part of the telegraph current passing through the telephone branch of the composite set and entering the telephone apparatus. The thump, in addition to being audible, may affect the telephone signalling equipment to the extent of causing false rings. In addition to the thump at the transmitting end of the circuit, thump is produced at the receiving end by the vibrating circuit through transformer action of the relay windings. In providing protection from thump, both phantom and side circuits have to be considered. The second kind of interference is the flutter effect* due to the fact that rapid changes in the telegraph currents momentarily increase the effective resistance of the loading coils, thereby varying the attenuation of the circuit at telephone frequencies.

The telegraph branch of the composite set (*see* Fig. 14) consists of series inductance and shunt capacity and therefore offers to line currents of telephonic frequencies high impedance and attenuation. It has little effect upon the low frequencies required for satisfactory telegraph transmission, and at the same time sufficiently attenuates the higher frequency components of the telegraph waves to avoid excessive thump. In order that the telegraph branch may be effective in reducing thump voltages in the phantom circuit, the two windings of the retardation coil are made with a negligible mutual inductance, and the bridged capacity consists of two balanced condensers with the midpoint grounded. It has been found necessary to make this retardation coil of very stable inductance by using a comparatively large amount of iron, since a coil with less stable characteristics would cause excessive thump, due to the generation of harmonics.

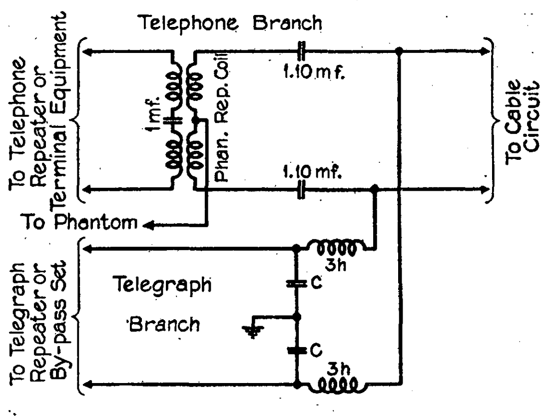


FIG. 14.—Composite Set.

The telephone branch consists of series condensers and a low inductance repeating coil or transformer and has high impedance and attenuation for line currents of telegraph frequencies, but has little effect upon telephone transmission. It supplements the telegraph branch in reducing thump and also serves to limit mutual interference between telephone

* *See* paper by Martin and Fondiller, *Journal A.I.E.E.*, February 1921, page 149.

signalling and telegraph. The repeating coil is also used for deriving the phantom circuit in the usual manner.

The composite set is sufficient to limit receiving-end-thump to a harmless amount, but greater protection is necessary against sending-end-thump. In order that the additional equipment for this purpose may have the minimum effect on telegraph transmission, it is placed in the transmitter branch where it affects outgoing signals only. It consists of series inductances and bridged capacities to suppress the high-frequency components of the telegraph impulses as in the composite set; the mutual inductance of the coils is made small so that they may be effective in reducing thump in the phantom circuit. In single-commutation repeaters, another coil is necessary in the transmitter branch to prevent excessive phantom circuit thump. This coil is connected with its windings parallel-aiding as regards the phantom circuit and therefore is series-opposed or non-inductive for the metallic telegraph operating currents. An examination of the circuits will show that in double-commutation, operation of the telegraph impresses voltage on the phantom circuit only if the two transmitting tongues fail to operate in exact synchronism; in single-commutation, voltage is impressed on the phantom circuit by the normal operation of the transmitter, since the telegraph current, being unbalanced, has a large longitudinal component.

To preserve the duplex balance when using a composited line, a composite balancing set, consisting of a series coil and a bridged condenser, is provided for insertion in the artificial line branch as shown in Figs. 10 and 13.

To protect the receiving relay from interference from the 135-cycle current used for telephone signalling, a resonant shunt is bridged across the telegraph set on the line side of the receiving relay and a balancing shunt is bridged across the set on the artificial-line side. A single coil is made to serve for both of these shunts, one winding being placed in the line side and the other in the artificial-line side.

Twenty-cycle ringing current, which is used for signalling in the local terminal equipment of the telephone circuit, and operation of the telephone receiver switch-hook, give rise to transient currents which tend to harm telegraph transmission. To minimise this effect, a condenser is connected between windings of the repeating coil.

Since metallic telegraph repeaters are spaced about 100 miles (160 km.) apart and telephone repeaters on many circuits about 50 miles (80 km.), means must be provided for passing the telegraph currents around the intermediate telephone repeaters. This is done by inserting an "intermediate" composite set on each side of the telephone repeater and connecting the telegraph branches together through a "by-pass" set. This arrangement is shown in Fig. 15. The intermediate composite set is very similar to the terminal composite set. The by-pass set consists of a retardation coil of high inductance and little mutual inductance between windings, with or without a resonant shunt. The purpose of this by-pass set is to keep the amplification characteristic of the telephone repeater from being affected by currents feeding back through the telegraph branches of the composite sets from the output into the input of the telephone repeater. For four-wire telephone circuits, on which repeaters work with comparatively high amplification, it is necessary to bridge a shunt, resonant at about 135 cycles per second, at one end of the by-pass to prevent excessive feedback at 135 cycles per second and neighbouring frequencies. It is grounded in the middle and two coils are provided, connected so that one will be effective for the side circuit and the other for the phantom circuit. For two-wire telephone circuits the resonant shunt is unnecessary.

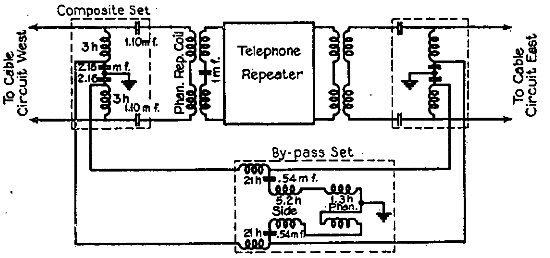


FIG. 15.—Intermediate Compositing Arrangements.

Q

Equipment Arrangements.

The terminal-type repeater is assembled as a complete unit at the time of manufacture and therefore the installation work consists only in arranging the repeaters in rows and connecting the line conductors, loops and batteries to the terminal strips. A typical installation is shown in Fig. 16. A terminal and a through repeater are shown in Fig. 17 and Fig. 18 respectively.

A terminal repeater stands 62 in. (1·57 m.) high and occupies a space 14 in. (36 cm.) wide and 12 in. (30 cm.) deep and weighs about 220 lbs. (100 kg.). The keyshelf is about 40 in. (1 m.) above the floor. On the top of the repeater is mounted the operator's "calling-in" lamp.

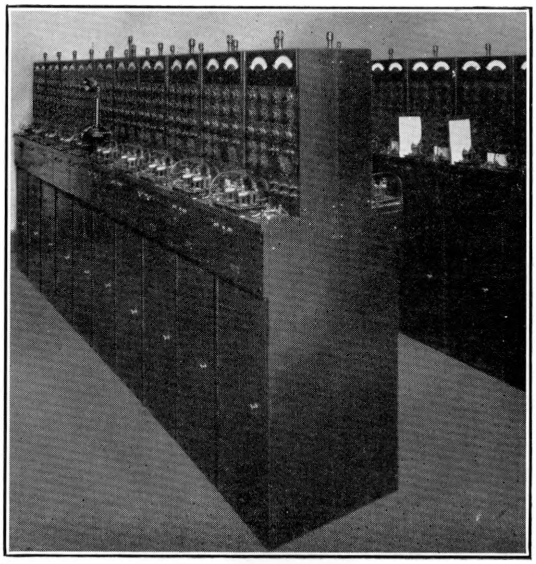


Fig. 16.—Installation of Metallic Telegraph Repeaters—Terminal Type.

The floor-mounted type of through repeater has the same equipment assembly for both the east and west sides and these are practically the same as the portion of the terminal repeater which operates on the cable section. The equipment in the right-hand section of the through panel is for repeating signals from the east line to the west line, and the left vice versa. This repeater weighs about 230 lbs. (105 kg.) and occupies the same space as a terminal repeater.

The rack-mounted through repeater was developed after experience with the floor-type had shown how little monitoring attention was required. For that reason the repeater was simplified by the elimination of the line meters and monitoring apparatus. A unit termed a "monitoring unit" is provided for a group of about seven repeaters, and it can be connected into any one repeater by means of cords and plugs. A rack-type repeater consists of three units—the relay and transmitter-branch unit, the balancing composite unit, and the artificial-line unit. Each of these units consists of a steel panel with necessary apparatus, arranged for mounting on two upright standard I-beams, thus forming a "bay." Generally there are four repeaters, or three repeaters and a monitoring panel, per bay. Fig. 19 shows an arrangement of repeaters on racks having a height of about 90 in. (2·3 m.). This type of repeater is supplied for single-commutation operation only, whereas both forms of "floor-mounted" repeaters are supplied for double-commutation operation. Considerable economy in first cost and maintenance is secured by the use of this rack-mounted equipment.

Operation and Maintenance.

The metallic telegraph repeaters require comparatively little attention on the part of repeater attendants. Under normal operating conditions one man takes charge of about 24 terminal repeaters or 40 through repeaters. The duties of the repeater attendants consist mostly in maintaining satisfactory impedance balance of the artificial lines against the real lines. This balance is, of course, more exacting for full-duplex operation than for half-duplex. The capacity balance varies only a slight amount. Variations in resistance balance are caused by temperature changes, the average daily variation being about 6 per cent. The differential milammeter is used as an indicator in determining the resistance and capacity values required to obtain a balance.

The equipment maintenance work required for these repeaters is exceedingly small. For a typical installation of 200 repeaters the adjustment of relays and general maintenance will necessitate not more than four or five man-hours per day.

The maintenance schedule for adjusting the relays is somewhat variable, depending upon the type of circuit in which they are operating. In general, a 209-*F A* relay in a terminal repeater will give uninterrupted service for two to three months and in a through repeater for four to six months. The 215-*A* relays are adjusted about every three weeks when used as " break " relays and every six months operating as pole-changing relays.

With proper maintenance the transmission of the metallic telegraph system is such as to furnish high-grade half-duplex manual service for distances up to 2,000 miles (3,200 km.) or more. For the longer distances the signal propagation time is increased to an amount which makes the time required to " break " appreciable, but not objectionable. For half-duplex printer operation the metallic circuits are satisfactory for speeds up to about 19 dots per second, which corresponds to about 300 characters per minute for the start-stop type of printer.

For full-duplex service, the metallic system affords very good transmission with manual operation for distances up to 1,000 miles or more. With careful maintenance of duplex balances, such a circuit is satisfactory for full-duplex printer operation at speeds up to about 16 dots per second, corresponding to about 260 characters per minute for start-stop printers and 385 for multiplex printers.

It is of interest to note that metallic circuits in cable are much more dependable and less subject to interruption than open-wire circuits. Such data as are available indicate that the annual lost time on a long metallic cable circuit is only about one-tenth as great as that on a ground-return polar-duplex circuit of the same length over open wire.

Commercial Use.

At the present time there are in operation in the Bell System about 55,000 miles (89,000 km.) of metallic telegraph circuits of this type, of which 30,000 miles (48,000 km.) are worked on a composited basis. Approximately 20 per cent. of the total mileage is operated full-duplex. There are now installed in the plant about 430 through repeaters and 1,050 terminal repeaters.

APPENDIX C.f., No. 3.

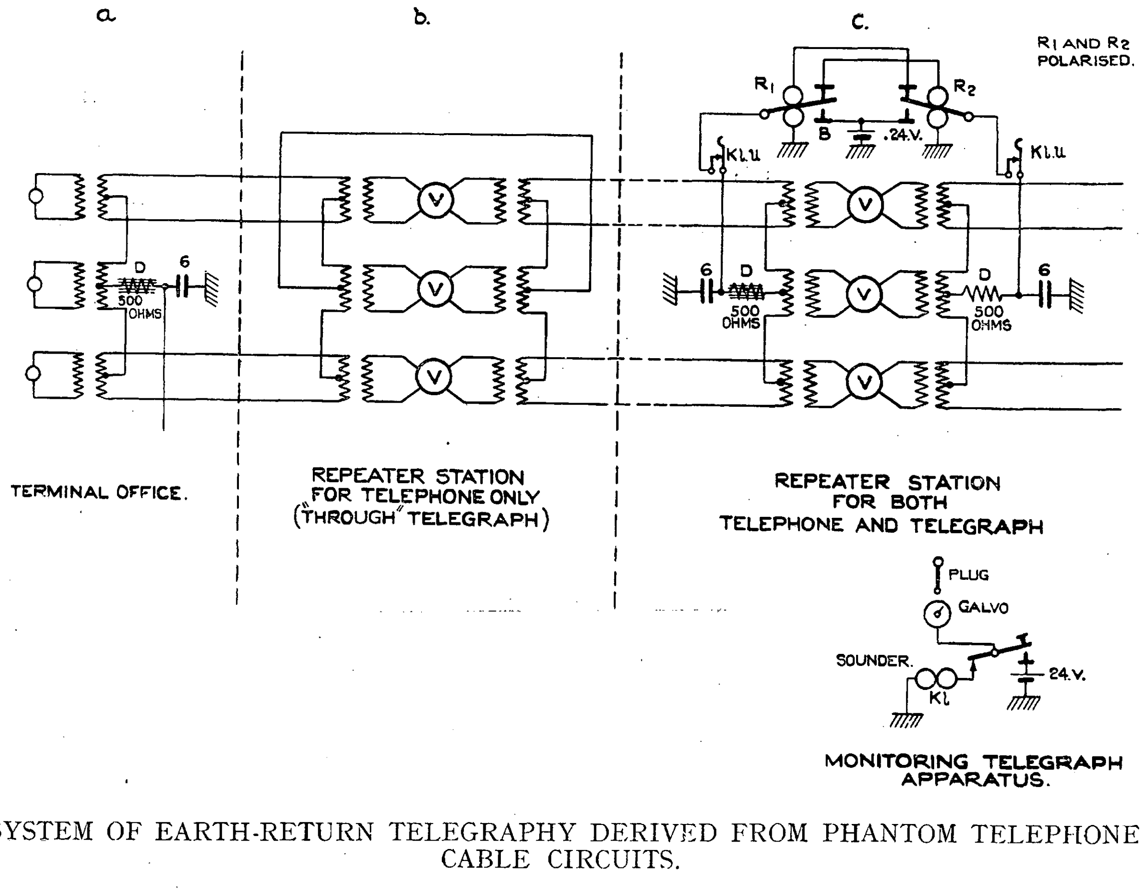
SYSTEM OF EARTH RETURN TELEGRAPHY, DERIVED FROM PHANTOM CIRCUITS, USED BY THE GERMAN ADMINISTRATION.

The phantom circuits of the German Telephone Toll Cable System are appropriated for earth return telegraphy used for the preparation of telephone communications. A schematic showing the circuit arrangements is attached. A coil of high inductance, associated with a 6 m.f. earthed condenser, serves to round off the telegraph currents in order to avoid interference with the telephone service. The power requirements of the telegraph circuits are supplied by the central battery (24 volts) at the telephone exchange. The ohmic resistance of the inductance coil must be fairly high in order to protect the first loading coil in the cable in the event of an earth fault occurring immediately beyond it.

The 24 volts obtained from the central battery is sufficient to assure good telegraph operation without the use of telegraph repeaters, over phantom circuits using 1·4 mm. conductors 300 km. long, and over phantom circuits using 0·9 mm. conductors 150 km. long.

At intermediate telephone repeater points in the 300 km. and 150 km. cable sections (1·4 mm. and 0·9 mm. conductors respectively), the mid points of the East and West phantom transformers are directly connected together. If it is desired to telegraph over greater distances, telegraph repeaters are used every 300 km. or 150 km., according to the diameter of the conductors, and they are arranged and shown in the schematic (Fig. 1).

TELEGRAPH REPEATERS ARE LOCATED :—
EVERY 300 KM. IN 0·9 MM. CIRCUITS.
EVERY 600 KM. IN 1·4 MM. CIRCUITS.



SYSTEM OF EARTH-RETURN TELEGRAPHY DERIVED FROM PHANTOM TELEPHONE CABLE CIRCUITS.

FIG. 1.

APPENDIX C.f., No. 4.

SYSTEM OF TELEGRAPHY, DERIVED FROM TELEGRAPH CIRCUITS, USED BY THE GERMAN ADMINISTRATION.

(Siemens and Halske System.)

In order that telephone cables may be operated under the most advantageous and economical conditions, the Siemens and Halske Company have produced a system which permits the use of telephone circuits for simultaneous telephony and telegraphy. Actually, the method is an old one—it is sufficient to mention the Van Rysselberghe System—but the arrangements which have been employed no longer meet present day requirements as regards speed of telegraph transmission and the protection of installations against disturbances.

The Siemens and Halske System can be used for high speed telegraphy and is so designed that there is no reason to fear that telephone traffic will have any adverse effect upon the transmission of telegrams, and vice versa.

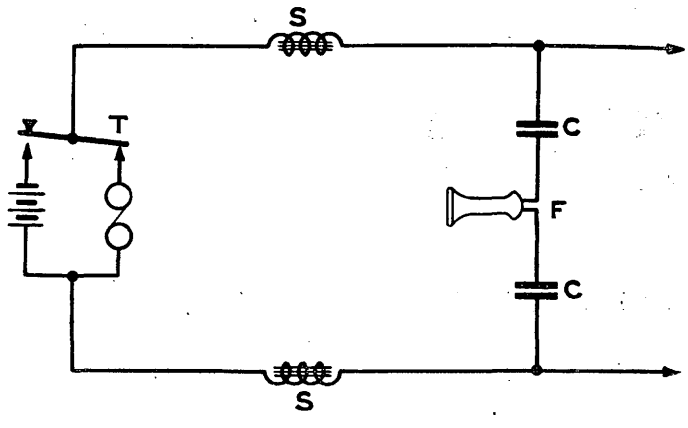
For the transmission of telephone currents a frequency band is used in which the lower limit is of the order of 300 periods, and the frequencies below 300 periods are available for telegraph purposes.

Normally, a high speed telegraph system handles 600 letters per minute. This speed corresponds to 3,000 current impulses per minute—that is, 50 impulses or 25 periods per second. To obtain good telegraph transmission at 25 periods it is sufficient to allot a frequency band of zero to about 60 periods. It will be seen, therefore, that although the speed of telegraph transmission depends upon the width of the frequency band to be transmitted over the telephone circuit, the maximum possible speed is not obtained in actual practice.

To establish telegraph communication between two offices, physical circuits in the same quad are generally used—one for transmission in one direction and the other for transmission in the reverse direction. It is also possible without serious difficulty to obtain satisfactory duplex service over a single circuit, but this is more costly than two communications operating on a simplex, or one way, basis. For this reason duplex service will not be used so long as a sufficient number of cable circuits suitable for simultaneous telephony and telegraphy are available.

I. Schematic of the Siemens and Halske Circuit.

Fig. 1 is a schematic of the Siemens and Halske system of telegraphy superimposed upon telephone circuits. Compared with the Van Rysselberghe system, it has important refinements. In the latter system (Fig. 2) separation of the telegraph and telephone currents is effected in



VAN RYSSELBERGHE SYSTEM.

FIG. 2.

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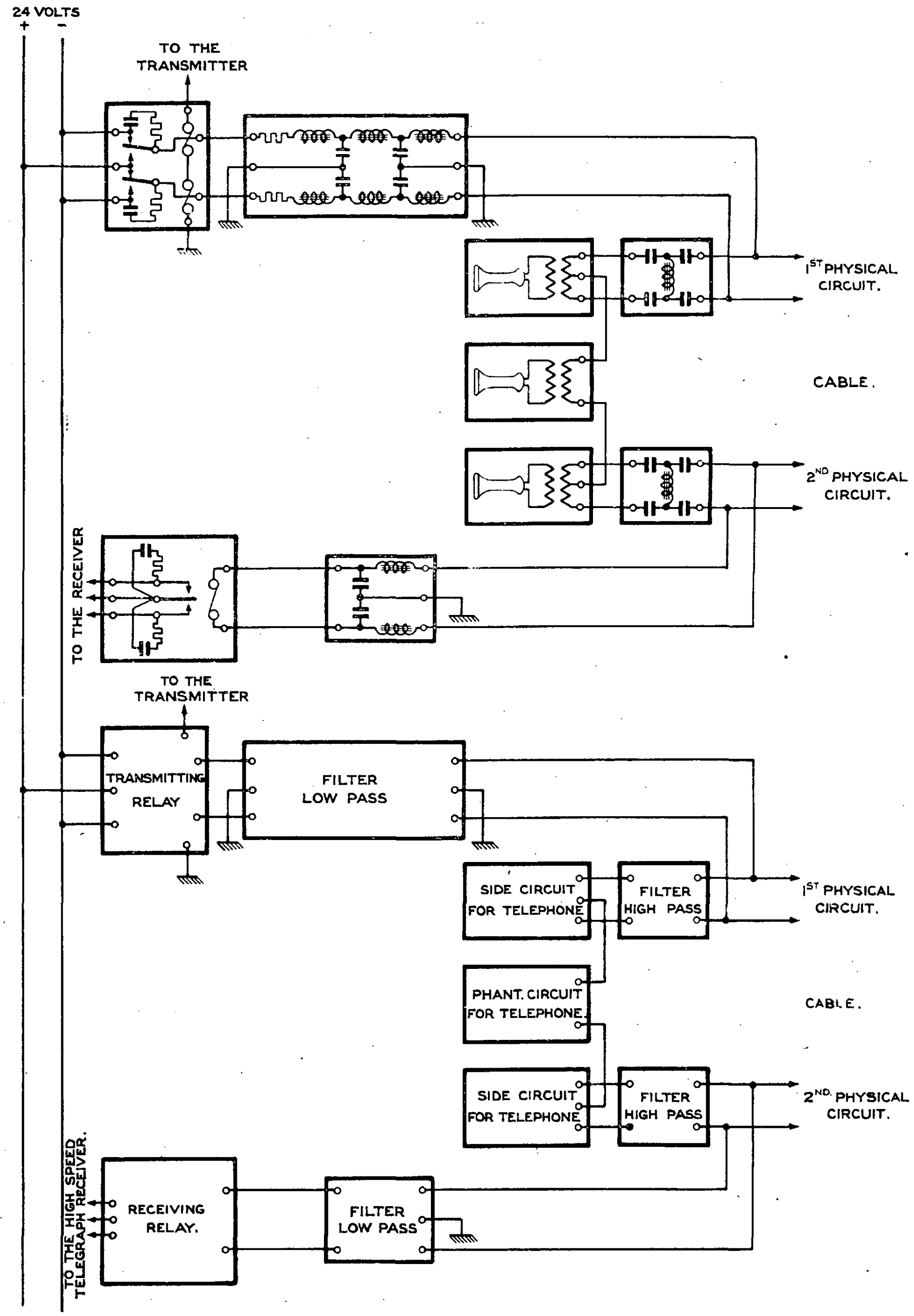


SYSTEM OF COMBINED TELEPHONY AND TELEGRAPHY USING FILTERS.

FIG. 1.

a very simple manner. The method consists in connecting, at the extremity of a line, the telephone apparatus between the condensers C and the telegraph apparatus between the inductance coils S. The new system differs from the Van Rysselberghe particularly in that electric filters are employed to limit more accurately the frequency bands. Thus, in front of the telephone is a high-pass filter with a cut off at 160 periods and in front of the telegraph is a low-pass filter with a cut off at 60 periods. Furthermore, double current telegraph working is used and it is arranged that the two poles of the battery can be connected to the two conductors of the telephone circuit (Fig. 1).

For transmission over the same distances, double current operation requires a lower voltage than single current operation, and, in consequence, there is less danger of the telegraph currents causing interference in the telephone circuits. In using both poles for transmission there is the advantage that a common battery can serve several telegraph circuits. With single current working this would undoubtedly cause interference. For instance, if the key T_1 (Fig. 3) is depressed, an impulse will circulate between the $-$ pole and $+$ pole of the battery by the path indicated by the dotted line. In using both poles (Fig. 4) the conductors 1*a* and 1*b* receive an equal charge but of opposite sign, and the effect upon neighbouring conductors will, therefore, be neutralised. The telegraph currents cannot reach the telephone because of the high selectivity of the filters used. If the two contacts of the transmitting relay do not close at the same instant, however, interference currents can reach the telephone receiver. As shown in Fig. 5, if the armature of the relay (*a*) touches the contacts connected to the $-$ pole of the battery when the contact is not closed at (*b*), and the relay armatures associated with lines 3 and 4 are resting on their lower contacts, it will be seen that a current impulse will circulate between the two poles of the battery and will traverse the telephone E as shown by the dotted line. To avoid this, the condensers C (Fig. 5) are each replaced by two condensers in series $2C$ (Fig. 6). With their mid points connected by conductors e and d, any interference impulses will thus follow the path indicated by the dotted line and without passing through the telephone receiver. If, during operation, the contacts of the transmitter relay are opened, the current will be interrupted and the energy resulting from the magnetic field collapsing in the coils of the low-pass filter will cause interference in the telephone. This is avoided by shunting the transmitting relay contacts with small condensers and resistances in series, as shown in Fig. 1. The condensers absorb the energy released in the inductance coils. During its travel the armature of the receiving relay induces currents in its operating windings which are perceptible in the telephone receiver connected across the same telephone lines. This objectionable effect is avoided by the insertion of a single section low-pass filter (Fig. 1) in front of the receiving relay.

The high-pass filter in the path of the telephone currents as well as impedance of the low-pass filters located at the entrance of the cable circuits are the cause of an increase in the attenuation of the telephone circuit. This increase affects particularly the low frequencies and corresponds to about $b = 0 \cdot 5$ at 300 periods. It becomes less pronounced as the higher frequencies are approached and at 1000 periods it is practically negligible. It is not possible to use signalling currents of 25 periods over the combined telephone and telegraph circuits, and modulated voice frequency signalling current is, therefore, used, as on 4 wire circuits (500 periods).

II. Mounting of the Equipment.

The supplementary apparatus required for telegraphy over telephone circuits is mounted upon a rack (Figure 7A) which can accommodate the panels required for five two-way communications; that is, for five incoming and five outgoing lines.

FIG. 3.

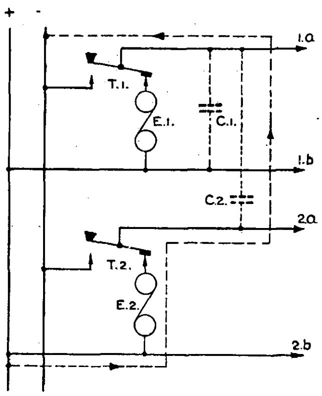
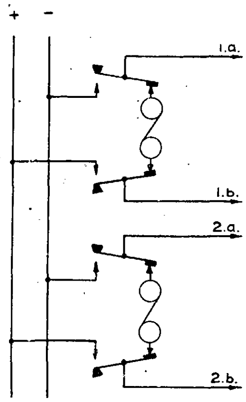


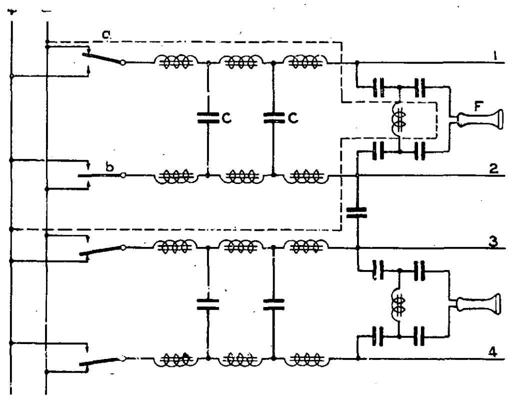
FIG. 4.



TELEGRAPH INTERFERENCE. WITH SINGLE COMMUTATION.

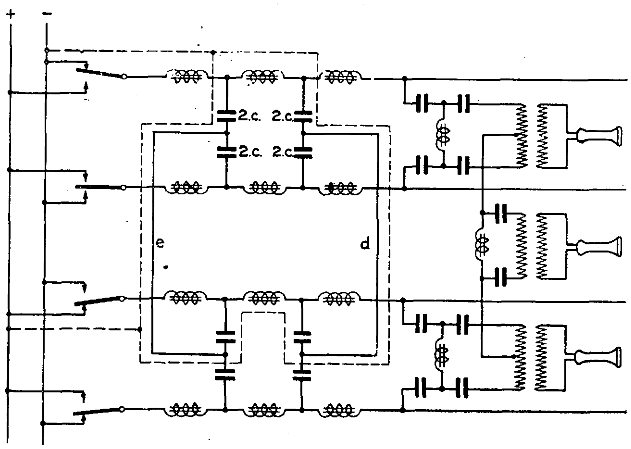
DOUBLE COMMUTATION.

FIG. 5.



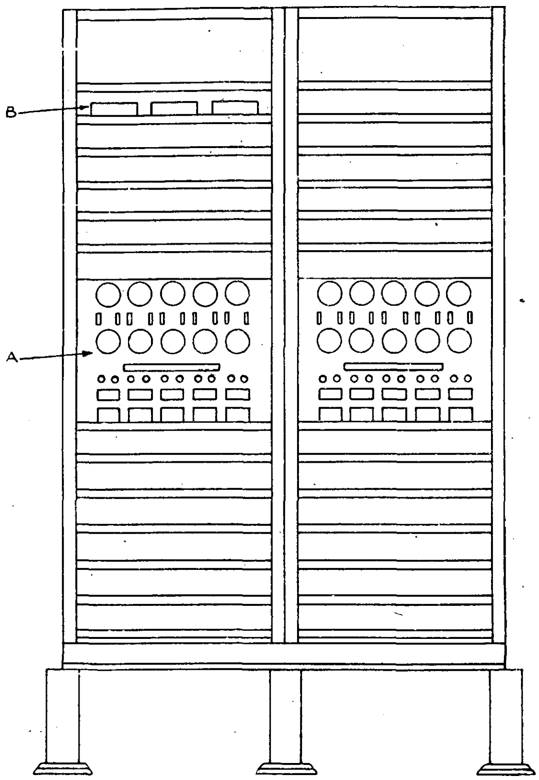
TELEPHONE INTERFERENCE CAUSED BY IRREGULAR OPERATION OF TELEGRAPH TRANSMITTING RELAYS.

FIG. 6.



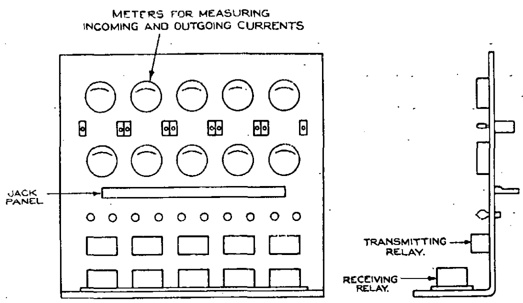
SUPPRESSION OF THE INTERFERENCE REPRESENTED IN FIG. 5.

Units which must be accessible are grouped upon an iron panel (Figure 7B); they are: transmitting relays, receiving relays, apparatus for measuring incoming and outgoing currents, and jacks for interchange of apparatus or replacement by stand-by apparatus. The panels in question occupy the central portion of the rack. Above and below are panels carrying the different parts of the low-pass and high-pass filters.



RACK FOR 2 × 5 OUTGOING CHANNELS AND 2 × 5 INCOMING CHANNELS.

FIG. 7A.



PANEL FOR THE TELEGRAPH RELAYS.

FIG. 7B.

In general, the racks are installed in the telephone repeater stations, but if required for technical or exploitation reasons the central panels carrying the relays can be located in the central telegraph office.

APPENDIX C.f., No. 5.

SYSTEM OF VOICE FREQUENCY CARRIER TELEGRAPHY USED BY THE GERMAN ADMINISTRATION.

(Siemens and Halske System.)

The Siemens and Halske Company have developed two voice-frequency carrier telegraph systems for loaded cables : a system using 6 frequencies and a system using 12 frequencies, or channels.

For the transmission of the carrier currents over long distance cables, the normal small-gauge medium-heavy loaded conductors (4-wire circuits), equipped with 4-wire telephone repeaters, are used. The transmission band of this type of line is between 300 and 2,000 periods. This band width includes 6 carrier frequencies for the sextuple system and 12 for the 12 channel system. The supervision required by the 12 channel system is naturally greater than in the case of the 6 channel system. At present moreover there exists only a limited number of places which require to be connected by a high speed telegraph system using 12 channels. For this reason, this system has not yet been adopted for European telegraph traffic, but in order to take care of future heavy traffic requirements, the 12 channel system is arranged so that it is easy to change from 6 to 12 channels by making slight modifications to the equipment.

Each pair of a 4-wire circuit is generally used for transmission in one direction only. There is no fundamental difference between the 6 channel and 12 channel systems.

CIRCUIT SCHEMATIC.

I. **Transmitter.**

Figure 1 is a schematic of the 6 channel system. The carrier currents of 400, 638, 877, 1,110, 1,350, 1,590 periods are produced by vacuum tube oscillators. The filaments of three vacuum tubes are in series. Frequency adjustment is made by modifying the inductance of the coil in the oscillating circuit and is effected by varying the position of its iron core.

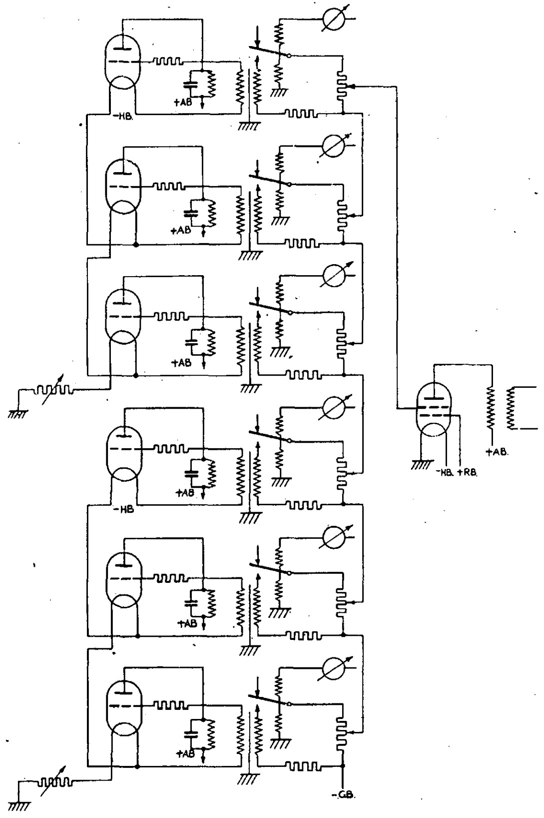
There is an earthed electrostatic screen between the winding in the oscillator circuit and the winding in the transmitter circuit in order to avoid capacity unbalance in the latter. This ensures that the current in the grid resistances of the transmitting amplifier is zero during current interruptions.

The circuits of the different transmitters comprise a fixed high resistance, and a control resistance to regulate the amplitude of the alternating current from the marking contact and armature of the transmitting relay. The transmitting relays, operated by the telegraph apparatus, connect the alternating voltage to the line in accordance with the signals transmitted by the telegraph operating equipment. The control resistances are potentiometers and they are joined in series across the grid circuit of the transmitting amplifier.

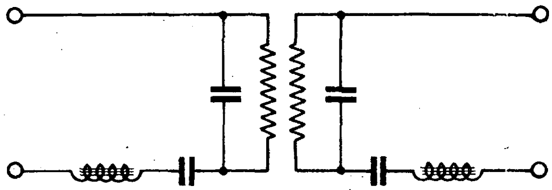
The transmitting tubes operate with zero grid current, as the grid voltages are negative, and consequently the A.C. voltage of one transmitter does not cause any voltage drop in the control resistances of adjacent transmitters; that is, the transmitters do not interfere with one another.

The series arrangement of the control resistances also ensures that the voltage amplitude of one frequency at the output of the amplifier does not change when the operating circuits of other frequencies are closed.

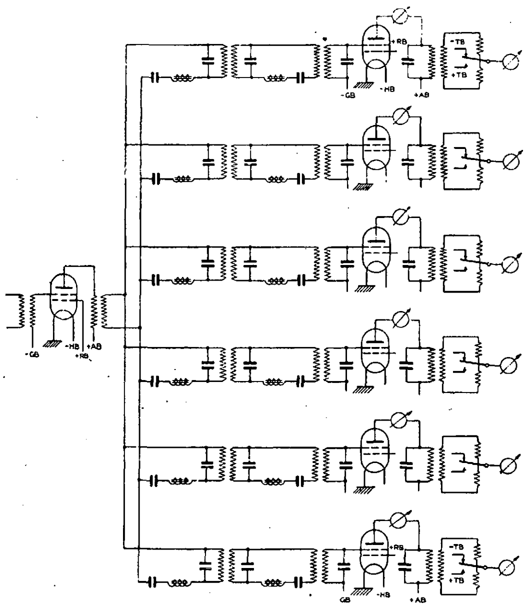
As the resistances of the operating circuits (Fig. 1) are high in comparison with the impedance of the operating windings, the vacuum tube oscillator provides practically no power during the transmission of signals, and the frequency of the transmitters remains constant. Transient phenomena in the transmitting tubes, due to load variations, is thus avoided and the speed of transmission is not restricted.



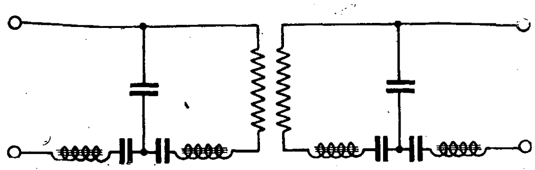
SEXTUPLE VOICE-FREQUENCY TRANSMITTER.
FIG. 1.



TRANSMITTER FILTERS.
FIG. 2.



SEXTUPLE VOICE-FREQUENCY RECEIVER.
FIG. 3.



RECEIVER FILTERS.
FIG. 4.

The voltages across the different resistances are superposed upon one another and cause proportional current variations in the plate circuit of the amplifying tube, which are transmitted to line by the output transformer.

To avoid crosstalk between adjacent circuits, the voltages of individual frequencies are chosen to provide 0·2 volts at the sending end of the line, and when all frequencies are transmitted simultaneously, the voltage is about 1 volt.

The transmitter of the 12 channel system is mounted in a similar manner. The 12 frequencies are located within the frequency band 300 and 1,700 periods and they are separated from each other by equal intervals. As in the case of the 6 channel transmitter, there is one common amplifier for all the currents transmitted. It may be stated that in the case of the 12 channel system the voltage dividers in the transmitting circuits are connected by filters to the oscillator side of the transmitting circuit (Figure 2). The purpose of the filters is to round-off the signals. The beginning and end of the signals is formed by the superposition of all frequencies and in order that no interference may be caused with the signals of adjacent channels, these filters are used. As the amplitude of interfering frequencies diminishes rapidly with distance from the carrier frequency, these filters are not required by the 6 channel system as its frequencies are more widely spaced.

II. Receiver.

The incoming superposed alternating currents are transmitted to the receiver (*see* Fig. 3, sextuple receiver) by an amplifier which compensates for the attenuation introduced by the line. Thus the currents of the different frequencies have the same value at the output of the amplifier as at the sending end of the line. The currents then pass to 6 filters, in parallel, the mid-points of their frequency bands corresponding to the carrier frequencies. The filters separate the different frequencies.

Behind each filter is a detector which transforms the alternating current signals into positive and negative direct current signals. Between each detector and filter is an input transformer with its secondary connected to the grid circuit of the detector tube. The grid bias is such that when the channel is idle the plate current is zero.

In the plate circuit is a transformer, suitable for the frequency of the current impulses, with its secondary connected to a polar relay adjusted for neutrality. A condenser is shunted across the primary of the transformer.

When a train of alternating currents reaches the grid of the detector tube, a pulsating direct current flows in the plate circuit; the alternating component of this current flows through the condenser and the direct current component through the transformer. When a direct current flows through the primary winding an impulse is produced by induction in the secondary, and the armature of the polar relay is moved to its marking contact. When the current in the primary ceases, an inductive impulse in the opposite direction traverses the secondary winding and moves the relay armature to its spacing contact.

The receiving telegraph apparatus (double current apparatus) is in series in the receiving relay circuit. The transformer, between the detector tube and the receiving relay, enables a polar relay to be used with its armature adjusted neutral.

The corresponding receiver for the 12 channel system is arranged in a similar manner. The total line current is amplified by a single amplifier. The filters used differ from those of the 6 channel system and are shown in Fig. 4. The two units of each filter are loosely coupled, a steeper attenuation curve thus being obtained at the ends of the filter transmission bands.

Mounting.

The apparatus of the 6 and 12 channel systems is arranged on racks, all the units of 6 frequencies being grouped on one rack. For 6 channel telegraphy, one transmitter rack and one receiver rack is required. For 12 channel telegraphy twice as many are required. It has been endeavoured to arrange all the apparatus units concerned with the same current, one upon the other and to mount them so that they are easily interchangeable

Transmitter Rack.

It has been arranged that all units connected with the same frequency are located on the same interchangeable mounting plate; thus if any troubles are experienced on one frequency it is easily possible to change all the apparatus involved. On these mounting plates are fixed the transmitting relays, the oscillator tubes with protection covers, the equipment for frequency and voltage adjustments, and a switch which enables a vacuum tube filament to be replaced by an equivalent resistance when any channel is thrown out of service. This is essential, for as already stated, three vacuum tubes are connected in series.

The transmitting relays can be operated either at the panel, by means of a control key, or from the telegraph office. The operating current of the transmitting relays traverses the meter located on the meter panel at the top of the rack. This enables the attendant to observe the operation of the telegraph transmitter.

On the vacuum tube panel is also a jack for connecting a telephone in circuit to make frequency measurements, or a vacuum tube voltmeter to measure amplitudes.

Below the 6 panels described are similar panels carrying keys which enable telephone communication to be obtained with the telegraph office, as well as with the distant station transmitting voice-frequencies.

For the adjustment of the equipment before service is commenced, the various stations in the circuit communicate with each other by telephone. For the telephone communication, the phantom derived from the two pairs allotted to the voice-frequency telegraph service is used. To call the distant station, or the intermediate stations, a current of musical frequency is transmitted over the quad.

The vacuum tube of the transmitting amplifier is mounted at the centre of the lowest row. Alongside is a spare tube which is automatically connected in circuit when the other tube fails. On the panel is a variable resistance for adjusting the filament current as well as a switch controlling the amplifier and plate supply. In the same position are mounted jacks for checking the voltages which the 6 transmitting tubes supply to the amplifier grid, and the currents transmitted over the line.

On the panels to the right and left of this centre panel are fuses for the various circuits, keys for the filament and plate supply of the oscillator tubes, a resistance in the filament circuit comprising 3 transmitting tubes connected in series, and a two-way key for meters associated with the 3 tubes in series. The key on the right enables the service voltages to be observed on a voltmeter mounted on the top panel. The key on the left enables a meter on the right of the voltmeter to be connected in the filament circuit of the oscillator and amplifier tubes. In principle this is a voltmeter, as it measures the voltage across the terminals of the fixed resistance in the filament circuits. It is calibrated in ampéres. On the top panel are also mounted signalling units for the visual indication of faults. Their ground glass windows carry the inscriptions: Filament Voltage, Plate Voltage, Auxiliary Grid Voltage, Telegraph Voltage, and Regulating Grid Voltage.

In the event of a supply failure the corresponding inscription is illuminated by a lamp behind the glass window. At the same time an acoustic signal (bell) is operated to attract the attention of the attendant. In the small frames mounted on the top panel are the necessary indication labels.

On the back of the rack panels are coils and condensers for smoothing the supply from the plate voltage generator.

Receiver Rack.

In the middle of the rack are 6 panels mounted side by side, each carrying the following units: A receiving relay for the particular frequency, a regulating resistance for the filament supply, a meter indicating the detector output resulting from a signal received from the sending station, two lamps protecting the marking and spacing contacts of the receiving relay, the detector tube under a protecting cover, a switch to interrupt the operating current of the receiving telegraph relay when it is required to adjust the latter, and a jack for connecting a telephone, or a vacuum tube voltmeter, for monitoring the A.C. currents at the output side of the filter.

Below these panels are 6 other panels carrying the filters for the 6 carrier frequencies.

In the middle of the bottom rows of panels is the receiving amplifier tube, together with a spare tube and associated automatic change-over device, a variable resistance for regulating the filament current of the receiving amplifier tube, 6 keys—3 for filament and 3 for plate supply—a jack for measuring the amplified alternating currents and a jack for measuring the currents before amplification.

The space to the right and left is occupied, as in the case of the transmitting rack, by fuses, keys, and switches for measuring apparatus.

The upper panel carries galvanometers for observing the positive and negative currents transmitted to the telegraph office, meters for reading the supply voltages and filament currents, and lamp indicator units.

The input and output transformers of the receiving amplifier and the transformer of the detectors, are located behind the rack as well as the coils and condensers used to smooth the direct current supply when obtained from machines.

Speed of Transmission.

The speed of transmission is limited by the band width of the receiving filters. The band width is a simple function of the duration of the transient period of the alternating current telegraph signal. Suppose that the duration of transient phenomena is equal to t seconds, then the narrowest transmission band permissible is given by the equation :—

$$\Delta f = (0 \cdot 8 \text{ to } 0 \cdot 88)\frac{1}{t}$$

To provide a margin of safety the equation used in practice is :—

$$\Delta f = 1.2 \frac{1}{t}$$

The filters in the system described have a transmission band of 80 periods; the transient period will be 0·015 second.

A satisfactory service is obtainable so long as the duration of transient phenomena is less than the duration of a dot. Therefore, it is possible to transmit 67 dots per second, say 4,000 dots per minute; that is, 800 five-unit signals. Actually this speed is not obtained with the Siemens high speed telegraph system, which normally only operates at 600 five-unit letters per minute.

Experience has shown that transient phenomena in long-distance cables has not affected the reliability of the service over lines exceeding even 1,000 km. The transient period of a signal is defined as the difference of the propagation time of the highest frequency and the lowest frequency used in the transmission of a signal. The band of frequencies transmitted is 80 periods, as stated above. The difference in propagation times is greatest in the case of the band corresponding to the highest carrier frequency. This band is located between 1,600 and about 1,680 periods. The propagation times of these frequencies, over a 0·9 mm. conductor 1,000 km. long, are 0·074 and 0·0763 second; the difference being 0·0023 second. For the normal speed of operation of the Siemens and Halske high speed telegraph system (600 five-unit letters per minute) a transient period of 0·02 seconds is satisfactory.

As the receiving filters introduce a transient period of 0·015 second, that introduced by the line must not exceed 0·005. The transient period will only reach this value over cables having a length of :—

$$\frac{0 \cdot 005 \;.\; 1{,}000}{0 \cdot 0023} = 2{,}200 \text{ km. approx.}$$

D.—BIBLIOGRAPHY.

ABBREVIATIONS.

(a) German Publications.

A. f. E.	Archiv für Elektrotechnik.
E. F. D.	Europäischer Fernsprechdienst.
E. N. T.	Elektrische Nachrichtentechnik.
E. T. Z.	Elektrotechnische Zeitschrift.
F. i. W.	Fernsprechen im Weitverkehr.
Fk.	Das Fernkabel.
M. TRA.	Mitteilungen aus dem Telegraphenreichsamt.
Ph. Z.	Physik. Zeitschrift.
T. u. F. T.	Telegraphen und Fernsprechtechnik.
W. V. S K.	Wissenschaftliche Veröffentlichungen aus dem Siemenskonzern.
Z. f. t. P.	Zeitschrift für technische Physik.

(b) English Publications.

Elec.	The Electrician.
El. Rev.	Electrical Review (London).
G. E. R.	General Electric Review.
I. P. O. E.	Institution of Post Office Engineers.
J. I. E. E.	Journal of the Institution of Electrical Engineers
P. O. E. E. J	The Post Office Electrical Engineers Journal.
Pr. Ph. S.	Proceedings of the Physical Society of London.

(c) French Publications.

A. P. T. T.	Annales des Postes, Télégraphes et Téléphones.
B. P. T. T.	Bulletin de l'Administration française des Postes, Télégraphes et Téléphones.
B. S. F E.	Bulletin de la Société française des Electriciens.
B. S. I. E.	Bulletin de la Société des Ingénieurs électriciens.
B. Techn. T. T. Suisses	Bulletin technique de l'Administration des Télégraphes et Téléphones suisses.
Ecl. Elec.	Eclairage électrique.
Gén. Civ.	Génie civil.
Ind. Elec.	Industrie électrique.
Ind. V. F. et T. A.	Industrie des Voies ferrées et des Transports automobiles.
Journ. Phys. et Rad.	Journal de Physique et le Radium.
Journ. Télégr.	Journal télégraphique (publié par le Bureau International de l'Union Télégraphique).
Lum. Elec.	Lumière électrique.
Onde Elec.	Onde électrique.
Q. S. T. et Rad. Elec.	Q. S. T. français et Radioélectricité réunis.
Rad. Elec.	Radioélectricité.
R. G. E.	Revue générale de l'Electricité.
R. T. T. et T.S.F.	Revue des Téléphones, Télégraphes et T.S.F.
Techn. Mod.	Technique moderne.

(a) German Publications.

Über das Fernsprech-Ubertragungsmass, von Dr. F. **Breisig**, *E.T.Z.*, 1924, pag. 73 et *F. i. W.*, 1923, pag. 25.

Verstärker für Fernkabel, von Dr. F. **Breisig**, *Fk.*, 1922, No. 1, p. 11.

Die Wahl eines internationalen Masses für die Güte von Fernleitungsverbindungen, von Dr. F. **Breisig**, *Fk.*, 1923, No. 3, p. 11.

Welche Bedeutung hat für die Fernsprechverwaltungen die Wahl eines neuen Übertragungsmasses? von Dr. F. **Breisig**, *E. F. D.*, 1926, No. 2, p. 21.

Der Stand der Frage des Fernsprech-Übertragungsmasses, von Dr. F. **Breisig**, *E. N. T.*, 1926, p. 55.

Ubertragungsmass und Vierpolparameter, von Dr. F. **Breisig**, *E. N. T.*, 1926, p. 161.

Neue Rechenbeheife für Berechnungen von Fernsprechübertragungen, von Dr. F. **Breisig**, *E. T. Z.*, 1925, p. 1726.

Neue Verfahren zur Nachbildung von Pupinleitungen, von A. **Byk**, *E. N. T.*, 1925, p. 104.

Das deutsche Fernsprechnetz als Teil des zukünftigen europäischen Netzes, von Dr. P. **Craemer**, *F. i. W.*, 1923, p. 3.

Das europäische Fernkabelnetz, von Dr. P. **Craemer**, *Fk.*, 1923, No. 4, p. 3.

Grundlagen und Entwicklungmöglichkeiten für das alleuropäische Fernsprechnetz, von Dr. **Craemer**, *Fk.*, 1925, No. 10, p. 5.

Neue Versuche mit pupinisierten Fernsprechseekabeln, von Dr. Ingr. P. **Craemer** und Oberpostrat Ew. **Müller**, *E. T. Z.*, 1925, p. 1577.

Die Verlegungsarten der europäischen Fernkabel, von Ing. Dipl. **Deibel**, *Fk.*, 1923, No. 4, p. 24.

Die Arbeiten der Deutschen Fernkabelgesellschaft, von **Deibel-Mentz**, *Fk.*, 1924, No. 7, p. 3.

Abgleichverfahren zur Beseitigung der Induktionsstörungen, von **Dohmen** und K. **Küpfmüller**, *F. i. W.*, 1923, p. 77; *E. T. Z.*, 1924, p. 266.

Die Bauart und technischen Eigenschaften der Fernkabel, von K. **Dohmen**, *F. i. W.*, 1923, p. 40; *E. T. Z.*, 1924, p. 89.

Fernkabel und Spulen im Deutschen Fernkabelnetz, von K. **Dohmen**, *Fk.*, 1924, No. 7, p. 28.

Grundsätzliches zur Frage des Nebensprechabgleichs, von K. **Dohmen** und R. **Deibel**, *Fk.*, 1925, No. 9, p. 39.

Die Entwicklung des Fernsprechkabelnetzes in Deutschland, von K. **Dohmen**, *Z. f. t. P.*, 1921, p. 291.

Über den Verwendungsbereich der Vierer nach Dieselhorst-Martin und der Sternvierer, von H. W. **Droste**, *Fk.*, 1926, No. 10, p. 16.

Über Induktionsstörungen in Mehrfachfernsprechkabeln und ihre Beseitigung, von Dr. Ingr. A. **Engelhardt**, *Fk.*, 1923, No. 4, p. 24.

Verfahren zur Verminderung der Induktionsstörungen in Mehrfachfernsprechkabeln, von Dr. Ingr. A. **Engelhardt**, *Fk.*, 1924, No. 5, p. 22.

Verkabelung von oberirdischen Fernsprechverbindungsleitungen, von R. **Feist**, *T. u. F. T.* 1923, p. 32.

Über den Eingangswiderstand von Vierpolen geringer Dämpfung, von R. **Feldtkeller**, *T. u. F. T.*, 1925, p. 189.

Die Berechnung der Rückkopplungsverzerrung bei Leitungen mit Zweidrahtzwischenverstärkern, von R. **Feldtkeller**, *T. u. F. T.*, 1925, p. 274.

Fernsprechbetriebsfragen, von **Feyerabend**, *T. u. F. T.*, 1925, p. 301.

Eine Vierdrahtverstärkerschaltung mit "natürlicher Leitungsnachbildung," von Dr. K. **Fischer**, *T. u. F. T.*, 1925, p. 99; *E. T. Z.*, 1924, p. 233.

Verstärkerröhren mit thorierter Wolframkathode, von A. **Gehrts**, *E. N. T.*, 1925, p. 189.

Versuche mit Vierdrahtkaskadenverstärkern auf Pupinkabeln mittlerer Belastung, von F. **Gehrts** und K. **Höpfner**, *E. N. T.*, 1926, p. 1

Das Verstärkerrohr, von G. **Gruschke** und B. **Pohlmann**, *E. T. Z.*, 1924, p. 334.

Entwicklung und gegenwärtiger Stand der Verstärkertechnik in Deutschland, von K. **Höpfner,** *E. T. Z.*, 1924, p. 109; *F. i. W.*, 1923, p. 50.
Verstärkerschaltungen und Verstärkerämter in deutschen Fernkabelnetzen, von K. **Höpfner,** *Fk.*, 1922, No. 2, p. 15.
Lange Fernsprechseekabel in Leitungen des Weitverkehrs, von K. **Höpfner,** *Fk.*, 1923, No. 4, p. 40.
Weitverkehr im Deutschen Fernkabelnetz, von K. **Höpfner,** *Fk.*, 1924, No. 5, p. 27.
Prüfungen und Messungen zur Unterhaltung der Fernkabelleitungen mit Verstärkern von den Endanstalten aus, von K. **Höpfner,** *E. F. D.*, 1926, No. 2, p. 24.
Deutsche Fernkabellinien nach dem Stande vom 1 Oct. 1924, von K. **Höpfner,** *E. N T.*, 1925, p. 137.
Weitverkehr über das Deutsche Fernkabelnetz, von K. **Höpfner,** *E. F. D.*, 1926, No. 1, p. 3.
Über Fernsprechverstärker, von K. **Höpfner,** Spezialausgabe der *T. u. F. T.*, 1919, No. 3.
Über Wechselstrommessungen. von K. **Höpfner,** Spezialausgabe der *T. u. F. T.*, 1919, No. 4.
Neuzeitliche Fernlinienverstärker, von K. **Höpfner** u. F. **Lüschen,** *Fk.*, 1925, No. 9, p. 33.
Sprachübertragung in langen Fernkabelleitungen, von K. **Höpfner** u. B. **Pohlmann,** *F. i. W.*, 1923, p. 61; *T. E. Z.*, 1924, p. 135.
Innere Einrichtung eines Verstärkeramts, von K. **Höpfner** u. K. **Stöckel,** *F. i. W.*, 1923, p. 86; *E. N. T.*, 1924, p. 156.
Masseinheiten für Mikrophone und Fernhörer, von K. **Hersen,** *F. i. W.*, 1923, p. 103; *E. T. Z.*, 1924, p. 398.
Die Entwicklung der Pupinspulen, von F. **Hörning,** *F. i. W.*, 1923, p. 66; *E. T. Z.*, 1924, p. 180.
Zur Einführung der Sternverseilung im Fernkabelbau, von Dr. H. **Jordan,** *Fk.*, 1924, No. 10, p. 23.
Neuere Geräte für Wechselstrommessungen an Fernsprechleitungen, von P. **Kaspareck,** *T. u. F. T.*, 1923, p. 61.
Die Erhöhung der Reichweite von Pupinleitungen durch Echosperrung und Phasenausgleich, von K. **Küpfmüller,** *E. N. T.*, 1926, p. 82.
Einschwingvorgänge, Echoeffekt und Temperatureinflüsse beim Fernsprechen über lange Pupinkabel, von K. **Küpfmüller,** *T. u. F. T.*, 1923, p. 53.
Über die Ortsbestimmung eines allgemeinen Isolationsfehlers in einem Fernsprechkabel, von K. **Küpfmüller,** *T. u. F. T.*, 1925, p. 234.
Über den Einfluss des Kabelmantelstromes auf die induzierten Spannungen, von F. **Lüschen,** *Fk.*, 1924, No. 6, p. 24.
Die Technik der Telegraphie und Telephonie im Weitverkehr, von F. **Lüschen,** *E. T. Z.*, 1924, p. 793.
Sternkabel—D. M. Kabel, von **Lüschen,** *Fk.*, 1926, No. 10, p. 29.
Die Messung des Übertragungsmasses von Vierpolen nach der Kompensationsmethode, von H. F. **Meyer,** *E. N. T.*, 1926, p. 141.
Uber die Frequenz der Fernsprechströme, von Dr. U. **Meyer,** *M. TRA.*, vol IX., 1922, p. 169; *T. u. F. T.*, 1921, p. 22.
Fernkabelmesszug, von A. **Mentz,** *Fk.*, 1926, No. 10, p. 11.
Seekabel im Fernsprechweitverkehr, von. Ew. **Müller,** *Fk.*, 1925, No. 9, p 23.
Schnurverstärker, von E. **Neumann,** *M. TRA.*, XI. 1926, p. 145; *T. u. F. T.*, 1924, p. 197.
Stand der Verstärkeramtstechnik, von B. **Pohlmann,** *E. N. T.*, 1926, p. 88.
Verstärkerämter, von B. **Pohlmann,** *T. u. F. T.*, 1923, pp. 21–29.
Grundlagen für die Beurteilung von Fernsprechverstärkern, von B. **Pohlmann u.** W. **Deutschmann,** *E. N. T.*, 1926, p. 8.
Über Maximalleistungen von Verstärkerröhren, von W. P. **Radt,** *E. N. T.*, 1926, p. 22.
Der Lorenz-Zweirohr-Zweidraht-Zwischenverstärker, von W. **Scheppmann,** *E. T. Z.*, 1924, p. 302; *F. i. W.*, 1923, p. 6.

Verfahren für Verstärkermessungen mit wissenschaftlicher Begründung, von H. **Schulz,** *M. TRA.*, 1926, p. 185; *T. u. F. T.*, 1925, p. 29.

Verfahren über Vierpolmasse, von H. **Schulz,** *T. u. F. T.*, 1923, p. 269.

Modulation and Frequenztrennung als Mittel der Mehrfachausnützung einer Leitung, von H. **Schulz,** *E. N. T.*, 1926, p. 95.

Über die neueste Entwicklung der deutschen Krarupkabel, von E. **Schürer,** *F. i. W.*, 1923, p. 46.

Die Pleijelspule. Ihr Aufbau und die ersten praktischen Anwendungen, von E. **Schürer,** *Fk.*, 1922, No. 1, p. 19; *E. T. Z.*, 1924, p. 213; *F. i. W.*, 1923, p. 73.

Über Dämpfung and Verzerrung von homogenen Fernsprechleitungen. Allgemein und beschränkt gültige Verzerrungsmasse, von H. **Schülz,** *T. u. F. T.*, 1924, p. 123.

Verzweigereinrichtungen in Fernsprechkabelanlagen, von **Schüller,** *T. u. F. T.*, 1922, p. 17.

Über die Frequenz der Fernsprechströme, von K. W. **Wagner,** *Ph. Z.*, 1910, p. 1122.

Die Messung der dielektrischen Ableitungen und Kapazitäten mehradriger Kabel mit Wechselstrom, von K. W. **Wagner,** *E. T. Z.*, 1912, p. 635.

Induktionswirkungen von Wanderwellen in Nachbarleitungen, von K. W. **Wagner,** *E. T. Z.*, 1914, pp. 639, 667, 705.

Das Fernsprechen auf weite Entfernungen, von K. W. **Wagner,** *F. i. W.*, 1923, p. 6; *E. T. Z.*, 1924, pp. 1–25.

Die Theorie des Kettenleiters nebst Anwendungen, von K. W. **Wagner,** *A. f. E.*, 1915, p. 315; *M. TRA.*, VIII. 1925, p. 211.

Spulen und Kondensatorleitungen, von K. W. **Wagner,** *A. f. E.*, VIII. 1919, p. 61; *M. TRA.*, VIII. 1925, p. 283.

Elektrische Kettenleiter und ihre technischer Anordnungen, von K. W. **Wagner,** *M. TRA.*, IX, 1923, p. 289; *Z. f. t. P.*, II. 1921, p. 297.

Der allgemeine Kettenleiter, von K. W. **Wagner,** *M. TRA.*, X. 1925, p. 141; *Telefunken Zeitung*, VI, No. 34/35 1924, p. 21.

Einschaltvorgänge bei Siebketten mit beliebiger Gliederzahl, von K. W. **Wagner,** *M. TRA.*, X., 1925, p. 1; *W. V. S. K.*, II, 1922, p. 189.

Der Einfluss von Ungleichmässigkeiten im Aufbau von Spulenleitungen auf den Wellenwiderstand, von K. W. **Wagner** u. K. **Küpfmüller,** *M. TRA.*, IX. 1923, p. 135; *A. f. E.*, IX. 1921, p. 461.

Der Einfluss des Leitungsabschlusses auf das Nebensprechen, von D. **Wehage,** *M. TRA.*, X. 1925, p. 109.

Praktische Vereinfachung der Ortsbestimmung von Ungleichheiten in den Spulenfeldern der Pupinkabel, von D. **Wehage,** *M. TRA.*, XI. 1926, p. 117; *T. u. F. T.*, No. 11, p. 185.

Messung der Differenzen der Erdkapazitäten in viererverseilten Fernkabeln, von D. **Wehage,** *Fk.*, 1924, No. 6, p. 29; *M. TRA.*, X. 1925, p. 189.

Ein neuer Streckendämpfungsmesser, von W. **Wolff,** *T. u. F. T.*, 1925, p. 337.

Die Messung des Übertragungsmasses von Vierpolen nach der Kompensationsmethode, von H. F. **Meyer**; *Electrische Nachrichtentechnik*, 1926, Part 4.

Über die Nachbildung des Scheinwiderstandes von Pupinleitungen unter Berücksichtigung der Amtschaltungen, von R. **Feldtkeller** and F. **Strecker.**

Über Nichtlineare Verzerrung in Fernverbindungen, von K. **Küpfmüller**; *Fachberichte der XXI. Jahresversammlung des V. D. E.*, Wiesbaden, 1926.

Über die Messung der Geschwindigkeitsamplitude und der Druckamplitude in Schallfeldern, von E. **Meyer**; *E. N. T.*, Vol. 4, Part 2, 1927.

Messungen an Mikrophonen und Telephonen, von C. A. **Hartmann**; *Fachberichte der XXI. Jahresversammlung des V. D. E.*, Wiesbaden, 1926.

Beiträge zur Untersuchung der Nachhalles, von E. **Meyer**; *E. N. T.*, Vol. 4, Part 3, 1927.

(b) English Publications.

Telephone Transmission, by J. E. **Statters**; Paper No. 101 of *I. P. O. E.*
Recent Research Work on Telephone Repeaters, by C. R. **Robinson** and R. M. **Chamney**; Paper No. 99 of *I. P. O. E.*
Applied Telephone Transmission, by J. S. **Elston**; Paper No. 88 of *I. P. O. E.*
Some Experiments on Carrier Current Telephony, by C. A. **Taylor** and R. **Bradfield**; Paper No. 86 of *I. P. O. E.*
Four-wire Telephonic Repeater Systems, by C. **Robinson** and R. M. **Chamney**; Paper No. 83 of *I. P. O. E.*
Telephone Repeaters, by A. B. **Hart**; Paper No. 75 of *I. P. O. E.*
Telephonometry, by B. S. **Cohen**; Paper No. 70 of *I. P. O. E.*
The Determination of Resonant Frequencies and Decay Factors, by Prof. E. **Mallett**; *J. I. E. E.*, 1924, p. 517.
Transmission Maintenance of Telephone Systems, by P. E. **Erikson** and R. A. **Mack**; *J. I. E. E.*, 1924, p. 653.
Faithful Reproduction in Radio-Telephony, by L. C. **Pocock**; *J. I. E. E.*, 1924, p. 791.
Power Circuit Interference with Telegraphs and Telephones, by S. C. **Bartholomew**; *J. I. E. E.*, 1924, p. 817.
Inductive Interference with Communications Circuits, by Dr. A. **Russell**; *J. I. E. E.*, 1924, p. 941.
The Nature and Reproduction of Speech Sounds (Vowels), by Sir Richard **Paget**; *J. I. E. E.*, 1924, p. 963.
Power Circuit Interference with Telegraphs and Telephones; *J. I. E. E.*, 1925, p. 389.
Some Acoustic Experiments with Telephone Receivers, by Prof. E. **Mallett** and G. F. **Dutton**; *J. I. E. E.*, 1925, p. 502.
Some Artificial Lines and Networks associated with the Uniform Telephone Transmission Line, by the General Electric Co., Ltd.; *J. I. E. E.*, 1925, p. 593.
The Performance of Amplifiers, by H. A. **Thomas**; *J. I. E. E.*, 1926, p. 12.
The Rugby Radio Station of the British Post Office, by E. H. **Shaughnessy**; *J. I. E. E.*, 1926, p. 113.
Low-Frequency Inter-Valve Transformers, by P. W. **Williams**; *J. I. E. E.*, 1926, p. 158.
The Life-Testing of Small Thermionic Valves, by M. **Thompson**, R. H. **Dudderidge** and L. G. A. **Sims**; *J. I. E. E.*, 1926, p. 187.
The Frequency Characteristics of Telephone Systems and Audio-Frequency Apparatus, their Measurement, by B. S. **Cohen**, A. J. **Aldridge** and W. **West**; *J. I. E. E.*, 1926, p. 206.
A Method for the Measurement of the Transmission Efficiency of Telephone Apparatus at a Subscriber's Office, by A. J. **Aldridge** and A. **Hudson**; *P. O. E. E. J.*, 1924, Vol. 17.
The Design of Filters for Audio-Frequencies, by C. A. **Beer** and G. J. S. **Little**; *P. O. E. E. J.*, 1925, Vol. 17.
A Modern Telephone Repeater Station, by A. B. **Hart**; *P. O. E. E. J.*, 1925, Vol. 18.
Aldeburgh Telephone Repeater Station, by R. J. **Nunn**; *P. O. E. E. J.*, 1926, Vol. 18.
The London–Glasgow Trunk Telephone Cable and its Repeater Stations, by A. B. **Hart**; *P. O. E. E. J.*, Vol. 19 (1926).
London–Berlin Telephone Circuit; *P. O. E. E. J.*, Vol. 19 (1926).
A High Quality Telephone Transmission System, by B. S. **Cohen**; *P. O. E. E. J.*, Vol. 19 (1926).
The Anglo-Dutch No. 3 Continuously Loaded Cable, by A. B. **Morice**; *P. O. E. E. J.*, Vol. 19 (1926).
Comparison of Frequencies by Cathode-Ray Tube, by D. W. **Dye**; *Pr. Ph. D.*, No. 37, pp. 158–166. Disc. 166–168 (April, 1925).
Resonant Vibrations of Telephone Receiver Diaphragms, by J. T. **MacGregor-Morris** and E. **Mallett**; *J. I. E. E.*, Vol. 61, pp. 1134–1138 (October, 1923).
Transmission Maintenance of Telephone Systems, by P. E. **Erikson** and R. A. **Mack**; *J. I. E. E.*, Vol. 62, pp. 653–679. Disc. 679–687 (Aug., 1924).

New Anglo-Dutch Telephone Cable; *Elec.*, No. 93, pp. 256–257 (Sept. 5, 1924), and *El. Rev.*, No. 95, pp. 384–385 (Sept. 12, 1924).

The Transmission Unit, by R. V. L. **Hartley**; *Elec.*, No. 94, pp. 58–59 (Jan. 16, 1925) and pp. 93–94 (Jan. 23, 1925).

The Economical Provision of Plant for Telephone Development, by G. H. A. **Wildgoose** and A. J. **Pratt**; *I. P. O. E.*, Paper No. 97 (1925), p. 41.

Carrier-Current Communication, by B. R. **Cummings**; *G. E. R.*, No. 29, pp. 365–367 (May, 1926).

The Long-Distance Telephone System of the United Kingdom, by Sir William **Noble**; *J. I. E. E.*, Vol. 59, p. 389 (1921).

Telephone Line Work in the United States, by E. S. **Byng**; *J. I. E. E.*, Vol. 60, p. 85 (1922).

Phantom Telephone Circuits, by J. G. **Hill**; *J. I. E. E.*, Vol. 60, p. 675 (1922).

Inaugural Address, by F. **Gill**; *J. I. E. E.*, Vol. 61, p. 788 (1923).

The Fourteenth Kelvin Lecture, Problems in Telephony, by Dr. J. A. **Fleming**; *J. I. E. E.*, Vol. 61, p. 613 (1923).

Transoceanic Wireless Telephony, by Dr. H. W. **Nichols**; *J. I. E. E.*, Vol. 61, p. 812 and p. 820 (1923).

Oscillator giving a Sinusoidal and Constant Output over the complete Audio-frequency Range, by B. S. **Cohen**; *P. O. E. E. J.*, Vol. 19, Part 4, January, 1927.

(*c*) **French Publications.**

Sur la propagation du courant en période variable, sur une ligne munie d'un récepteur, par **Poincaré**; *Ecl. Elect.*, année 1904, vol. XL, pages 121, 161, 201, 241.

Introduction à la théorie des courants téléphoniques et de la Radiotélégraphie, par J.-B. **Pomey** (Gauthier-Villars et Cie., Paris, 1920).

Lignes téléphoniques hétérogènes, par **Devaux-Charbonnel**; *Lum. Elec.*, année 1914 (janvier).

Applications diverses des formules générales de la transmission des courants électriques sinusoïdaux, par L. **Cahen**; *Lum. Elec.*, mai 1914, p. 16.

Propagation du courant sur une ligne téléphonique homogène.—Régime variable avec appareil aux extrémités, par J.-B. **Pomey**; *R. G. E.*, 2 août 1919, p. 131.

Sur l'équation des télégraphistes appliquée à l'étude de la propagation des courants, par **Béthenod**; *Rad. Elec.*, octobre 1922, p. 424.

Remarques relatives aux lois des courants alternatifs, par **Collet**; *A.PTT.*, juillet 1926, p. 631.

Contributions théoriques et pratiques à la technique des communications à longue distance. Exposé critique des principales méthodes d'étude de l'équation des télégraphistes et de ses conséquences, par P. **Lévy**, de la Société d'Etudes pour liaisons téléphoniques et télégraphiques à longue distance, Paris.

Propagation des courants sinusoïdaux sur les lignes quelconques, par **Ravut**; *R. G. E.*, tome VIII, No. 19, 8 mai 1920.

A propos du Standard de transmission, par **Carvallo**; *Livre S.E.L.T.*, p. 65.

Le quadripôle, par J.-B. **Pomey**; *Journ. Télégr.*, janvier 1925, p. 3.

Sur la transmission d'énergie par les systèmes dits quadripôles passifs, par **Ravut**; *R. G. E.*, p. 17, 24 avril 1926.

Le quadripôle, par **Collet**; *A. PTT.*, novembre 1926, p. 439.

Sur quelques propriétés générales des réseaux parcourus par des courants alternatifs en régime permanent, par **Ravut**; *R. G. E.*, 8 mai, 20 et 27 octobre 1923, 8 mars 1924.

Théorie des filtres éléctriques, par **Lange**; *A. PTT.*, octobre 1923, p. 1256.

Etude sur les lignes en T et TT dyssymétriques; applications aux filtres de bandes, par **Lecorbeiller et Lange**; *Onde Elec.*, octobre 1923.

Essai sur la théorie des filtres électriques, par **David**; *Onde Elec.*, janvier, février 1926.

Lignes artificielles, par J.-B. **Pomey**; *R.G.E.*, 26 janvier 1918, p. 123.

Sur les lignes artificielles, par **Béthenod**; *Radio Electricité*, année 1920, t. I, p. 128.

La contribution des ingénieurs français à la téléphonie à grande distance par câbles souterrains. Vaschy et Barbarat, par **Devaux-Charbonnel**; *R.G.E.*, 25 août 1917, p. 288.

Les câbles téléphoniques pour communications à longue distance, par **Marchay**; *Gén. Civ.*, 3 et 10 juillet 1926.

Etude des ensembles téléphoniques. Mesures et calculs de l'affaiblissement et des caractéristiques, par **Puget**; *Lum. Elec.*, 8 et 15 mai 1915.

Les pertes d'énergie dues à la suppression des liaisons, par J.-B. **Pomey**; *A.PTT.*, décembre 1916.

Longueur d'onde d'affaiblissement des circuits téléphoniques, par J.-B. **Pomey**; *R.G.E.*, 20 juillet 1918, p. 72.

Effet de la variation de la distance entre bobines de charge d'un circuit, sur l'impédance caractéristique, par **Collard**; *B. Techn. T.T. suisses*, année 1925, No. 2.

Impédance caractéristique et affaiblissement kilométrique des câbles sous papier et plomb, par **Collet et Chavasse**; *A.PTT.*, février 1926.

Les lignes Krarup et la téléphonie à grande distance, par **Devaux-Charbonnel**; *B.S.I.E.*, février 1916.

Progrès et état actuel de la technique des lignes pupinisées, par L. **Cahen**; *B.S.F.E.*, août 1924.

Sur la définition et la mesure du crosstalk, par J. **Carvallo**; *A.PTT.*, septembre 1925, p. 887.

Contribution à la théorie des câbles téléphoniques à paires combinables. Etude de la diaphonie, par **Dunand**; *R.G.E.*, 30 octobre 1926, p. 621 et 6 novembre 1926, p. 661.

La mesure de la diaphonie sur les circuits théoriques, par **Maria Prudhon**; *R.G.E.*, 5 février 1927, p. 205.

Quelques considérations d'ordre pratique sur l'emploi du pont de Wheatstone en courant alternatif, par J. **Carvallo**; *R.G.E.*, 28 février, 1925, p. 337.

Perfectionnement aux méthodes potentiométriques utilisées en courant alternatif, par A. **Pages**; *R.G.E.*, 6 mars 1926, p. 381.

Contribution à la théorie du transformateur téléphonique, par J. **Carvallo et Renault**; *A.PTT.*, septembre 1926, p. 788.

Phénomènes de résonance dans les transformateurs téléphoniques, par J. **Granier**; *R.G.E.*, 27 novembre, 1926, p. 789.

Filtres acoustiques, par **Canac**; *Journ. Phys. et Rad.*, juin 1926, p. 161.

Les filtres électriques, par **Michaud**; *Rad. Elect.*, 25 mai 1926, p. 192.

Etude de l'affaiblissement dû à un circuit intercalé dans une ligne téléphonique; *R.G.E.*, 21 novembre 1925, p. 849.

Etude de l'affaiblissement dû à un circuit intercalé dans une ligne téléphonique, par Dr. M. **Merker**; *R.G.E.*, 7 novembre 1925, p. 803.

La technique de la Téléphonie à grande distance par câbles; *R.T.T.* et *TSF.*, juin 1925, p. 430.

Note sur la théorie des lignes artificielles; *A. PTT.*, avril 1925, p. 385.

Induction et capacité des lignes; *R.G.E.*, 23 août 1924, p. 233.

Le Téléphone électrostatique, par K. **Dobrski**; *R.G.E.*, 5 avril 1924, p. 571.

Théorème de Pleijel, par J.-B. **Pomey**; *R.G.E.*, 26 avril 1919, p. 622.

Le câble Paris–Strasbourg, par M. **Viard**.—Le câble Paris–Le Havre, par M. **Cahen**; *R.G.E.*, 15 janvier, 1927, p. 81.

Etude sur l'établissement des canalisations téléphoniques multiples dans Paris, par J. **Mailley**; *A. PTT.*, août 1926, p. 703.

La fabrication et la pose des câbles Paris–Strasbourg et Paris–Boulogne; *R.T.T.* et *TSF.*, novembre 1925, p. 841.

La Téléphonie à grande distance en Europe; *Ind. Elect.*, 10 août 1924, p. 308.

Une formule pratique pour la détermination du diamètre des fils d'un câble souterrain destiné à être pupinisé; *A. PTT.*, juin 1924, p. 649.

Tension de grille négative, par J. **Marcot**; *R. T. T.* et *TSF.*, décembre 1926, p. 970.

La théorie de la lampe à 3 électrodes, par Y. **Doucet**; *Q. S. T.* et *Rad. Elec.*, octobre 1926, p. 36.

Circulaire relative à la surveillance et à l'entretien des relais amplificateurs téléphoniques; *B. PTT.*, No. 9, mars 1926, p. 257.

Etude analytique de l'émission et de la modulation par lampes triodes, par R. **Maillet**; *Onde Elec.*, décembre 1925, p. 506.

Construction d'amplificateurs de puissance sans distorsion, par E. W. **Kellogg**; *Onde Elec.*, nov. 1925, p. 474 et déc. 1925, p. 540.

Sur un dispositif de modulomètre utilisable pour le contrôle des émissions radio-télégraphiques, par A. **Blondel**; *Comp. rend. Acad. Sciences*, 14 septembre 1925, p. 345.

Les phénomènes de résistance négative dans les lampes à deux grilles; production et utilisation du phénomène, par P. **Amye**; *Ond. Elec.*, juillet 1925, p. 297.

L'influence de la température sur les tubes thermoioniques, par **Courtines**; *Ond. Elect.*, nov. 1924, p. 521.

Réduction de la variation de l'intensité dans les lampes par l'emploi de résistances en fer; *R. G. E.*, 24 mars 1923, p. 477.

Contribution à la théorie des audions générateurs; condition d'amorçage et degré d'amortissement des oscillations de faible amplitude obtenues par ces appareils; *R. G. E.*, 20 décembre 1919, p. 875 et 27 décembre 1919, p. 923.

Amplificateurs divers; *R. G. E.*, 22 novembre 1919, p. 709.

De la théorie du circuit magnétique déformable, par A. **Guilbert**; *R. G. E.*, 23 octobre 1926, p. 581.

Choix d'un type de bobine toroïdale pour combinaison de circuits; *A. PTT.*, août 1924, p. 929.

Le pont de Wheatstone et ses applications, par J. **Granier**; *Q.S.T. et Rad. Elec.*, 1er novembre 1926, p. 6.

Méthode proposée pour la localisation de défauts sur les lignes, par **Chavasse** et **Mocquart**; *A. PTT.*, novembre 1926, p. 987.

Stroboscope à corde vibrante A. Guillet et lampe à néon, par **Bertrand**; *B.S.F.E.*, avril 1926, p. 277.

Localisation des défauts de câbles par des mesures d'inductance à fréquence musicale, par **Wente**; *Ind. V. F. et T. A.*, avril 1926, p. 197.

Utilisation d'un ohmmètre industriel pour les mesures de localisation par la bouche, par E. **Crouzet**; *A. PTT.*, avril 1926, p. 347.

Sur l'emploi des mesures de capacité pour rechercher et localiser les ruptures de circuits, par V. **Pons**; *A. PTT.*, mars 1926, p. 267.

Nouveau fréquencemètre à échelle très étendue, par A. **Campbell**; *A. PTT.*, février 1926, p. 166.

Sur un nouvel appareil stroboscopique à grand éclairage.—Note de MM. **Laurent** et Augustin **Séguin**, présentée par M. Georges Claude à l'Académie des Sciences, 26 octobre 1925.

Nouveaux appareils pour la mesure directe des résistances, fréquences, différences de phases, températures, etc., par S. **Held**; *R. G.E.*, 10 octobre 1925, p. 611.

Un nouvel oscillographe électromagnétique et son application aux mesures en courant alternatif, par R. **Dubois**; *A. PTT.*, août 1925, p. 709.

Sur l'application des thermo-couples à la mesure des courants alternatifs de fréquence musicale, par P. **Chavasse**; *A. PTT.*, juillet 1925, p. 662.

Henrymètres, capacimètres, tellurohmmètres, par R. **Barthélmey**; *Onde Elec.*, juin 1925, p. 419.

Circuit de référence pour les mesures de transmission téléphonique, par L. J. **Sivian**; *A. PTT.*, juin 1925, p. 560.

Un nouvel oscillographe électromagnétique à grande sensibilité, par R. **Dubois**; *R. G. E.*, 20 juin 1925, p. 977.

Instruments de mesures de courants alternatifs employés en téléphonie, par P. **Kaspareck**; *A. PTT.*, mai 1925, p. 461.

Appareils de mesures des courants alternatifs de faible intensité, par **Béthenod**; *B. S. F. E.*, mai 1925, p. 470.

Mesure, aux fréquences téléphoniques, de la fréquence propre d'une bobine d'inductance (variomètre), par **Unkiyama** et **Kobayashi**; *A. PTT.*, mai 1925, p. 505.

Etalonnage d'un système thermo-élément-galvanomètre, par **Abadie**; *Onde Elec.*, avril 1925, p. 133.

Procédé pour localiser les pertes à la terre dans une câble souterrain; *R. T. T.* et *TSF.*, décembre 1924, p. 944.

Comment localiser l'humidité dans les câbles; *R. T. T.* et *TSF.*, août 1924, p. 620.

Les mesures des grandeurs électriques sans courant alternatif de fréquence musicale, par L. **Cahen** et J. **Carvallo**; *Journ. Phys.*, avril 1924, p. 113.

Méthodes d'essais des appareils téléphoniques. Postes d'abonnés, microphones, récepteurs; *B. S. F. E.*, décembre 1923, p. 671.

Appareils sensibles à lampes amplificatrices pour les mesures en courant alternatif; *R. G. E.*, 23 août 1919, p. 227.

Etude de la voix humaine et des sons musicaux au point de vue radiophonique, par **Reynaud-Bonin**; *Radio Revue*, août 1924, p. 125.

Théorie des relais téléphoniques et télégraphiques, par R. **Parésy**; *R. G. E.*, 1er janvier 1927, p. 3 et 8 janvier 1927, p. 43.

Remarques sur la rapidité de la transmission télégraphique sur les lignes exploités au moyen d'appareils à mouvements synchrones, par L. J. **Collet**, *A. PTT.*, janvier 1927, p. 1.

Le développement des réseaux télégraphiques privés. Les appareils modernes. Les "start-stop," par J. **Jacob**; *Techn. Mod.*, 15 juillet 1926, p. 417.

Les surtensions de rupture dans les réseaux téléphoniques, par **Chavasse**; *A. PTT.*, juin 1926, p. 522.

La transmission téléphonique dans une grande cité moderne et dans sa banlieue, envisagée au point de vue économique, par L. **Aguillon** et G. **Valensi**; *A. PTT.*, octobre 1925, p. 905 et novembre 1925, p. 1025.

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COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE.

Plenary Session,

Paris, November 26—December 6, 1926.

THIRD PART.

Questions of Traffic and Operating.

COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE.

Plenary Session, Paris, November 26—December 6, 1926.

THIRD PART.

Questions of Traffic and Operating.

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GENERAL SUBJECT INDEX.

THIRD PART.

Traffic and Operating.

1.—GENERAL.

Extracts from the Regulations for International Service.

(Revision of Paris, 1925.)

Chapter XXIV.—Article 71.

Section T.

General Arrangements.

The provisions of the Regulations which are not contrary to the stipulations of this chapter and which relate to the same objects as the latter are applicable to the telephonic service.

Section A.

International System.

. . . .

§ 3.—(1) The Administrations concerned determine by common accord the services to be opened and the routes to be employed for each of these services.

(2) Each Administration publishes the names of the districts and of the public call offices of the countries with which telephonic communication can be established.

§ 4. Except in the case of a contrary decision taken by common accord by the Administrations concerned, the international means of communication are reserved exclusively for the international telephone services for which they have been established.

§ 5.—(1) When the internal means of communication have to serve for international calls, the latter have priority over internal calls of the same category (*see* Section O).

(2) For calls using means of communication connecting districts near the frontier, the limitrophic Administrations may abrogate this priority.

§ 6.—(1) The Administrations concerned inform one another of the composition of the means of communication on their respective territories and of all important changes of such composition.

Section B.

Duration of Service.

§ 1. Each Administration fixes the days and hours of the working of its offices.

§ 2. Offices which are not permanently open are bound to prolong the service beyond the regulation hours by six minutes in favour of calls actually proceeding and of calls already prepared.

§ 3. Offices in direct connection assure themselves, as often as is necessary, and at least once a day, of the agreement of time. There should not exist a difference of more than a minute between the time of the office clocks and the legal time of the countries.

Section C.

List of Subscribers and Call Offices.

§ 1.—(1) Each Administration publishes official district lists of subscribers and call offices.

(2) The days and hours of opening and closing of exchanges and public call offices are indicated in these lists.

§ 2. Important exchanges and the principal public call offices receive official lists of subscribers of the foreign systems with which they are in communication.

§ 3. For this purpose each Administration supplies gratuitously to the Administrations of the countries with which telephonic communication is open a sufficient number of copies of its official lists.

§ 4. The Administrations take the measures necessary in order that the public may be able to purchase foreign official lists.

RECOMMENDATIONS OF THE INTERNATIONAL CONSULTATIVE COMMITTEE.

Duration of Service.

The International Consultative Committee

Unanimously advises :—

That the arrangements of Section B, § 2, of the Regulations for International Service (Revision of Paris, 1925) be extended, not only to calls already prepared, but also to calls of which the distant exchange has already been advised, since these calls generally take place during the hours of light traffic.

Decentralisation of International Traffic.

The International Consultative Committee

Considering :—

That the international network should not be a network connecting capitals exclusively, since such a network incurs delay in transmission of calls, a prolongation of the routes followed and a congestion of the internal network.

Unanimously advises :—

That for decentralisation of the network, large international transit centres be set up, similar to zone or regional centres in internal service, these centres being connected either directly or indirectly by circuits having the same characteristics as the international circuits.

Wherever possible, existing centres shall be chosen as the large international transit centres.

In order to facilitate the application of § 6, Section A, of the Regulations for International Service (Revision of Paris, 1925), the International Consultative Committee will undertake the publication of the lists of international circuits.

Obsolete Lists of Subscribers.

The International Consultative Committee

Considering :—

That it is absolutely desirable to avoid delays and errors in international service resulting from the use of obsolete lists of subscribers.

Unanimously advises :—

That the Administrations be requested to destroy the lists of the subscribers for their exchanges which have become obsolete and replace them by new ones.

Maximum Waiting Time for Ordinary International Calls.

The International Consultative Committee

Considering :—

That, although it is desirable to put into service a sufficient number of circuits to allow for " no delay " calls on international service, it is not always possible to do this for economic reasons; but that, in all cases, it is preferable to reduce the waiting time for each international telephone connection to a minimum, compatible with the cost of establishing each of the circuits used in this connection.

Unanimously advises :—

That endeavours should be made to fulfil the following conditions ;—

1st. For international circuits of less than 500 km. the number of circuits should be such that during the busy hour the waiting time shall not habitually exceed one half-hour in normal times.

2nd. For international circuits of between 500 and 1,000 km. this delay shall not habitually exceed one hour.

3rd. For international circuits of over 1,000 km. this delay shall not habitually exceed one and a half hours.

2.—VARIOUS CLASSES OF CALLS AND FACILITIES TO BE OFFERED TO THE PUBLIC.

EXTRACTS FROM THE REGULATIONS FOR INTERNATIONAL SERVICE.
(Revision of Paris, 1925.)

Chapter XXIV.—Article 71.

Section D.

ORDINARY PRIVATE CALLS.

By ordinary private calls are meant paid calls which enjoy no priority.

Section E.

Urgent Private Calls.

§ 1. Urgent private calls having priority over ordinary private calls may be admitted by special arrangement concluded between the Administrations concerned.

§ 2. Urgent calls are announced by the caller and afterwards from exchange to exchange by the word " Urgent."

§ 3. The charge for an urgent call is fixed at three times the charge applying to an ordinary private call made during the same period of charge.

Section F.

" Lightning Calls."

§ 1. " Lightning " calls having priority over all other private calls may be admitted by special arrangement concluded between the Administrations concerned.

§ 2. " Lightning " calls are announced by the caller, and afterwards from exchange to exchange, by the word " Eclair."

§ 3. The charge for a " lightning " call is fixed at 10 times at least the charge applying to an ordinary private call made during the same charge period.

Section G.

Government Calls.

§ 1.—(1) Government calls are those which are demanded as such by :—

(*a*) Chiefs of State, Ministers, Commanders-in-Chief of the Forces of Land, Sea and Air, Diplomatic Agents (Ambassadors, Ministers Plenipotentiary, Chargés d'affaires) and full-time Consular Agents;

(*b*) Consular Agents other than those mentioned above, but only with the authorities specified in section (a).

(2) These calls include urgent Government calls and ordinary Government calls.

(3) In services where urgent private calls are not admitted there may exist urgent Government calls.

(4) The calls demanded as State calls by the General Secretary of the League of Nations are assimilated to those mentioned in section (a).

§ 2.—(1) Government calls are announced by the caller and afterwards from station to station by the words "Etat urgent" or "Etat," as the case may be.

(2) Urgent Government calls enjoy priority over all other calls.

(3) Ordinary Government calls enjoy priority only over ordinary private calls and non-urgent service calls.

(4) In direct services where private urgent calls are not admitted Government calls enjoy priority over all other calls.

(5) The duration of Government calls is not limited. Nevertheless, transit Administrations have the right to limit to six minutes the duration of State calls when these calls are established by the intermediary of one of their offices.

§ 3. The demander of a Government call is obliged, if he is asked, to declare his name and rank and, in the case provided for in § 1, section *b*, the name and status of the called party.

§ 4. Urgent Government calls and ordinary State calls are subject to the charges applicable respectively to urgent private calls and ordinary private calls exchanged during the same charge period.

Section H.

Calls by Subscriptions.

§ 1.—(1) By special arrangements concluded between the Administrations concerned, calls by subscription, at fixed hours, may be authorised if no inconvenience results therefrom to the service in general.

(2) These calls should exclusively concern the personal business of the correspondents or that of their establishments.

(3) Sufficient intervals are reserved between the subscription calls to allow the exchange of other calls.

(4) Subscription calls are subject to the following charges:—

(*a*) During the periods of light traffic, half the unit charge, as a minimum;

(*b*) During other periods, three times the unit charge, as a maximum.

§ 2.—(1) Subscription calls are those which take place daily between the same stations and at the same hour agreed in advance, and are booked for a whole month at least.

(2) The subscription is prolonged from month to month unless it has been cancelled in writing by either party at least eight days before the expiration of the current period of the subscription.

§ 3. As a general rule, the maximum duration of a subscription call is six minutes. Nevertheless, calls of a longer duration may be consented to after agreement between the Administrations concerned.

§ 4. The subscription may be contracted for from any date, but the monthly period only commences from the 1st of each month. The amount of the subscription relating to the first monthly period is increased, if need be, by the part of the amount of that subscription corresponding to the period comprised between the date of its coming into force and that of the commencement of the monthly period.

§ 5. The amount of subscription is calculated on a mean duration of 30 days. It is payable in advance.

§ 6.—(1) The subscription call is officially established between the two stations at the hour fixed, unless another conversation is in progress or a demand for an urgent Government call is on hand.

(2) It is officially disconnected at the expiration of the time allowed for each call-period (*séance*) if the correspondents have not already given the signal that the conversation is finished. Nevertheless, the correspondents may continue their conversation if there is no

other demand on hand the additional call is subject to the general rules of ordinary private calls.

§ 7.—(1) No compensation is given and no refund is made if by the act of the correspondents the call has not taken place or had its prescribed duration. The charge relating to such a call is carried into the international accounts.

(2) A subscription call which by the act of the telephone service has not been able to be effected or has not lasted for the prescribed duration is, if possible, before the end of the period subject to a like rate of charge, replaced or compensated for by a call of a duration equivalent to the unused period. If the call cannot be replaced or if the compensation of time has not been given, the corresponding charge is not carried into the international accounts. The Administration of origin makes a refund on the demand of the subscriber.

(3) The refund is fixed in the first case at one-thirtieth of the monthly amount of the subscription; in the second case at the part of the thirtieth of the amount of the subscription corresponding to the time lost.

§ 8.—(1) Applications for subscription calls should, as a general rule, be made in writing to the outgoing office. The applications are satisfied according to the order in which they are made.

(2) The hours and durations of conversations, after having been fixed by agreement between the offices interested, are confirmed in writing.

(3) The subscription calls form the subject of agreements which are concluded between the office responsible for collecting the charge and the applicant.

Section I.

Service Calls.

§ 1.—(1) Calls referring exclusively to the international telephonic or telegraphic services may be exchanged, free of charge, between the officials of the Administrations authorised to that end.

(2) In claiming the exercise of this facility, these officials are bound to declare their name and rank.

(3) Service calls are limited to calls where the employment of the telephone route is justified. They take place during the hours of light traffic. However, in important and urgent cases they are exchanged as soon as it is necessary; they are then considered as "urgent service calls."

§ 2. Service calls are announced by the demander and afterwards from office to office, as the case may be, by the words "service urgent" or by the word "service."

§ 3. In the case of necessity, the telegraphic route is employed for communications relative to the execution of the telephonic service.

Section M.

Demands for Calls.

§ 1. In demanding a call, the called subscriber's station is designated by the name of the town (*réseau*) of destination and, if possible, by his distinguishing number or letter, preceded, where appropriate, by the name of his central exchange. Public call offices asked for should be designated by the name of their exchange and their number, or by their denomination.

§ 2. The validity of demands for calls booked for any day and not set up expires at the moment of the closing of the service for the day in those offices where service is not continuous.

§ 3. The number of demands for calls emanating from the same correspondent and destined for the same town (*réseau*) may be limited by common agreement between the Administrations interested.

Section N.

Avis d'Appel and Telephonic Préavis.

§ 1.—(1) A demand for a call may be accompanied by an avis d'appel or by a préavis.

(2) The object of an avis d'appel is to summon a correspondent to a public call office to make a call.

(3) The object of a préavis is to advise a subscriber's station that the demander of a call wishes to exchange a conversation either with a person designated or with a specified extension station.

(4) The avis d'appel and the préavis may be admitted by a special arrangement concluded between the Administrations concerned.

§ 2. Avis d'appel and préavis are subject to a charge fixed at one-third ($\frac{1}{3}$) of the unit charge, with a minimum of fifty centimes (0 fr. 50). This charge is divided between the Administrations interested in the same proportion as the charges for calls.

§ 3.—(1) Avis d'appel and préavis contain only the following indications :—

1st. The name of the caller and, as the case may be, his number or other indication (*son indicatif d'appel*) ;

2nd. The name and full address of the recipient (*destinaire*) (in the case of an avis d'appel) or sufficient indication of the person or of the extension station demanded (case of a préavis) ;

3rd. In the case of the arrangements specified under Section L, § 8, the time after which the demand shall be cancelled.

(2) These indications alone are transmitted from the office of origin to the office of destination.

(3) Avis d'appel and préavis are transmitted as quickly as possible from office to office.

(4) They are announced respectively by the words "avis d'appel" and by the word "préavis."

(5) The delivery at an abode of avis d'appel takes place under the conditions fixed by the Administration of destination. It falls to the caller to consider previously, taking account of these conditions, whether the avis d'appel can be delivered to the recipient.

(6) Préavis are communicated by telephone to the subscriber for whom they are destined.

(7) If for any reason delivery of an avis d'appel cannot take place, the office of origin is informed. The caller is, in his turn, advised by the office of origin. A similar procedure is followed, in the case of a préavis, if the distant office is informed that the person designated is absent or that the communication cannot be established with the extension line indicated. In these two cases the charge for an avis d'appel or a préavis is not refunded. The demand for the call is cancelled officially.

§ 4. The calls which follow an avis d'appel and préavis are subject to all the rules of international telephonic communication.

RECOMMENDATIONS OF THE INTERNATIONAL CONSULTATIVE COMMITTEE.

Calls by Subscriptions.

The International Consultative Committee

Unanimously advises :—

That the Administrations should admit in their arrangements that the extension of a subscription call be considered as a new call and charged to the subscriber's account.

The International Consultative Committee

Considering :—

That Article 17 of the St. Petersburg Convention gives to the Administrations the right to adopt, by common agreement, in their private regulations, arrangements different from those of the Regulations for International Service, And that subscription calls during hours of heavy traffic generally take place on working days only,

Unanimously advises :—

That it is desirable that in the arrangements concluded between Administrations the stipulations of Section H, § 2 of the Regulations of Paris, shall be completed in the following manner :—

The caller in a subscription call to be effected during the hours of heavy traffic has the right to exclude Sundays and Feast Days. In this case the amount of subscription shall be calculated on a basis of 25 working days per month, and such reimbursements as are covered by § 7, sub-paragraph 3 be fixed at a twenty-fifth part of the amount of subscription, or that fraction of a twenty-fifth part of the subscription corresponding to the lost time.

The International Consultative Committee

Unanimously advises :—

That the interested exchanges be authorised without the intervention of the Administration to agree to subscription calls of a duration exceeding six minutes during the hours of light traffic.

Requests for Information.

The International Consultative Committee

Considering :—

That there is a necessity for satisfying, as far as possible, requests from the public for information and that a charge is applicable to those requests which require service calls between exchanges.

Unanimously advises :—

That certain requests for information relating to international service shall be admitted, thus giving the subscribers the right to ascertain, without passing a call, if such and such a person in the area of another exchange is a telephone subscriber when the information operator of their own exchange is unable to tell them; of asking the name of the person in another exchange corresponding to a definite telephone number; of ascertaining the name of a person who has asked for his own number;

That these requests for information shall be subject to a charge not exceeding one-third of the unit for an ordinary call between the places concerned.

3. METHODS OF OPERATION.

EXTRACTS FROM THE REGULATIONS FOR INTERNATIONAL SERVICE.

(Revision of Paris, 1925.)

Chapter XXIV.—Article 71.

Section O.

Establishment and Disconnection of Calls.

§ 1. Calls subject to a charge are passed in the following order :—

(*a*) Urgent Government calls.
(*b*) " Lightning " calls.
(*c*) Urgent private calls.
(*d*) Ordinary Government calls.
(*e*) Ordinary private calls.

§ 2.—(1) Demands for calls (with avis d'appel or préavis, if such there be), and notices of cancellation not emanating from the terminal office of the international means of communication are transmitted as rapidly as possible to the terminal office—originating end—of the international means of communication. This latter office classes them with those originating from the district it serves, taking into account the category to which they belong and the hour of reception.

(2) The terminal office—originating end—of the international means of communication transmits immediately to the corresponding foreign office avis d'appel, préavis and notices of cancellation.

(3) The terminal offices make arrangements between themselves, so that the calls may be exchanged in their proper order.

(4) Demands for calls, including the names of the offices of origin and of destination and the designation of the correspondent demanded, avis d'appel, préavis and notices of cancellation, should be collated by the exchanges.

§ 3. Calls of the same category are established in alternation. Nevertheless, terminal offices connected with one another by several international means of communication may, by common agreement, allocate certain routes for the establishment of transit calls or for the flow of traffic in a single direction.

§ 4.—(1) One call at least should be prepared before the finish of the call actually in transmission.

(2) Preparation consists in effecting the operations necessary in order that the two correspondents (caller and called) may communicate with each other without any loss of time.

(3) When the technical conditions permit, local calls are officially interrupted in favour of international calls.

(4) Calls already prepared should not be delayed in favour of calls of superior rank.

(5) The flow of traffic on the international means of communication should be assured in the corresponding offices in such a manner that it may not be retarded, especially by reason of work which the telephonists have to perform.

(6) The designation, between telephonists, of each call is made by means of an order number assigned to that call.

§ 5. Telephone communications are established by the agreed route. In case of interruption or congestion (*encombrement*) they may, according to arrangements made for that purpose, be established by another route, at the charges prescribed by these arrangements.

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§ 6. Calling signals on the international routes should be answered immediately. If the called office does not give an answer after a suitable period of waiting, it is asked on another telephonic line, or, if that does not exist, by telegraph, to resume service on the route in question.

§ 7.—(1) Terminal offices verify that the hearing between the correspondents is satisfactory; they take note of the time of commencement and finish of a call and, further, where appropriate, the period during which the hearing was unsatisfactory.

(2) The signal of the conclusion of a call should be given by the correspondents. Each of the distant offices immediately notifies its terminal office thereof. The terminal office first advised severs the connection.

§ 8. Offices have the right officially to cut off a private call as soon as its duration reaches six minutes and another demand is in preparation. The correspondents are advised.

§ 9.—(1) The terminal offices of the international means of communication take note of the data necessary for drawing up the international accounts, and of incidents of the service.

(2) The terminal offices determine, by common accord, the duration of every call the duration of which exceeds three minutes. They agree upon the duration to be carried into the accounts when conversation has been difficult.

(3) In cases of divergence between the terminal offices the opinion of the originating terminal office prevails.

(4) The terminal offices fix daily, by telephone, during the hours of light traffic the number of minutes for which the charge should be entered in the international accounts.

(5) To determine this number, account is taken of the coefficients corresponding to each category of communication ("lightning," urgent, avis d'appel, préavis, etc.). The minutes are, for each period to which a like tariff applies, grouped by the zones of destination.

§ 10. For the preparation, setting up and severing of calls the French language is used between Administrations of different language, unless special arrangements are made between them for the use of other languages.

RECOMMENDATIONS OF THE INTERNATIONAL CONSULTATIVE COMMITTEE.

Establishment of Calls during Heavy Traffic.

The International Consultative Committee

Considering :—

That it is necessary to explain Section O, § 2, sub-paragraph 3, of the Regulations of Paris as regards the exchange of calls between terminal exchanges.

Unanimously advises :—

That where traffic is sufficiently heavy, demands for calls shall be so transmitted between terminal exchanges that each terminal exchange shall have at least two requests for calls ready in each direction over and above the conversation in progress.

Method of Establishing Calls with Préavis or Avis d'appel.

The International Consultative Committee

Considering :—

That the International Regulation (Revision of Paris, 1925) does not contain sufficient detailed information concerning the establishment of calls with préavis or avis d'appel.

Unanimously advises :—

That the Administrations shall, in this respect, conform to the following rules :—

"Calls with préavis or avis d'appel shall only be established in their order when the controlling exchange (terminal exchange—originating end—in case of direct calls, transit exchange in the case of transit calls) has been advised that the called party is ready to receive the call."

For the establishment of a **call with préavis** the procedure shall be as follows :—

(*a*) The exchange of destination shall find out on receipt of the préavis from the subscriber concerned if the person or extension instrument called is ready to receive the call.

(*b*) If the reply is in the affirmative, shall immediately advise the controlling exchange. The latter shall establish the call as soon as its turn arrives.

(*c*) If the exchange of destination is informed that the person or extension set required cannot and does not wish to receive the call, the controlling exchange and the originating exchange shall be advised. The latter exchange shall inform the caller, the request for the call thereby being cancelled (Section N, § 3, sub-paragraph 7).

(*d*) If the exchange of destination is informed that the called party cannot receive the call until later, the subscriber shall be asked to advise, as soon as possible, the hour at which the call may be established. The exchange of destination shall make known this information to the controlling exchange as soon as possible. If at the time at which the called party is ready to receive the call the turn for setting up this call has not yet arrived, the call shall retain its normal sequence.

If its turn has already passed the request shall take its place in the normal sequence of its category, following calls already in preparation at that moment.

If after two or three hours the exchange of destination has not received any advice from the subscriber, it may repeat the demand in the case of calls destined, for example, to hotels or boarding houses.

The exchange of origin should avoid, as much as possible, requests for information from the controlling exchange and the probable time of the establishment of the call. If the caller finds the delay too long, he may cancel his call. When a préavis cannot be transmitted to the called subscriber through no reply from that station on the first call, the station should be again called at least once, and, in the case of no reply half an hour after the first endeavour, the call shall be cancelled. The caller shall be advised and the charge for the préavis shall be collected.

(*e*) When the turn for setting up a call with préavis has arrived, the exchange of destination shall indicate to the subscriber's station the person or extension instrument called, both at the time of the first advice and the time of the actual call.

If the subscriber cannot accept the call when he receives one or the other of these advices, because the called person or extension cannot be reached, a three-minute fee for the category of the requested call shall be charged.

For setting up a **call with avis d'appel,** the procedure shall be as follows :—

(*a*) As soon as the called party presents himself at the public call office or makes known that he is ready to receive the call at a subscriber's station which he indicates, the exchange of destination shall immediately advise the controlling exchange. The latter shall set up the call as soon as its turn arrives.

(*b*) If the exchange of destination is informed that the called party cannot, or does not wish to, receive the call, the controlling exchange and the exchange of origin shall be advised. The latter shall inform the caller. The request for call shall be immediately cancelled (Section N, § 3, sub-paragraph 7).

(*c*) If the exchange of destination is informed that the called party cannot receive the call until later, note shall be made of this fact, but no advice shall be given to the controlling exchange until the particular person is ready to receive a call.

(*d*) If at the time when the called party is ready to receive a call the turn for setting up the call has not yet arrived, the request shall retain its normal sequence. If the turn has already passed, the request shall take its turn according to category, following calls in preparation at that moment. If the caller cancels a call with préavis or avis d'appel, after the transmission of the indications provided for in Section N, § 3, has already been commenced, the charge for the préavis or avis d'appel shall not be returned. The exchange of destination shall be informed of the cancellation and, in turn, shall advise the called station and the called party himself if he is already at the public call office. Furthermore, in the case of an avis d'appel if the caller requests that the called party be advised at his house of the cancellation, a further tax, corresponding to an avis d'appel, shall be charged.

If before the establishment of a call, or, when necessary, before the first call, the called party makes known that he cannot await the call, the calling party shall be advised. In the case of a préavis he shall be requested to make known whether he shall cancel or maintain his request for a call. In the case of an avis d'appel, the demand for a call is thereby cancelled.

The special charge pertaining to préavis and avis d'appel shall only be returned in the following two cases :—

(*a*) When through defective service the transmission of the préavis or avis d'appel has not been effected.

(*b*) When after the receipt of a préavis or avis d'appel the call cannot take place through faults happening on the line or in the installation.

Operation of International Circuits.

The International Consultative Committee—

Considering :—

That, on the one hand, the regulation of the telephone accounts between States necessitates control from both ends of the circuit on the duration of calls and that, on the other hand, the operation by order wires of heavy traffic routes and numerous circuits makes it practically impossible to properly control all these durations at the incoming end of the circuits.

Unanimously advises :—

That, on account of the number of circuits and the present conditions of the international regulations, order wire operation shall be excluded from international service.

Instruction of the Personnel of Telephone Exchanges.

The International Consultative Committee—

Considering :—

That the professional instruction of the operating and supervisory staff is of primary importance in order to ensure good efficiency of the international circuits :

That in this respect it is very useful to train the supervisors and operators in the language of the connecting countries and to permit them to become acquainted with the customs of the subscribers, organisation of service, and operating methods at the other end of the circuit.

Unanimously advises :—

That exchange of supervisors and operators shall take place frequently between the central exchanges of the different countries whenever this is justified by circumstances and the intensity of the traffic.

The International Consultative Committee—

Considering :—

That, no matter how perfect the operators may be, the circuits have a greater efficiency when they are always served by the same operators.

Unanimously advises :—

That it is desirable, if internal service will permit, for the international circuits to be always served by the same operators.

Preparation of Calls.

The International Consultative Committee—

Considering :—

That it is especially desirable, during the hours of heavy traffic, to reduce as far as possible the time during which a telephone circuit is occupied with service connections :

And that good results have been obtained by different Administrations in their internal service by the preparation of calls by telegraph.

Unanimously advises :—

That preparation by telegraph shall be used whenever it is technically possible.

Telegraphic Preparation of Telephone Calls.

The International Consultative Committee—

Considering :—

That it is indispensable to set up common rules according to which telegraphic preparation of international telephone calls will be effected in order to obtain in each case the best service possible.

Unanimously advises :—

That the Administrations shall conform, in this connection, to the following suggested regulations :—

SUGGESTED INTERNATIONAL REGULATIONS FOR THE TELEGRAPHIC PREPARATION OF TELEPHONE CALLS.

Definition and Object.

Telegraphic preparation of telephone calls consists in utilising a telegraphic connection formed by taking into use a physical or phantom telephone circuit in order to pass, by telegraph, all service calls relating to conversations which will take place over the circuits connecting two exchanges.

Telegraphic preparation, consequently, tends to increase the efficiency of the circuits by freeing them of all service calls. It goes without saying that this is particularly important in the operation of circuits carrying heavy traffic. In no case must the use of the line for telegraphic calling affect the operation of the circuits. If, at a given moment, the telegraph signals cause any disturbance on the telephone circuit telegraphic preparation must be provisionally suspended.

Selection of Operating Staff.

The operators appointed to serve international circuits on which the method of telegraphic preparation is used, must not only be experienced telephonists, trained in the different operations for setting up calls, but also good telegraphists.

Telegraph Apparatus to be used.

The telegraphic preparation of telephone calls must be carried out by means of apparatus with audible reception. Two exchanges may, however, by common agreement, decide to use tape machines.

Conventional Abbreviations.

In order to accelerate telegraphic transmission of the various service calls, and to avoid the difficulties due to the fact that two operators speaking different languages are on the circuit, a code of international abbreviations for the more common expressions used in telephony, independent of the telegraphic abbreviations and signals provided for in the Regulations of International Circuits at the Convention of St. Petersburg, shall be used.

This code of abbreviations, which is reproduced below, can be supplemented, by agreement between exchanges concerned, by a series of abbreviations employed between these exchanges for the designation of important towns or exchanges :—

Ordinary Private Call	P
Urgent Private Call	D
Service Call	A
Urgent Service Call	AD
Ordinary State Call	S
Urgent State Call	SD
Lightning Call	ER
Call by Subscription	AB
Agreement of Duration	C
Cancelled	AL
Avis d'appel	M
Subscriber has replied	AR
To set up	AP
To transform	TRF
" Bourse "	B
Central Telephone Exchange	BU
Public Telephone Station	BP
Circuit	CT
Checking	TC
Interrupted Call	IT
Difficult	DIF
Ineffective (cancellation for inaudibility)	IF
To put on one side	ZL
No reply	N
Busy	O
Extra fee	NP
Préavis	V
Nothing for me	?
Nothing	R
To ring	SR
Come in on Circuit No. X	RZx

Numbering of Demands for Calls.

Demands for calls passed between two exchanges must be given a serial number, which is determined by the terminal exchange, at the originating end, when the demand is passed to the incoming terminal exchange. The even numbers are reserved for calls in one direction, the odd numbers for calls in the other direction. The numbering commences each morning when the daily service begins.

Subsequently, the calls are denoted by both operators by their serial numbers only.

If circuits connecting two towns are distributed over many toll positions, each position shall have its special numbering scheme.

Transmission of Demands for Calls.

Demands for calls are transmitted whilst conversations are in progress, when the presence on the lines of the operators is no longer necessary.

The connecting exchanges transmit alternatively their demands in such a manner that besides the conversations in progress each exchange has at least two requests for calls waiting in each direction per circuit.

If one of the two exchanges has no demand waiting, signal " R " is sent out ; the other exchange can then proceed afresh to send its demands. If the signal " R " has not been sent out, the exchange must be recalled by the signal of interrogation (?).

The use of abbreviations is compulsory in the transmission of demands or in the exchange of service calls between the connecting exchanges.

When the exchange which has just called has received from the other exchange the signal " K " (— • —) it commences to transmit the series of demands by the starting signal in all transmission — • — • —

Transmission of a demand is ended by the signal — • • • —

Transmission of a series is ended by the signal • • • — •

Punctuation marks are not transmitted.

Abbreviations are not used for the transmission of figures except for checking.

Information to be included in the Transmission of a Demand.

The transmission of all demands shall include the following information :—

1. If the call makes use of a direct circuit only :
   - (*a*) Serial number.
   - (*b*) Class of call, in the case of a call other than an ordinary private call.
   - (*c*) The telephone number of the called subscriber preceded by the designation of his central exchange.

   The names of the originating and terminating exchanges are omitted.
2. If the call makes use of several circuits :
   - (*a*) Serial number.
   - (*b*) Class of call, if other than an ordinary private call.
   - (*c*) Name of terminating exchange if this is not the exchange which is being called.
   - (*d*) Telephone number of the called subscriber preceded, if necessary, by the designation of his central exchange.
   - (*e*) Name of the originating exchange if this is not the calling exchange.

In the case of a connection requested " en Bourse " the designation of the terminating exchange shall be completed accordingly.

Examples of the transmission of demands :—

Private call No. 12 from Brussels for subscriber Marcadet 4628 Paris :

— • — • — 12 Marcadet 4628 — • • • —

Urgent private call No. 14 from Lyons for subscriber Central 9417 Berlin :

14 D Central 9417 Lyons — • • • —

Urgent Service call No. 16 Lyons for subscriber 14794 at Antwerp switched at Brussels :

16 AD Antwerp 14794 Lyons • • • — • —

The transmission of avis d'appel and préavis shall include the particulars relating to the establishment of a call to which the avis d'appel or préavis gives rise (name or telephone number of the caller, name and full address of the person wanted—in the case of an avis d'appel—telephone number and sufficient designation of the person or the extension called—in the case of a préavis).

Checking of Demands.

The checking of a single demand or series of demands for calls should follow immediately the transmission and be terminated by the signal • • • — • (understood). It must include the class of call, except for ordinary private call, the terminating exchange, if necessary, the number of the called subscriber and the serial number of the demand.

The checking of avis d'appel or of a préavis which follows its transmission should include the name or the telephone number of the calling and called subscriber and the address.

If the checking is correct the calling exchange shall reply with the signal • • • — • (understood) ; correction should be made if necessary.

Cancellation or Modification of Demands for Calls.

To cancel a demand for a call the originating exchange shall transmit to the terminating exchange the designation "AL," followed by the serial number given to the call. The terminating exchange shall reply in the same way.

The modification of the class of a demand for a call shall be notified by the designation "TRF," followed by the new class of the call and its serial number. The terminating exchange shall reply by repeating the demand transmitted.

Examples :—

Modification of a demand for an ordinary private call numbered 124 to an urgent call:

TRF D 124

Modification of a demand for an urgent call numbered 138 to an ordinary call:

TRF P 138.

Agreement of the Duration of Calls Passed.

This agreement shall be made by telephone.

Different Instances of Operation of Circuits with Telegraphic Preparation.

For the operation of international circuits with telegraphic preparation it is desirable only to allot to a telephonist-telegraphist a single line when the conversations transmitted by the line are passed alternatively in both directions, or two circuits at the most, when it is a question of circuits worked exclusively in the same direction either for outgoing or incoming calls.

In both cases the telephonist-telegraphist will use telegraphic preparation to its fullest extent—that is to say, she will use the telegraph for the transmission and reception of the demands for calls, for avis d'appel or préavis, for service calls during progress of call (busy, no reply, cancelling calls, modifying calls) and requests to come in on the circuit.

If, as an exception, an operator attending to two circuits used in alternative directions has charge of the telegraphic preparation the information relating to the transmission or reception of préavis and avis d'appel may be made telephonically.

Operating Rules for International Transit Traffic.

The International Consultative Committee—

Considering :—

The difficulties which are encountered when using an intermediate exchange for transit calls;

Unanimously advises :—

1. That it is desirable to have direct circuits across transit countries in all cases where traffic justifies this:

2. That, failing these permanent direct circuits, it is advantageous, if circumstances are favourable, to allocate circuits at definite times so as to allow direct connections temporarily, according to the needs of the traffic.

Considering, on the other hand :—

That when it will not be possible to set up permanent direct circuits or temporary connections, it is desirable to standardise, as far as possible, the methods of operation in transit exchanges.

Unanimously advises :—

That it is desirable that the following rules for operation should be adopted for transit traffic in those cases where the connection passes through one transit exchange :—

(*a*) It is necessary for the transit exchange to control the call—that is to say, it will direct the preparation and the establishment of the circuit.

(*b*) Demands for calls shall be transmitted as quickly as possible to the transit exchange. However, it is desirable for this exchange to have more than two demands for calls waiting in the same direction. Service advices of préavis or avis d'appel shall be transmitted in priority independently of demands for calls.

(*c*) After a transit conversation the terminal exchanges may pass directly other calls even if the demands corresponding to these latter have not been transmitted to the transit exchange, providing that there are no calls of a higher class waiting at the transit exchange, the direct connection remaining established between the two terminal exchanges as long as the transit exchange considers it advisable.

(*d*) The tickets for demands for transit calls of the same order in both directions shall be arranged on the same operator's position (controlling position); they shall take their turn amongst the other demands which are waiting at this position, according to their class and the time received by the transit exchange.

(*e*) The first transit call established in the same series is necessarily the oldest call of the highest class that is waiting on the controlling position, whatever has been the direction of the preceding call established between the two terminal exchanges and the transit exchange. Other transit calls of the series will then follow alternatively. The transit exchange will recommence alternation on the two circuits after the connection has been broken down.

(*f*) Before the commencement of the last but one call which has to be passed between the transit exchange and the two terminal exchanges, the two corresponding positions at the transit exchange shall advise the two other exchanges to prepare the transit connection. The terminal exchanges shall proceed then to warn the subscribers. If one of the subscribers does not reply, the transit exchange should be advised of this before the commencement of the last call preceding the transit connection, in order to avoid taking into use these two international circuits unnecessarily, and, should the case arise, to permit the preparation of the following transit connection.

(*g*) Circuits of the internal network and subscribers' lines should be available to the terminal exchanges in order to establish, without delay, transit calls when their turn arrives.

(*h*) In the case of disagreement between the terminal exchange on the caller's side and the transit exchange concerning the duration of the calls, the opinion of the transit exchange shall prevail.

> *Note.*—In the case where a connection passes through several transit exchanges connected either by international circuits or by internal circuits, assuming that great difficulties are met with in the establishment of the connection, and since no Administration has any experience on the subject, the International Consultative Committee does not for the moment recommend any particular rules for this class of operation.

Conditions which should be fulfilled concerning the Operation of Intercommunication Systems between International Circuits of 4-wire and 2-wire.

The International Consultative Committee—

Unanimously advises :—

That, from the point of view of operation, it is advisable for the operating personnel to have always the same operations to perform for connecting the two circuits, no matter what be the nature of these circuits.

4. RATES AND TARIFFS.

EXTRACTS FROM THE REGULATIONS FOR INTERNATIONAL SERVICE.

(Revision of Paris, 1925.)

Chapter XXIV.—Article 71.

Section K.

Tariffs—Collection of Charges.

§ 1.—(1) The unit charge for each service is that applicable to an ordinary private call of a duration of three minutes exchanged during the period of heavy traffic.

(2) The amount of the unit charge is fixed by means of agreements between the Administrations concerned, on the basis of the franc (*see* Art. 24).

§ 2. The charges for calls are composed of terminal charges and, if appropriate, of transit charges.

§ 3.—(1) For the fixing of terminal charges the territory of the Administrations may be divided into zones.

(2) A uniform charge is adopted throughout the same zone.

(3) Each Administration fixes the number and extent of the zones for its relations with each of the other Administrations.

§ 4. Each transit Administration fixes its transit charge. In the same conditions of transit an Administration applies the same transit charges.

§ 5. Each Administration which furnishes a direct transit means of communication has the right to demand from the terminal Administrations a guarantee of a minimum revenue.

§ 6. The amount of the unit charge may be reduced during the hours of light traffic. The Administrations concerned fix by common accord these hours and the amount of the reduced charge or charges.

§ 7. The charge is collected, as the case may be, from the subscriber by whom the call has been demanded or from the person who has demanded the call from a public call office.

§ 8. Each call is charged according to the tariff applicable in the Administration of origin at the moment when the call commences, even when it terminates at a time when another tariff is in force.

Section L.

Method of Application of Charges—Duration of Calls.

§ 1.—(1) All calls of a duration equal to or less than three minutes are charged for as for three minutes.

(2) When the duration of a call exceeds three minutes, a charge per minute is made for the period exceeding the first three minutes.

(3) Nevertheless, in services between systems near the frontier the charges are levied by indivisible periods of three minutes. The Administrations concerned determine these services by common accord. The charge per minute is one-third of the charge applicable for three minutes.

§ 2. The charge for calls between subscribers commences from the moment when communication is established between the calling station and the called station, after the two stations have responded to the ring.

§ 3. When the call is demanded by a public call office station and destined for a subscriber's station, the charge commences from the moment when, the subscriber's station having responded to the ring, the caller is put into communication with the latter station.

§ 4. If the call is destined for a public call office station, the charge commences from the moment when, the two stations concerned having answered the ring, the caller in the public station or the calling subscriber's station (as the case may be) is put into communication with the person called.

§ 5. In all cases where, after correct establishment of communication, there is a reply (from a subscriber's station) to the ring, the charge is due whoever may be the person answering.

§ 6. A demand for a call may be cancelled, without collection of the charge applicable to the call, up to the moment when the caller is rung by his exchange. The Administration of origin may collect from the caller a special charge to remunerate it for the work of booking, cancelling, etc., the demand for the call. The whole of this charge is retained by the Administration of origin.

§ 7.—(1) When the calling or the called subscriber refuses the call, the charge for a conversation of three minutes' duration of the category of call asked for is applied.

(2) In the case of refusal by the called subscriber, the caller is advised thereof.

§ 8.—(1) At the moment when he formulates his demand, the caller has the right of specifying that the communication should not be established after a certain interval which he indicates.

(2) Administrations may agree between themselves that, in case of non-reply by the caller or the called, there may be levied on the caller a special charge which shall enter into the international accounts.

(3) The Administrations concerned fix by common accord the amount and the hours of application of this charge.

§ 9.—(1) The length of time a subscriber is rung, as also that necessary for calling to a public call office station a correspondent in waiting, is limited to one minute from 7 h. to 21 h.,* and to three minutes during the other hours (legal time of the country of destination).

(2) This period of ringing having elapsed and no reply being received from the caller, the called, or from one of them, the demand for the call is officially cancelled.

§ 10. Modifications of the arrangements forming the subject of § 4 and § 9 above may be made by common agreement between the Administrations interested so far as relates to calls originating from or destined for commercial bourses, financial or other.

§ 11. Except for state calls and subscription calls, correspondents have not the right to prolong a call beyond six minutes when a demand is on hand for a call over the means of communication used.

Section P.

Partial and Total Reimbursements.

§ 1. When, by the act of the telephone service, a demand for a call is not followed by the caller being placed in communication with the station asked for, the charge is not applied. If the amount of the charge has been paid, it is reimbursed.

§ 2.—(1) When, after the commencement of a call, the conditions of hearing are not satisfactory, the charge is not levied.

(2) When, in the course of a conversation, the correspondents experience difficulties by the act of the telephone service, compensation is, as far as possible, accorded immediately.

(3) When it has been impossible to give compensation, the charge should not be levied if the duration of satisfactory hearing has not reached three minutes; it should be reduced to the charge corresponding to the duration of satisfactory hearing if this has been at least three minutes.

* From 7 o'clock in the morning to 9 at night for the countries which have not adopted the 24-hour clock.

(4) The demander of a call cannot demand the application of the provisions (2) and (3) above unless the central offices or, as the case may be, the public call offices concerned have been asked to note the insufficiency of the hearing or the difficulties experienced during conversation. Note is taken of these incidents.

(5) When, after connection is made, the offices observe that the conditions of hearing will not be sufficient, connection is severed in order to avoid any delay in the setting up of other calls.

§ 3. All claims made after the severance of connection are dealt with by the office of origin. The terminal offices correspond directly with one another in order to collect the information which may be necessary for inquiry. The reimbursements are accorded by the office of origin and at their charge.

Section Q.

Accounting.

1. Telephone charges form, on the part of each Administration, the subject of a special account independent of the telegraphic account.

2. The settlement of telephonic accounts is effected according to the arrangements applicable to telegraphic accounts (*see* Chapter XXVII.).

Section R.

Records.

The dockets which have served for the establishment of international telephone accounts are preserved for twelve months.

RECOMMENDATIONS OF THE INTERNATIONAL CONSULTATIVE COMMITTEE.

No Reply from a Subscriber.

The International Consultative Committee—

Considering :—

That the Regulations for International Service (Revision of Paris, 1925) allow Administrations full liberty to settle the cases of no reply from calling or called subscribers (Section L § 8 (2) and (3)).

Unanimously advises (with two dissenters) :—

That Administrations shall agree in their particular arrangements to charge, in the case of no reply from the calling subscriber, a tax for a call of three minutes' duration, according to the class of the required call :

Unanimously advises (with one dissenter) :—

That, in the case of a no reply from the called subscriber, no charge shall be made :

Unanimously advises (with two dissenters) :—

That when a subscriber, having replied when warned of a call, does not reply when the central exchange recalls to set up the connection, a charge corresponding to a three-minute call of the class required shall be made.

Tolerance and Arrangements for Registering the Duration of Calls.

The International Consultative Committee—

Considering :—

That the method of charging minute by minute after the first unit of conversation is more favourable to the subscribers than the old methods of charging, by which a certain tolerance was allowed in practice.

Unanimously advises :—

That for the exact application of the Regulations for International Service no tolerance shall be allowed in determining the duration of calls;

That the Administrations shall be advised to adopt methods of registering the duration of calls which are as near the same degree of accuracy as possible;

That the Administrations of Great Britain and Switzerland shall communicate to the International Consultative Committee the results of investigations which they intend to make shortly on this subject.

Calculation of International Telephone Charges.

The International Consultative Committee—

Unanimously advises :—

1. That the charge for international telephone calls should consist, normally, of :—

(*a*) terminal charges accruing to the Administrations of origin and destination (Terminal Administrations);

(*b*) of transit charges accruing to the intermediate Administrations, if such exist (Transit Administrations);

2. That, in fixing terminal charges, each country shall be divided into zones, the charges within the same zone being the same for the same country and calculated in accordance with the distance between the zone and the frontier, this distance being fixed for each zone by the Administration concerned, the latter being free to determine the limit of its zones in accordance with its own traffic or in accordance with financial or other considerations, different zones being, if necessary, defined in the same country for the traffic with different countries.

3. That in the distance used for the purpose of calculating charges the length of any submarine section shall be multiplied by a coefficient to be decided upon by the Administration concerned, regard being paid to the annual charges (including interest, depreciation and maintenance);

4. That, in the case of countries of a hilly nature, or having a special geographical situation, in which the actual route followed by the circuits is unavoidably very devious, it shall be admitted that the distance upon which the charges are calculated can be considerably higher than the distance measured as a straight line between the frontier and that point of the zone in question which is the greatest crowfly distance from it;

5. That, when telephone calls between two Administrations make use of the territory of one or more intermediate Administrations, the charges applied by the transit countries shall be calculated in accordance with the average crowfly distance between the points where the international circuits enter or leave, this crowfly distance being liable to increase in accordance with § 3, if submarine cables have to be used and increased in accordance with § 4, if a mountainous country has to be traversed or a country possessing a particular configuration.

6. In all cases the charges for international telephone calls per unit of distance shall be calculated in each country on the basis of their net cost.

The International Consultative Committee—

after having studied the net cost of international telephone communications in each country,

Unanimously advises :—

1. That under favourable conditions of operation the net cost of the communication can be considered provisionally as covered by the following amounts :—

Operating charge :

Terminal exchange	0 fr. 80
Transit exchange	1 fr.

Amortisation, interest on capital and maintenance of the telephone route :

0 fr. 60 per 100 km. crowfly distance or fraction thereof.

2. That it will be convenient to adopt, in a general way, frontier charges not exceeding 0 fr. 60 for crowfly distance between networks less than 25 km. and 1 fr. for crowfly distance between 25 and 50 km.

Minimum Traffic to be Guaranteed to Transit Countries.

The International Consultative Committee—

Considering :—

That, on the one hand, terminal Administrations should have ample liberty to request transit Administrations to place circuits at their disposal and that, on the other hand, transit Administrations ought to be able to satisfy the requests for direct circuits without being deterred by the fear that the traffic carried by these circuits will not provide sufficient revenue to meet the construction and maintenance costs of transit circuits.

Unanimously advises :—

That it be admitted that an Administration from which a circuit for transit traffic is requested shall have the right to demand, in return, the guarantee of a minimum revenue.

Considering :—

That the traffic which can be carried by a particular circuit depends largely on the manner in which it is maintained, and that it appears desirable to interest the transit country, by some more efficacious means than the establishment of an agreed annual payment, in the maintenance of an excellent quality of service producing a satisfactory revenue by reason of the maintenance in perfect condition of the portion of the circuit under the charge of that transit country, and that this objective can be attained by interesting the transit country in the total traffic carried by the circuit by means of a proportional participation in the number of communications effected, with a guaranteed minimum revenue,

Unanimously advises :—

That this procedure shall be preferred to the establishment of any agreed payment, without the latter, however, being completely excluded :

Considering :—

That the experience acquired does not appear sufficient to justify the fixing, even provisionally, of a standard minimum value and that the point of view of transit countries on this subject will depend, to a great extent, on present-day installation costs of the circuits requested, also on the possible use to which the available wires will be put.

Unanimously advises :—

That the determination of this minimum by direct negotiations shall be left to the Administrations interested :

Considering :—

That the receipts obtained from a telephone circuit depend, to a large extent, on the day-to-day maintenance of that circuit.

Unanimously advises :—

That, if a minimum revenue is guaranteed, it is also advisable to effect a reduction in this revenue in respect of interruptions to the circuit in the transit country, at least when the transit country does not undertake to replace the defective circuit by another circuit; this reduction shall take into account all the interruptions of a whole day, a complete day being regarded as the interval of time between 9 a.m. and 3 p.m. If the replacing route involves the intervention of an exchange, the charge due to the transit Administration is not modified :

Considering :—

That the legal time of the interested countries may not coincide.

Unanimously advises :—

That the precise hours of commencement and termination of the period of interruption that must be taken into account (9 a.m. to 3 p.m.), as well as all other details relative to the reduction arising out of interruptions, shall be fixed by direct agreement between the interested countries :

The International Consultative Committee—

Unanimously advises :—

That the guaranteed minimum shall be only applicable to lines allocated by the transit Administrations for the exclusive use of the terminal countries, the partial use of other lines being remunerated in the usual manner by means of a transit charge for each call effectively passed over the circuit.

Relation between the Cost of Leasing a Circuit and the Value of the Cut-off Frequency of this Circuit.

The International Consultative Committee—

Unanimously advises :—

That the normally applicable tariffs for the use of lines for radiophonic transmission shall be so fixed that amortisation of the additional expense incurred in obtaining a high critical cut-off frequency and a more complete reduction of the echo effect, shall be as rapid as possible (for example, three to five years). It is necessary, in fact, to amortise this expense quickly because one must not lose sight of the fact that technical progress which develops so rapidly brings forth new and better means than those existing for the transmission of radiophonic programmes.

5. PROPOSED TYPICAL FORM OF AGREEMENT BETWEEN ADMINISTRATIONS FOR INTERNATIONAL TELEPHONE SERVICE.

The International Consultative Committee—

Considering :—

That the rapid development of international telephone service and the more and more frequent opening up of new international means of communication renders it desirable to facilitate the formulation of agreements between Administrations.

Unanimously advises :—

That the Administrations shall adopt, as soon as possible, a typical form in their agreements relating to international telephone service and that they shall take the following text as a basis for the establishment of this agreement.

PROPOSED TYPICAL FORM OF AGREEMENT BETWEEN ADMINISTRATIONS FOR INTERNATIONAL TELEPHONE SERVICE.

TELEPHONE SERVICE BETWEEN (THE FIRST TERMINAL COUNTRY ACCORDING TO ALPHABETICAL ORDER) AND (SECOND TERMINAL COUNTRY).

AGREEMENT.

Article 1.*—A telephone service is organised between (the first terminal country) and (the other terminal country) to be completed as follows when the service is organised by the intermediate transit Administrations:

By means of routes of communication established in the territory of.................... (the name of the transit country or countries).

Article 1 or 2.—The arrangements provided in Chapter XXIV (Telephone Service) of the International Regulations (Revision of Paris, 1925), attached to the International Telegraph Convention of St. Petersburg, are applicable to the telephone service between (the first country according to alphabetical order) and (the other terminal country) :

To be completed as follows when the service is organised by the intermediate transit Administrations :—

By the means of routes of communication established in the territory of.................... (name of the transit country or countries), according to the following provisos and additions :—

Section A.—International System.

§ 5.—(2) Indicate according to the case :

sub-paragraph suppressed;

or

Priority on interior calls of the same category is not given to calls which make use of the routes connecting neighbouring frontier networks—that is to say, which make use of the following circuits (list circuits).

* This article shall only figure in an agreement which relates to the establishment of telephone connections between the two countries.

Section C.—List of Subscribers and Call Offices.

§ 4. The requests relating to list of subscribers (telephone directories) which must be sold to the public shall be addressed..........................(indicate here the interested services of the Administrations of the two countries in question). This service shall send a request to the house charged with a sale of the requested document, that house shall forward a bill for the purchase price and then, once the money has been received, send this document to the interested person either by letter or by parcel post.

Section E.—Urgent Private Calls.

§ 1. Urgent private calls are (*or* are not) admitted.

Section F.—" Lightning Calls."

§ 1. " Lightning " calls are (*or* are not) admitted.

Add in the first case :

§ 3. The tax for a " lightning " call is fixed at ....*

Section G.—State Calls.

§ 1.—(2) In the case where urgent private calls are not admitted, state if ordinary State calls or urgent State calls exist. Specify according to the decision taken.

Urgent State calls are not admitted *or* urgent and ordinary State calls exist.

§ 2.—(5) In the case where calls are to be established by means of one or more exchanges of a transit Administration. State whether the Administration or Administrations will make use of the right to limit the duration of a State call to six minutes. Specify according to the decision taken :

The duration of State calls is not limited. However, the Administrations (*or* Administration) (state the transit Administration *or* Administrations) reserve the right to limit the duration of State calls to six minutes, when such calls are established through the intermediary of their exchange or exchanges,

or

The duration of State calls is not limited. The Administrations (*or* Administration) (state the transit Administration *or* Administrations) will not use their right to limit the duration of a State call to six minutes when these calls are established through the intermediary of one of their exchanges.

Section H.—Calls by Subscriptions.

§ 1.—(1) Subscription calls are authorised

or

Subscription calls are not authorised

(specify according to the case)

During periods of light traffic

or

From such a time to such a time (legal time of the country of origin) or during the following periods (indicate the exchanges, adding the legal times of the country of origin) :

or

During periods of light traffic as well as during the other periods.

* The majority of the Administrations represented on the International Consultative Committee advise in this case the application of ten times the tax corresponding to an ordinary private call passed during the same period.

§ I.—(4) Subscription calls are subject to the following rates :—

(a) During periods of light traffic : half of the unit charge ;
(b) During other periods : ....*

§ 3. During the hours of light traffic subscription calls of a duration greater than six minutes may be admitted by the interested exchanges, providing that the traffic normally passed over the circuits to be made use of permits this.

Section K.—Tariffs—Collection of Charges.

§ 3. *Zones.*—For the determination of terminal charges the territory of (first terminal country in alphabetical order) is divided into N zones

or

has only one zone.

The territory of (second country in alphabetical order) is divided into N zones

or

has only one zone.

Limit of zones :

(first country in alphabetical order).

The first zone comprises :

Indicate as the case may be:
- The departments (*or* provinces *or* geographical divisions) as follows : (list them in alphabetical order)
  or
- the networks to the west (north, south *or* east) of a line to the east (north, south *or* west) of the following towns (list in geographical order, starting from a definite point on the frontier).

The second zone comprises :

....

(second terminal country in alphabetical order).

The first zone comprises :

The departments (*or* provinces *or* geographical divisions) as follows : (list them in alphabetical order) ; the networks to the west (north, south *or* east) of a line to the east (north, south *or* west) of the following towns (list in geographical order, starting from a definite point on the frontier).

The second zone comprises :

....

Connections between Frontier Networks.

By connection between frontier networks is meant those between :

Indicate as the case may be:
- networks whose crowfly distance apart is not greater than ....kilometres,
  or
- the following networks.

* The majority of the Administrations represented on the International Consultative Committee advise the application of three times the unit charge in this case.

Amount of Unit Charge for Connections between the different Zones between (first terminal country) and (second terminal country).

The amount of unit charge for each connection and the amount payable to each country are indicated in the following table :—

Connection between	Unit Charge.	Part for Country A.	Part for Country B.	Part for Transit Country.	Remarks.
Network whose crowfly distance apart is not greater than........km.					
Country A, 1st zone, and Country B, 1st Zone					
Country A, 1st zone, and Country B, 2nd Zone					
Country A, 1st zone, and Country B, 3rd Zone					
Country A, 2nd zone, and Country B, 1st Zone					
Country A, 2nd zone, and Country B, 2nd Zone					
Country A, 2nd zone, and Country B, 3rd Zone					
Country A, 3rd Zone, and Country B, 1st Zone					
Country A, 3rd Zone, and Country B, 2nd Zone					
Country A, 3rd Zone, and Country B, 3rd Zone					

§ 5. (Establishment of a direct circuit through transit country.)

In the case of a direct circuit between (the first terminal country) and (another terminal country) through (transit country), the terminal Administrations each guarantee a half of an annual minimum revenue of :

x francs
or
corresponding to x unit charges.

§ 6. The hours of light traffic are the following................. (legal time of the originating country). For subscription calls the originating country is that in which the subscription has been paid.

During the period of light traffic the charge applicable to an ordinary private call is fixed at three-fifths of the unit charge.*

Section L.—Method of Application of Charges—Duration of Calls.

§ 1.—(3) By connections between neighbouring frontier networks in which the charge is made by indivisible periods of three minutes is meant connections between networks whose crowfly distance apart does not exceed .... kilometres.

§ 8.—(2) and (3) Specify as follows : In the case of a no reply from a caller, a charge for a three-minute call of the particular class required is made. In the case of no reply from the called subscriber no charge is made.

When, after having replied to the warning call, the calling or called subscriber does not reply to the actual call, this no reply is equivalent to a refusal. The charge for a three-minute call of the particular class required is, in this case, made.*

* This paragraph was recommended by the majority of the Administrations represented on the International Consultative Committee.

Section N.—Avis d'appel and Telephonic Préavis.

§ 1.—(4) Préavis and avis d'appel calls are (*or* are not) allowed. Add where necessary. In setting up these calls the Administrations concerned agree to conform to the advice of the International Consultative Committee under heading "Method of establishing Préavis and Avis d'appel Calls," recommendations which complete the International Regulations (Revision of Paris).

Section O.—Establishment and Disconnection of Calls.

Additional arrangements (only in the case where calls are set up by an exchange of a transit country).

When the connection necessitates the use of two international circuits entering the same transit exchange,

Indicate as the case may be { it is this exchange which controls the preparing and establishing of the circuit
or
(arrangement agreed upon mutually).

§ 2.—(3) If the traffic is large enough, the demand for calls must be transmitted between terminal exchanges in such a manner that, besides the call in progress, each terminal exchange has at least two demands for calls in each direction waiting.

§ 4.—(5) During the hours of heavy traffic the international long-distance circuits should be, as far as possible, attended to by one operator per circuit.

Article 2.*—The present Agreement will come into force at the date which will be fixed by the contracting Administrations as soon as it will have become definite according to the particular laws of the States interested.

* This article will only figure in the Agreement when it relates to the establishment of the telephonic connections between the two countries.

6. TRAFFIC STATISTICS.

RECOMMENDATIONS OF THE INTERNATIONAL CONSULTATIVE COMMITTEE.

The International Consultative Committee—

Considering :—

That to facilitate the control of the traffic and to provide the necessary arrangements for improving the service, it is desirable to collect statistics in a standard form :

That in order to arrange for a programme of future work it will be of importance to adopt common rules for traffic forecasts and to establish for the traffic between one country and other countries to which it is connected or will be connected, statistics of a uniform type.

Unanimously advises :—

1. That each Administration shall collect separately once a year statistics concerning each group of important international circuits and that, provisionally, this information be presented on Tables 1A, 1B, 2, 3 and 4, attached.

2. That each Administration shall collect, at the control desk in one day in every three months, details of the time taken for the different operations in setting up an important international connection, showing in particular the coefficient of utilisation of the circuit and that the Administrations interested shall communicate this information amongst themselves, making use, for example, of Table 5 attached.

3. That in order to estimate the probable increase of traffic the rate of increase shall be taken as that for the five normal preceding years. If the delay, the audibility, or the rates have been changed during these five years, or may be so during the future period, this must be taken into account in estimating the probable future traffic and all useful information on this subject must be furnished; if places under consideration are not yet in telephone communication, an estimation can be made from the telephone and telegraph traffic report of similar places or localities, at the same time allowing a suitable proportion for future traffic.

Recommendations regarding Traffic Statistics.

The International Consultative Committee—

Unanimously advises :—

That Administrations shall advise their telephone exchanges serving international circuits to communicate directly to connecting exchanges in the other countries the data collected at the control desk, as called for in Table 5.

The International Consultative Committee—

Considering the importance of knowing what traffic fluctuations there are on the principal groups of international circuits in the course of the same year.

Unanimously advises :—

That the Administrations shall send, every three months, to the Secretariat of the International Consultative Committee, the average daily call minutes (separated, if possible, into outgoing, incoming and transit) on the principal groups of international circuits during the past three months and also the average daily number of cancelled demands.

TABLES OF TELEPHONE TRAFFIC STATISTICS ON CIRCUIT(S) NO(S).................

between...and.. { *outgoing. / used in alternate directions. / incoming. }

(†) ....192..........

TABLE IA.

CIRCUIT(S) UNOCCUPIED OWING TO LACK OF CALLS.

Unoccupied time shown in minutes for each hour indicated below.

Dates	Hours.																
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Total																	
Average unoccupied time																	

* Strike out the words which do not apply.

† Indicate the dates on which the statistics were taken. It is recommended that statistics be taken, if possible, during six consecutive working days.

TABLE IB.

AVERAGE OCCUPIED TIME PER HOUR.

Minutes.	Hours.																	Minutes.
60	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	60
50																		50
40																		40
30																		30
20																		20
10																		10
0																		0

Table 2.

Waiting Time.

Dates.	Number of Outgoing Calls.											Number of Ineffective Calls.
	Established without delay.		With delay								Total Calls.	
			not exceeding							Exceeding 90 min.		
	*	Others.	10 min.	20 min.	30 min.	40 min.	50 min.	60 min.	90 min.			
Total												
Per cent... ..												

* Contract calls and fixed time calls.
Ordinary calls shall be shown in black and urgent calls in red.

TABLE 3.

NUMBER OF UNITS OF CONVERSATION.

Dates.	Hours.																Total.
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22 23	
Total for each hour ..																	
Average ..																	

Ordinary calls shall be shown in black and urgent calls in red.

TABLE 4.

NUMBER OF REQUESTS WAITING AT THE COMMENCEMENT OF EACH HOUR.

Dates	Hours.																
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Total for each hour																	
Average																	

Among the requests waiting must be included the subscription calls and fixed time calls to be completed during the following hour.
Ordinary calls shall be shown in black and urgent calls in red.

TABLE 5.

TABLE 5.

NAME OF EXCHANGE.	DESIGNATION OF THE CIRCUIT.	DESIGNATIONS OF THE OTHER CIRCUITS OF THE TABLE.
....	....	....
a.	*b.*	*c.*

Hour of commencement of observation (end of conversation).	Serial numbers of calls effected.	No. of called subscriber.	Time elapsed from end of preceding conversation until						Duration of conversation (difference between 8 and 7).
			Calling.	Reply from Exchange.	End of service conversation.	Beginning of conversation between subscribers.	End of conversation between subscribers.	Lines disconnected.	
1	2	3	4	5	6	7	8	9	10

TABLE 5.

DURATION OF DELAY		NAMES		DATE AND HOUR.
	from the commencement of the observation		of the Sectional Supervisor	....
	to the termination of the observation		of the Operator observed	....
	d.		*e*.	*f*.

RECAPITULATION.					CHECK.					OBSERVATIONS.
Times given by the difference between columns.				Total time shown in cols. 10–14.	Duration indicated by the calculograph.	Difference between cols. 10–16.		Number of units indicated		Indicate briefly the causes of lost time, subtracting col. 6 from col. 7. *Example:* lack of preparation; caller does not appear; waiting for extension, etc.
5–4.	6–5.	7–6.	9–8.			plus.	minus.	by observation.	on the ticket.	
11	12	13	14	15	16	17	18	19	20	

LIST OF QUESTIONS RELATING TO TRAFFIC AND OPERATING, SUBMITTED OR RE-SUBMITTED FOR INVESTIGATION.

1. General principles for determining the routes to be normally used for connections between two countries.

2. Standard method of designating circuits in all countries.

3. Standard form of agreement to be made between exchanges responsible for the collection of accounts and fees for the establishment of subscription calls.

4. The manner in which the distribution of avis d'appel is arranged in each country (International Regulation, Paris Revision, Section N, § 3).

5. In international service should fixed time calls be allowed, which the Paris Conference has only permitted as subscription calls? If the answer is Yes, what should be the charges for these connections, and should these connections be deferred some minutes when the utilisation of the circuits make this necessary?

6. How can requests for information be allowed in practice on international service so as to give subscribers the right of inquiring, without having a call, if such and such a person in the area of another exchange is a telephone subscriber, when the information operator at his own exchange cannot give these particulars; or of asking what subscriber corresponds to a certain number in another exchange; or find out the name of the person who has called his own number? What should be the charge for this information?

7. In transmitting successive demands for connections, should the number of a connection be assigned by the operator on the calling or called side?

8. Standardisation of different procedures and operating practices in effective use in all countries by the operating services.

9. Results of tests regarding the methods of diminishing lost time in international telephone connections, due to the delay by the subscriber in answering the call of the local exchange.

10. What modifications should be made in the arrangements as outlined in § 4 and § 9 of Section L of the International Regulations (Revision of Paris, 1925) concerning calls originated by, or incoming to, Stock Exchange, banks, etc.?

11. Simplification of methods of checking the number of calls passed each day between terminal exchanges (International Regulations, Section O, § 9).

12. Determination of the coefficient by which the submarine sections must be multiplied in calculating international telephone charges, in order to express the equivalent length of underground cable.

13. Is it expedient, to aid the development of international telephony, to make an exception in the obligation of guaranteeing a minimum traffic to transit countries, when it is a question of the only transit circuit?

14. Regulations governing the rental of international circuits for private service.

15. The possibility of simplifying international accounts by making general the method used for frontier connections.

Printed by Eyre and Spottiswoode, Ltd., East Harding Street, London, E.C.4.