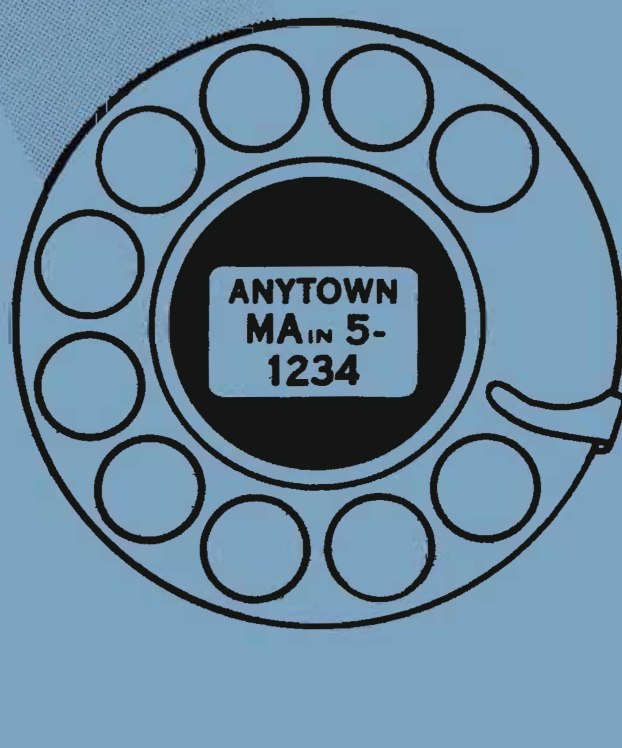
AMERICAN TELEPHONE & TELEGRAPH CO.
BELL SYSTEM
AND ASSOCIATED COMPANIES

Notes on DISTANCE DIALING

1956



NOTES ON DISTANCE DIALING

AMERICAN TELEPHONE AND TELEGRAPH COMPANY
DEPARTMENT OF OPERATION AND ENGINEERING

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Revised
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FOREWORD

These Notes outline the technical requirements for nationwide operator distance and direct distance dialing. They are a revised edition of "Notes on Nationwide Dialing - 1955", which superseded the Notes on "Nationwide Operator Toll Dialing" furnished to the U.S.I.T.A. in 1945 and published in Volume 130 (January-June 1946) of Telephony.

In the period since the Notes were first issued, several suggestions have been made to include additional material and to expand the discussion on certain subjects. In this interval, too, there have been some changes in basic plans. Therefore, it was decided to revise and reissue the Notes to provide up-to-date information.

The important changes covered by the revision are:

1. Elimination of National Center Concept (Section III).
2. Change in requirements for supervision on trunks to distant point information (Section V, Part 4B).
3. Change in requirements from "full" intercept to "adequate" intercept including a definition of "adequate" intercept (Section V, Part 4A).
4. Establishment of single-channel operation as a Bell System long range objective (Section V, Part 4G).

In addition to these changes, this new edition brings the planning maps up to date. Also, technical requirements have been revised in a few instances and charts modified for clearness. Each new or revised page is so indicated under the page number. Specific revisions and new material are indicated by arrows and brackets in the outside margin (as shown on this page).

The Notes are confined to matters bearing directly on distance dialing. In addition to the technical data required by manufacturing and engineering personnel, discussions are included covering in some detail the National Numbering Plan, the Switching Plan, Equipment, Transmission and Maintenance Considerations, etc., which should be of value to operating and maintenance people, generally. For those interested in the over-all plan rather than the technical details, the "General" section briefly outlines the contents and scope of the other sections in non-technical terms, and also discusses some of the fundamentals that are usually considered when preparing to incorporate offices into the distance dialing network.

In many instances it has been necessary to specify the particular requirements or design objectives without including a discussion of the factors underlying their selection. Also, there are many problems in the Accounting, Commercial, Public Relations and Traffic fields relating to distance dialing that are not covered by the Notes. Nevertheless, it is expected that the Notes will go a long way in furnishing information needed by the Telephone Industry for the successful integration of distance dialing plans.

It should be emphasized that the transition from local manual and ringdown toll operation to operator and direct distance dialing as described by these Notes will require an orderly program extending over a number of years. Also, it should be recognized that while the Notes describe the requirements as visualized today, details will necessarily change as experience is gained and new instrumentalities are developed. However, the fundamental plan is considered sound and it is believed that the minor changes which may be necessary will not have any serious effect on plant designed to meet the requirements outlined in the Notes.

In certain situations the requirements of the Notes need not be rigidly adhered to for operator and direct distance traffic items which will not reach the nationwide network and where exception to the provisions of the Notes will result in significant industry economy. It is recognized, too, that a book of such general nature as the Notes can not cover all details of every technical requirement for distance dialing. As to questions concerning technical matters not discussed in the Notes, direct contact at the local or state level between the Independent and Bell segments of the Telephone Industry is encouraged.

During the next few years, planning for distance dialing will involve the entire Telephone Industry in the United States and Canada. Accordingly, all Telephone Companies participating in distance dialing will be interested in the Notes. The importance of early and continuous joint planning by Independent and Bell Companies can not be overemphasized since the plans of one are bound to effect the plans of others. In this connection, the technical discussion in the minutes of the meetings of the U.S.I.T.A. Technical Subcommittee of the Subscriber and Operator Toll Dialing Committee held with representatives of the American Telephone and Telegraph Company on October 7, 1953 and on April 6 and 7, 1954 are of interest and will serve as a worthwhile supplement to the Notes.

Quite recently a proposal was made to eliminate flashing signals on the intertoll network. If adopted, this would permit the elimination of separate toll switching trains in new step-by-step offices. Advantages which would be realized if these steps are taken are:

1. Reduced central office equipment costs.
2. More economical provision of inward dialing to P.B.X. stations.
3. More rapid integration of offices not arranged for flashing signals into the distance dialing network.

Originally the Bell System and many Independents provided separate toll switching trains in the larger step-by-step offices for transmission reasons. Subsequently, three other features, flashing signals, controlled start of ringing, and prepaid coin control, were added to the toll train. With improved station instruments, the transmission requirement for toll grade battery has been eliminated. Flashing signals could be eliminated by employing tones in their place. This means that the operator would remain on the connection a little longer on some station-to-station sent-paid calls until she heard audible ringing, answer, or busy. Preliminary study indicates that this operating penalty would not be great and would tend to decrease as customer dialing of these calls is extended. With elimination of controlled start of ringing, relatively few calls would experience a slight service penalty. As to the prepaid coin control feature now provided by the toll train, study is under way to determine other means of handling this.

Since this proposal is still in the formative stage and requires further analysis and study, no changes have been made in this revision of the text concerning the features that might be affected. Should the proposal be adopted, several years would be required to complete the program. Until that time, the Notes will continue to reflect the present features.

GENERAL

CONTENTS PAGE

1. INTRODUCTION

1.01 Distance dialing (nationwide dialing) as used in these Notes, and as commonly understood within the telephone industry, means the maximum completion of dialable calls (both local and long distance) by customers, with operators dialing as much as possible of the remaining traffic which cannot be customer dialed. To designate calls dialed by customers to points outside their local or extended service area, the phrase "Direct Distance Dialing" has been adopted; and when such calls are dialed by operators, the designating phrase "Operator Distance Dialing" is used. Distance dialing has been generally accepted as an ultimate industrywide objective since this method of operation will usually provide the fastest, most accurate, and most dependable telephone service and at the same time should result in over-all operating economies. The distance dialing plan is also frequently referred to as "Continentwide" rather than "Nationwide" since it provides for the handling of long distance traffic both within and between the United States and Canada.

1.02 The Notes are intended to serve as a general reference for the Telephone Industry on the subject. They describe the minimum requirements which need to be met. Since the basic plan is designed for both operator and customer dialing, no distinction has been made between the two except in instances where the requirements are not common. Detailed description of circuit operation has been avoided and the requirements for local and toll switching systems have not been covered except where they affect distance dialing.

1.03 Generally, the Notes describe the requirements that will apply when distance (nationwide) dialing has been realized and do not cover interim arrangements which may be both expedient and appropriate during the transitional period.

2. DESCRIPTION OF SECTIONS

2.01 The Notes have been divided into seven additional sections. The first six discuss the following major elements:

(A) The National Numbering Plan - Section II

(B) Switching Plan for Distance Dialing - Section III

(C) Interoffice Signals - Section IV

(D) Equipment Requirements - Section V

(E) Transmission Considerations - Section VI

(F) Switching Maintenance Requirements and Considerations - Section VII

The remaining section furnishes supplementary material:

(G) Bibliography - Section VIII

(A) The National Numbering Plan — Section II

2.02 A primary requisite for distance dialing is that each customer be assigned a distinctive telephone number that does not conflict with the number of any other customer in the United States and Canada. It is essential that these numbers be similar in form, be convenient to use, and that they be compatible with local and extended area dialing arrangements.

2.03 Telephone numbers in distance dialing will consist of two parts:

(a) A directory number, consisting of the first two letters of the central office name followed by five numerals, commonly termed 2-5 numbering, and

(b) An area code consisting of three numerals to designate the geographical numbering plan area.

An area code is normally prefixed to the 2-5 numbers of called stations located in numbering plan areas different from that of the calling station.

2.04 Conversion to 2-5 numbering can be accomplished most economically by establishing a careful program for its introduction into all new offices and for orderly, well-planned changes in existing offices. Basically, the requirements are 2-5 directory listings, 2-5 station number cards, and a combination of letters and numbers on dial number plates. These and related numbering plan subjects are discussed in Section II.

(B) Switching Plan for Distance Dialing – Section III

2.05 A second requirement for distance dialing is a switching plan that provides for routing traffic automatically and rapidly to its destination. A general toll switching plan for handling long distance traffic on a manual basis has been in operation for more than 20 years. Some modifications are being made in this plan to adapt its use to distance dialing.

2.06 The proposed modifications of the switching plan will take full advantage of the over-all economies offered by alternate routing. The ability of the automatic switching machines to test rapidly a number of different routes makes this possible and economical. The modified plan, which is now being introduced in an orderly fashion, permits the automatic routing of calls over alternate routes when "all circuits busy" conditions are encountered on direct routes and makes possible the use of margins in one route to relieve congestion on another route to a much greater extent than under manual operation. The plan will ultimately make feasible long distance service with essentially no delays.

2.07 Section III describes the switching plan for distance dialing in considerable detail and includes in the appendices an explanation of what alternate routing is, why it is used, and how it is used.

(C) Interoffice Signals – Section IV

2.08 One of the most important needs for industrywide information brought about by distance dialing is a statement of the signaling requirements. Under manual ringdown operation, the requirements were relatively simple; signaling information was passed between toll switching centers either verbally by the operators or by "ringing" on the line. With machine switching, however, a complex system of signals will be needed to pass information over the dialing network. These signals include digital information, supervisory and charging conditions, control data, etc. They must be designed to actuate and be recognized by switching and transmission systems of many different types and manufacture, and they must be capable of being accurately and rapidly transmitted over many types of line facilities. Also, they must be applicable during the transition from manual to machine operation.

2.09 Section IV discusses the signals required for distance dialing and related matters. Considerable technical information has been included regarding the nature of the signals themselves, as well as the equipment arrangements for their generation and detection. Where necessary, the signaling capabilities and requirements of several types of toll switching and transmission systems have been specified. For informational background, a number of charts and schematic diagrams illustrating signaling fundamentals have also been included. Section IV covers in much more detail the larger part of the type of information included in the superseded Notes on "Nationwide Operator Toll Dialing." Again, since the basic signaling requirements are the same for both operator and customer dialed traffic, no distinction has been made between the two except where necessary.

(D) Equipment Requirements — Section V

2.10 There are several miscellaneous equipment requirements for distance dialing in addition to the signaling requirements detailed in Section IV. Section V summarizes these requirements and also includes brief discussions of the effect of distance dialing on station equipment, central office switching facilities, long distance switchboards, automatic equipment for recording message billing data, and miscellaneous central office and traffic administrative facilities.

2.11 Section V is confined to those specific central office equipment arrangements which will need to be provided to interconnect with the distance dialing network. No attempt has been made to cover the many other requirements for local and long distance service. The type of equipment employed is not important from the standpoint of distance dialing as long as the minimum requirements outlined in this Section and in Section IV on Signaling are met. For this reason, Section V covers a number of miscellaneous and somewhat unrelated items.

(E) Transmission Considerations — Section VI

2.12 The switching plan for distance dialing contemplates that most calls will be completed on direct circuits or over two or three intertoll links switched together in tandem. There will be a small portion of the total number of calls that will encounter as many as 7 intertoll circuit links within Canada or the U.S. and 8 intertoll circuit links between Canada and the U.S. This will require careful transmission design as well as more concentrated effort than in the past in maintaining transmission values close to design objectives. Transmission design and transmission maintenance are discussed generally in Section VI.

2.13 The transmission requirements for distance dialing raise no design problems that differ in degree from the transmission design problems of the Telephone Industry since its beginning. Design factors and objectives for trunk plant are covered in some detail in Section VI. In addition, since satisfactory transmission over subscriber loops to the local offices is as important to distance dialing as is transmission on the trunk plant, subscriber loop design is also discussed.

2.14 It will become increasingly important that transmission stability be improved as distance dialing is extended. Improved procedures and techniques will be required because with automatic multi-alternate routing, often involving a number of intertoll links connected together on a particular call, the problem of identifying a particular circuit having transmission trouble will become more difficult. Section VI also discusses a new method of rating transmission performance together with transmission maintenance considerations on trunk plant.

(F) Switching Maintenance Requirements and Considerations — Section VII

2.15 Alternate routing involving machine multi-switched connections will also require a high level of equipment maintenance performance at the toll switching centers. This can be best accomplished by the use of automatic test and fault recording devices so that troubles may be promptly detected and corrected before they have any serious impact on service. Unless adequate steps are taken to keep trouble conditions within reasonable limits, they will not only react unfavorably on the customers, who will normally be the first to detect them, but also will result in the inefficient use of the nationwide distance dialing network.

2.16 Means have been developed for the automatic detection and recording of troubles, and their correction where feasible, so that most circuit and equipment troubles may be cleared before they can cause service reactions. These means consist of automatic testing equipment, test lines and various carrier and other testing facilities. Testing facilities suited to the needs of distance dialing are described in Section VII together with suggestions for their application.

(G) Bibliography — Section VIII

2.17 As mentioned in the beginning of Section I, it is intended to describe in these Notes the minimum requirements to be met in order to connect with the nationwide distance dialing network. For those who may wish to explore in more detail subjects related to nationwide dialing, the Bibliography, Section VIII, is furnished as a source of reference material.

3. FUNDAMENTAL PLANS

3.01 In addition to the above subjects which are covered in detail in the remaining sections, it may be found worthwhile to consider briefly the fundamental plans which are the keystone to the inclusion of every office, large or small, in the nationwide dialing network. If plans are made early, the transition from local manual and ringdown toll operation to nationwide operator distance and direct distance dialing can be made in an orderly manner and without incurring unwise expenditures. Flexible plans can be developed which will permit adjustments as necessary to meet changing conditions. It is desirable that the plans be kept up-to-date in order to take full advantage of new developments in the art.

3.02 Fundamental planning for distance dialing includes the following broad fields:

(1) Analysis of fundamental traffic data and methods.

(2) Plans for equipment for automatically recording and processing message billing data for direct (customer) dialed extra charge traffic.

(3) Design of local central offices (and subscriber loops), including numbering plans.

(4) Design of trunk plant, including the types of transmission facilities and machine switching equipment.

3.03 Traffic analysis is an early step in fundamental planning and includes the determination of such items as:

(a) Future routings under the general toll switching plan for distance dialing.

(b) Estimates of future traffic volumes and possible changes in the characteristics of traffic to include consideration of the portion of traffic which may be dialed economically by customers and the portion which will continue to be operator dialed.

3.04 Because of the service improvements and operating economies that can be obtained from direct dialing of extra charge traffic, systems for automatically recording and processing message billing data usually receive early and detailed consideration in fundamental planning. The factors pertaining to this phase of planning which may be studied include:

(a) The type of station identification to be employed.

(b) Whether individual recording systems at each local office or one centralized system to serve several offices should be employed.

(c) Traffic volumes and the relative proportion of detailed and bulk billed direct dialed calls.

3.05 The fundamental planning for a local exchange that is to be connected to the nationwide distance dialing network includes provision for:

(a) A 2-5 numbering plan.

(b) The 2-5 directory listing of customers' numbers.

(c) The segregation of coin boxes (public or semipublic telephones) in certain recommended thousand series to the extent possible.

(d) Adequate interception of non-assigned station numbers and vacant central office codes.

(e) The signaling requirements outlined in Section IV.

(f) Subscriber loop design (as described in Section VI) which will establish the lowest loop loss consistent with economy.

3.06 Fundamental planning for trunk plant (switching equipment, outside plant and terminal facilities) takes the following to account in looking forward to distance dialing:

(a) All plant should be equipped with or arranged for the addition of the features needed to meet the minimum requirements outlined in these Notes.

(b) The most economic transmission facilities (e.g., carrier, radio, voice frequency, etc.) should be selected for relief on existing routes and on new routes that may be established. This will involve such factors as:

(1) Future traffic volumes and trunking requirements.

(2) The transmission design objectives under the general toll switching plan for distance dialing.

(3) The establishment of an approximate but realistic timetable for the programming of the various phases of mechanization for both operator and direct dialed traffic - incoming and outgoing.

THE NATIONAL NUMBERING PLAN

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1. GENERAL

1.01 An essential element of distance dialing is a uniform system wherein each local central office will have a unique designation which is, nevertheless, similar in form to that of all other offices connected to the nationwide distance dialing network. With such an arrangement operators or customers, wherever located, may use that designation as a "destination code" to reach the required office through the dial switching network. All offices, in effect, become a part of one huge multioffice area with each office having its own distinctive identity for routing purposes. In addition to being readily understandable and convenient to use, these designations should be capable of being used accurately, since a misdialed call results in uneconomic circuit and switching usage and, more important, may result in a charge to a customer's account if not reported to the operator.

1.02 The numbering plan discussed in this section meets these requirements. A maximum of 10 digits is required. The first 3, reading from left to right, are the "area code" and the next 3 are the "office code." Together they comprise the required unique designation for each central office. The remaining 4 digits constitute the "station number" of the telephones served from the particular office. The 3-digit office code plus the 4-digit station number make up the 2-letter, 5-numeral (2-5) customer's number as listed in the telephone directory. The arrangement is shown on Chart 1, attached, and is described in detail in the following paragraphs.

2. NUMBERING PLAN AREAS

2.01 The United States and Canada have been divided geographically into numbering plan areas each of which is assigned a distinctive 3-digit designation called the area code. Calls between numbering plan areas (foreign area calls) will, in general, require dialing the code of the area in which the called station is located as well as the called customer's listed telephone number. Home area calls, which originate and terminate within the same area, will ordinarily require dialing only the called customer's listed number which consists of the office code and the station number. In this geographical division into numbering plan areas, borderlines between states and between Canadian Provinces have generally been used as area boundaries. Since, as will be shown later, only about 500 central offices can be served in a numbering plan area without office code conflicts, it was necessary to divide the more populous states and provinces into two or more areas. New York State is divided into seven numbering plan areas; Texas and California each has five; and Pennsylvania, Illinois and Ohio each has four. Other divided states have three or two areas depending upon the number of offices to be served. 109 areas, as shown on Chart 2, have been established to date. Appendix A to this section is included to show the numbering plan area codes in convenient tabular form.

2.02 In fixing the intrastate numbering plan boundaries of subdivided states, effort was made to avoid cutting across heavy toll traffic routes in order to have as much of the toll traffic as possible terminate in the area in which it originates. Also, wherever possible, the boundaries have been set to avoid having central offices in one area be tributary to toll offices in an adjacent area. With the numbering plan areas arranged in this manner much intrastate dialing can be kept on a 7-digit basis.

3. NUMBERING PLAN AREA CODES

3.01 As shown on Chart 1, the numbering plan "area code" consists of three digits. If the middle digit is either a "1" or a "0" (zero) the switching equipment will be able to distinguish the area codes from the central office codes, for the latter will always have a letter (corresponding to a numerical digit from 2 through 9) in the middle position, as explained in Part 4 below. Accordingly, the area codes consist of three digits with either a "1" or "0" (zero) in the middle position; e.g., 516, 201, 607, etc.

3.02 There are 80 possible combinations with "0" in the middle (called X0X codes), digits "2" to "9" in the first position*, and all digits "0" to "9" in the third position. However, only 72 usable "X1X" combinations are available for area codes since "1" may not be used in the third position because such codes as 211, 411, etc., are used in many places for service codes. There are, then, 152 possible area code combinations. Since 109 of these have been assigned to date, it is evident that, because of the limited supply, assignment of area codes must be made on the basis of actual needs. Chart 2, attached, shows the present area code assignments. It will be noted that assignments are made from the X0X and X1X series without regard as to whether the areas are entire states or subdivisions of states, although at one time it was thought that such a distinction might be made.

4. CENTRAL OFFICE CODES (2-5 NUMBERING PLAN)

4.01 The central office codes that meet the requirements of the national numbering plan consist, as shown on Chart 1, of three digits, the first two of which are the first and second letters, respectively, of the central office name. The third digit is a numeral. When the four numerals that designate the station number of a particular telephone in a central office are added to the central office code the resulting 7-digit number becomes the customer's 2-5 number. This 2-5 number completely and uniquely describes each telephone within any numbering plan area as long as no two central offices in the area employ identical "office codes." The 2-5 form was selected for nationwide distance dialing because it has been used in the largest cities for local dialing for a number of years with satisfactory results, and, now more important, it furnishes the largest number of office codes of any system in use.

4.02 A typical 2-5 number is LOcust 4-5678; the office code is the LO4 and the last four digits are the station number. This 2-5 number, when combined with an area code, forms the number for foreign area dialing, for example 613-LO4-5678.

4.03 Any one numbering plan area is limited to about 500 central office units. The 2-5 numbering system will theoretically furnish 640 office code combinations (8 x 8 x 10, for letters appear only on dial positions 2 to 9, inclusive), but it is difficult, and in some cases impossible, to find suitable names with initial letters corresponding to certain code combinations such as 55, 57, 95, and 97. Accordingly, these combinations are reserved for radiotelephone use. In addition it has been considered desirable to avoid the use of the digit 0 (zero) as

*It is not practical to use either "1" or "0" (zero) for the initial digit of the area code since customers dial "0" to reach the operator and most local dial equipments are arranged to ignore an initial "1" which may be a preliminary pulse.

the third digit of an office code because of possible confusion with the letter O (oh). These factors, together with some other limitations on the availability of office codes, make the practical upper limit of the 2-5 numbering system about 500 codes.

5. CENTRAL OFFICE CODES - CONVERSION OF EXISTING NUMBERING PLANS TO 2-5 FORM

5.01 Offices now using 4-digit numbers may be converted to 2-5 numbering by the addition of a central office name and a numerical digit; 5-digit offices may be given 2-5 numbering by adding a central office name and allowing the initial numeral of the present 5-digit number to become the third digit (the numeral) of the new office code. Offices having 6-digit, all numerical, telephone numbers may be changed to 2-5 numbering by prefixing a name whose second letter corresponds to the present initial digit; the present second digit will then be the third or numerical digit in the office code of the 2-5 number. In 6-digit offices employing central office names (2-4 numbering), where the initial two letters of the name represent the office code, the transition to 2-5 may sometimes be accomplished by inserting a digit between the present office code and the thousands digit of the station number. In other instances it may be more practical to change the two initial digits of the office code, which means that a different office name must be selected.

5.02 In the ultimate plan the total number of letters and numerical digits in each telephone number should be limited to 7. Mixtures of 7- and 8-digit numbers, resulting either from prefixing office names to existing 5-6-digit mixtures, or retention of party line letters, should be avoided. Such mixtures would not be too serious an obstacle to operators with keysets since a start key is operated after the complete number has been keyed to start the call on its way. Direct distance dialing will, however, be penalized because common control equipment at an originating point will not know whether to expect 7 or 8 digits following an area code and must, therefore, wait for a possible eighth digit on all calls. This means that a delay of some few seconds will be introduced on all direct dialed calls terminating in any area having even one office with 8-digit numbers or party line letters. This forced delay seems inconsistent with direct distance dialing speed objectives and adds to equipment costs at distant places. Also, mixed 7- and 8-digit numbers would undoubtedly increase dialing errors on both operator and direct dialed traffic. Accordingly, the design requirements specified for Bell System equipment now under development do not provide for the completion of direct dialed calls to places having 2-6 numbers, or 2-5 numbers with party line letters. The program to consolidate all offices on a 2-5 basis will be completed in a few years and it seems prudent to move toward this objective at every appropriate opportunity.

5.03 Although 2-5 numbering is needed for distance dialing, local calls may be completed by using the last four digits, the last five digits, or the entire 7-digit number. The choice depends upon the number of telephones in the local dialing area, the proximity to a city where the entire 2-5 number is dialed, the frequency with which the local service is used by visitors and transients accustomed to dialing all of the digits of 2-5 numbers, and other factors. For extended area (local service) dialing, a 2-5 arrangement will be desirable; in some multioffice cities it may be mandatory and in many instances it may be economically attractive from a trunking standpoint. If desired, 7-digit local dialing in small offices can usually be provided for new installations at little additional expense by the use of digit-absorbing or "drop-back" selectors or equivalent relay equipment.

5.04 With regard to numbering arrangements, the requirements for nationwide direct dialing include:

2-5 directory listings,
2-5 numbers on station number cards, and
a combination of letters and numbers on dial number plates.

Even though local dialing may be on a 4- or 5-digit basis, it is desirable that arrangements be provided to complete those local calls for which the entire 2-5 listed number is dialed. Digit-absorbing selectors in the first stage of the local train will usually accomplish this quite inexpensively. These selectors may be adjusted to absorb two or three of the office code digits as required, and to trunk on the proper numerical digit, or to trunk at once when the abbreviated local number is dialed. At existing step-by-step offices, digit-absorbing selectors may be installed on all growth projects to provide, on a "stock-piling" basis, the necessary equipment for future conversion to 2-5 listings. The regular selectors thus displaced may be used elsewhere in the switching train. Selection of office codes should be made with due consideration for the digit-absorbing features that will be available.

6. THE RELATION OF CENTRAL OFFICE CODES TO CENTRAL OFFICE EQUIPMENT

6.01 Conservation of Central Office Codes, which in turn saves area codes, is essential since over two-thirds of the available numbering plan area codes have been assigned. Should the area codes ever become exhausted it would be necessary to revise the entire numbering plan which might require exceedingly expensive changes in the design of common control equipment. It is important, therefore, that plans for dial conversions and new offices avoid terminal-per-line equipment where its use will consume an excessive number of central office codes. With typical line fills in T.P.L. offices one office code will be needed for each 2000 to 4000 main stations, whereas one code will care for a theoretical maximum of 10,000 subscriber numbers in a terminal-per-station office. This follows because each "code" can be associated with only 1000 line numbers in a T.P.L. office since one of the last four digits of the 2-5 number must be used to select a ringing code or frequency in step-by-step and similar offices arranged for T.P.L. operation.

6.02 Another situation which may deplete the number of available office codes is the establishment of small local switching centers at new locations. When considering such new centers proper weight should be given to the numbering plan aspects as well as to other economic and service factors. Use of line concentrators may help to permit economical service to new groups of telephone customers from existing switching centers.

6.03 Office Codes for Operator Dialing to Other Than 2-5 Numbers: Thousands of central offices do not yet have 2-5 type numbers and it will necessarily be several years before they can all be converted. During this period it may be necessary to employ office codes for operator toll dialing which are unlike those used for local dialing. Some of these codes can be derived from the customers' telephone numbers; others cannot. For example, Minneapolis presently has mixed 2-4 and 2-5 numbers. On a call to the 2-4 Cedar office, the operator dials CED for the office code; on a call to the 2-5 Victor 4 office, she dials VI4. However, to call a telephone in Fairburn, Georgia, a tributary of Atlanta with only four digits in the local numbers, the operator uses an arbitrary numerical code, 894, which must be different from all other office codes in this numbering plan area. The code used to reach an office where the listed number does not furnish complete information is secured from a position bulletin or the route operator. This reference work takes time, costs money, and imposes a delay in completing the call.

6.04 Customers could not be expected to follow complex rules such as these. Nationwide direct distance dialing is feasible only when the central office code of the called number is an integral part of the listed number. Accordingly, only places using 2-5 numbers will be connected to the nationwide distance dialing network for inward distance dialing.

6.05 Manual offices in some exchanges have numbers such as LO4-6789-J and LO4-10325. Such numbers do not meet the ultimate numbering plan requirements because of the penalties discussed in Paragraph 5.02.

6.06 It is desirable to change all numbers in a city to 2-5 at one time. However, in many of the larger cities, practical considerations frequently require passing through an intermediate stage where mixed numbering systems, such as combinations of 2-4 and 2-5, or five digits and 2-5 are employed. Usually additional numbers are changed to 2-5 with each new directory, until after two or more directory issues, the entire city is converted. Mixed numbers should not be continued longer than necessary since they impose expense and service penalties on inward operator distance dialing and preclude inward direct distance dialing. They also tend to increase the dialing errors on local calls. It is especially desirable that the cities to be served through a 4A toll switching system be placed on a 2-5 basis prior to the service date of this equipment to avoid subsequent equipment alterations at the 4A office and changes in routing information at many widely separated points.

7. TOLL CENTER AND OPERATOR CODES

7.01 In addition to the distinctive 3-digit code assigned to every central office, each toll center (Class 1, 2, 3, or 4C offices as defined in Section III) is also given a 3-digit "terminating toll center" (TTC) code to enable outward operators in distant cities to reach inward, information, delayed call, and similar operators at that toll center. Calls to these operators will be routed in the same manner as calls to subscriber numbers except that the assigned TTC code will be used instead of a central office code and an "operator" code will be used instead of a station number.

7.02 Terminating toll center (TTC) codes consist of three numerical digits selected from outside the local office and radio telephone series, i.e., should have a 0 (zero) or 1 (one) in the first and/or second places and may have any number 0 to 9 as the third digit. An example of a TTC Code is 169.

7.03 Operator codes used for reaching the various toll operators are:

121	Inward	181	Toll Station
131	Information		
141	Route	* 11XX or *11XXX	Delayed Call (TX)

*X = any number from 0 to 9

7.04 On an operator call from a city in a foreign area to Youngstown Information the code series might be 216 + 146 + 131 where 216 is the numbering plan area code, 146 the toll center code, and 131 the operator code for Information. Similarly, on a call from a foreign area to the Akron inward operator, since Akron is in the same area as Youngstown, the code series might be 216 + 162 + 121. On calls to operators at toll centers in the home numbering plan area, the area code would be omitted.

7.05 There will be a few exceptions to the practice described above. In order to economize operator and machine work time, the toll center code for one major city in most numbering plan areas will be eliminated. For example, there will be no TTC code for Des Moines in the central Iowa numbering plan area. To reach the Des Moines Information operator from a foreign area, it will merely be necessary to dial the area code plus 131, i.e., 515 + 131. To reach the operators at this major city from other places in the same numbering plan area where the intertoll trunks appear in the multiple it is ordinarily necessary to dial only the desired operator code. From locations where the intertoll trunks are reached via tandem trunks and common control toll switching equipment, it may be necessary to dial the area code plus the desired operator code as when calling to a major city from a foreign numbering plan area.

8. NUMBERING OF COIN BOX STATIONS

8.01 On a collect toll call the outward or originating toll center operator must determine whether or not a coin box station (public or semi-public telephone) is being called. The switchboard bulletin usually indicates the thousand series used for coin station numbers in a given city. If the number called happens to be in one of these thousand series, or if the point is not on the position bulletin, the operator must call "information" at the terminating toll center to obtain the status of the number. This check consumes operator work time and slows the service. Greater segregation of coin numbers improves the service and increases operating efficiency. The ideal arrangement is to have all coin stations assigned to the 9 thousand series, e.g., CAnal 5-9XXX. However, other series such as the 7 and 8 thousands are also employed; the 8 thousand series is next in preference after the 9 thousand series.

8.02 The larger Bell and Independent exchanges, for the most part, have their coin numbers segregated in the 9 thousand or the 8 and 9 thousand series. In small exchanges employing digit-absorbing selectors, such segregation may make certain office codes unusable or may even require another stage of selectors. Nevertheless, segregation of coin numbers in all exchanges is a most desirable ultimate objective. If all coin numbers were segregated in the 9 thousand series, outward operators would never need to check the bulletins for the possible presence of coin numbers in other thousand series.

9. CENTRAL OFFICE NAMES

9.01 The central office names now in use throughout the country were generally chosen for customer dialing within the local exchange area. In fact, many were selected before the introduction of dial service. Frequently these names have local significance but are totally unfamiliar to operators and customers in distant cities; consequently, their use may contribute materially to dialing errors. This situation is gradually being corrected by selecting names for new offices from a suitable list, and by replacing existing names, which experience has shown to be particularly troublesome, with names from this list. A list of suggested central office names is included as Appendix B to this section.

9.02 With the general adoption of 2-5 numbers, the retention or selection of town or community names for office names will be virtually impossible because of code conflicts or difficulties in pronunciation and spelling which would be a continual cause of errors. Furthermore, many places are served by direct control central office equipment in which the trunking arrangements are directly related to the dialed digits of the telephone number. In order to provide economical trunking, office code digits should conform to the trunking pattern; the letters of locality names seldom meet these requirements.

9.03 From these considerations, it is inevitable that a large number of offices will require nonlocality names in their 2-5 numbers. Therefore, it will be advantageous to choose all central office names from the recommended list, instead of using this list only to resolve code conflicts, replace undesirable place names, or meet step-by-step trunking requirements. Uniform name assignments benefit both operator and direct distance dialing since the letters of an office name, rather than a town name, will always be used when dialing a toll call.

9.04 Through misunderstanding, customers in suburban communities and small towns often resent the transition to 2-5 numbering employing a central office name other than their locality name because they are under the impression that the name of their exchange is being changed. This situation can be avoided if publicity effectively explains that a central office name is being added to their number in order to provide for distance dialing.

9.05 It is suggested that the ultimate office code assignments in a numbering plan area be developed by:

(a) Giving each unit or partial unit the numerical code which will result in the most economical trunking arrangement.

(b) Selecting a name, corresponding to this code, from the list given in Appendix B.

The ultimate arrangement should include provision for offices required for growth and for the possible expansion of local dialing areas (extended area service).

9.06 A sound numbering plan is an essential part of long range planning. Plans made now will vitally affect later equipment arrangements, directory listings, public relations, and the benefits that will be derived from operator and direct distance dialing. In addition the cost of converting from the present to the proposed arrangement may be materially reduced by advance planning, while permitting a transition in an orderly manner.

10. NUMBERING FOR AN OFFICE SERVING CUSTOMERS IN TWO NUMBERING PLAN AREAS

10.01 A central office located on or near the boundary of a numbering plan area may furnish local service to customers located in the adjacent area. Chart 3 shows, as an example, an office in Nebraska (402 Area) that serves stations located in Kansas (913 Area). The assignment of central office codes should be such that all calls, long distance as well as local, to and from these customers, will be properly routed and properly charged. There must be no ambiguity.

10.02 The 2-5 number central office code assignments are to some extent dependent upon the arrangement of the originating portion of the central office equipment. Referring again to Chart 3:

(1) If the Nebraska customers and the Kansas customers are not segregated in the originating portion of the C.O.E. the customers located in Kansas should be given a 2-5 number, such as ADams 3-1234, with a code not used elsewhere in either the 913 or 402 Areas. The Nebraska customers, of course, will be assigned numbers in conformity with the numbering plan for the 402 Area.

(2) If the 402 Area and 913 Area customers are segregated in the originating portion of the C.O.E. -

(a) The code given the Nebraska customers should not be used in the Kansas 913 Area.

(b) The customers located in Kansas (913 Area) should be given a code not used elsewhere in either the 913 or 402 Areas.

→ 10.03 Outgoing Calls: With either arrangement, all customers served by the central office may call each other on a 7-digit, local service, basis. For outward direct distance calling, if the customers in Nebraska and those in Kansas are segregated on the originating portion of the equipment, each group could dial other offices in their respective areas on a 7-digit basis, while dialing to all other areas would be on a 10-digit basis. However, if the two groups are not segregated all customers must use the same dialing procedure; i.e., that used by the Nebraska (402 Area) customers. Both groups will then dial all Nebraska 402 Area offices on a 7-digit basis, and all other areas, including Kansas and the Nebraska 308 Area, on a 10-digit basis.

10.04 Incoming Calls: In order to meet interstate tariff regulations, the directory and also the Toll Rate and Route Guide should indicate the numbering plan area in which the customers are actually located. That is, the customers in Kansas should be shown as being located in the 913 Area even though they are served from central office equipment located in the 402 Area. Direct distance dialing, from places other than those in the appropriate home numbering plan area, will ordinarily be on a numbering plan area (10-digit) basis.

11. NUMBERING FOR OFFICES SITUATED IN ADJACENT NUMBERING PLAN AREAS WITH EXTENDED SERVICE BETWEEN THEM

11.01 It is desirable to avoid the use of an area code on calls between offices where no extra charge is involved. Hence a customer served by office "M" in, say, the 218 numbering plan area, should be able to make extended area service calls to office "N" in, say, the 612 Area by dialing only the listed 2-5 number. To make this possible the code of office "N" must not be used in the 218 Area and, likewise, the code of office "M" must not be used in the 612 Area.

Attached:

Charts 1 through 3

→ Appendix A - Numbering Plan Areas With Codes

→ Appendix B - List of Suitable Central Office Names

THE NATIONAL NUMBERING PLAN

Figure 1

Composition of the National Number

The National Number consists of ten digits arranged as follows:

			Listed Directory Number						
Area Code			Office Code			Station Number			
X	X'	X"	L	L	N	N	N	N	N

Where L = A letter from Figure 2 below
N = Any numeral from 0 to 9
X = Any numeral from 2 to 9
X' = 0 (zero) or 1
X" = Any numeral from 0 to 9 when X' = 0
Any numeral from 0 to 9 except 1 when X' = 1

Figure 2

Dial Pulses Corresponding to Letters of the Office Code Portion of the National Number

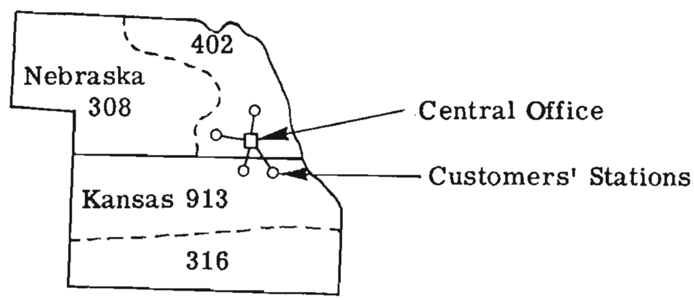
Letters	No. of Dial Pulses
A B C	2
D E F	3
G H I	4
J K L	5
M N O	6
P R S	7
T U V	8
W X Y	9

NUMBERING PLAN AREAS WITH CODES

Revised
September 1956

SECTION II
Chart 2

NUMBERING FOR AN OFFICE SERVING CUSTOMERS IN TWO NUMBERING PLAN AREAS



Originating Equipment Arranged:	Nebraska Customer's Code must be:	Kansas Customer's Code must be:
Not to Segregate Kansas Customers	In conformity with numbering plan for the 402 area.	Protected in both Nebraska (402) and Kansas (913) areas.
To Segregate Kansas Customers	Protected in Kansas (913) area.	Protected in both Nebraska (402) and Kansas (913) areas.

NUMBERING PLAN AREAS AND CODES - BY AREA CODE NUMBER
SEPTEMBER 1956

Numbering Plan Area	Area Code
New Jersey	201
District of Columbia	202
Connecticut	203
Manitoba	204
Alabama	205
Washington	206
Maine	207
Idaho	208
Unassigned	209
New York	212
California	213
Texas	214
Pennsylvania	215
Ohio	216
Illinois	217
Minnesota	218
Indiana	219
Maryland	301
Delaware	302
Colorado	303
West Virginia	304
Florida	305
Saskatchewan	306
Wyoming	307
Nebraska	308
Unassigned	309
Illinois	312
Michigan	313
Missouri	314
New York	315
Kansas	316
Indiana	317
Louisiana	318
Iowa	319
Rhode Island	401
Nebraska	402
Alberta	403
Georgia	404
Oklahoma	405
Montana	406
Unassigned	407
Unassigned	408
Unassigned	409
Pennsylvania	412
Massachusetts	413
Wisconsin	414
California	415
Ontario	416
Missouri	417
Quebec	418
Ohio	419
Arkansas	501
Kentucky	502
Oregon	503
Louisiana	504
New Mexico	505
The Maritimes	506
Minnesota	507
Unassigned	508
Washington	509
Texas	512
Ohio	513
Quebec	514
Iowa	515
New York	516
Michigan	517
New York	518
Ontario	519
Mississippi	601
Arizona	602
New Hampshire	603
British Columbia	604
South Dakota	605
Kentucky	606
New York	607
Wisconsin	608
New Jersey	609
Minnesota	612
Ontario	613
Ohio	614
Tennessee	615
Michigan	616
Massachusetts	617
Illinois	618
Unassigned	619
North Dakota	701
Nevada	702
Virginia	703
North Carolina	704
Ontario	705
Unassigned	706
Unassigned	707
Unassigned	708
Unassigned	709
Iowa	712
Texas	713
California	714
Wisconsin	715
New York	716
Pennsylvania	717
Unassigned	718
Unassigned	719
Utah	801
Vermont	802
South Carolina	803
Unassigned	804
California	805
Unassigned	806
Unassigned	807
Unassigned	808
Unassigned	809
Indiana	812
Florida	813
Pennsylvania	814
Illinois	815
Missouri	816
Texas	817
Unassigned	818
Quebec	819
Tennessee	901
The Maritimes	902
Unassigned	903
Unassigned	904
Unassigned	905
Unassigned	906
Unassigned	907
Unassigned	908
Unassigned	909
Georgia	912
Kansas	913
New York	914
Texas	915
California	916
Unassigned	917
Oklahoma	918
North Carolina	919

Unassigned Codes ending in "0" have not been shown. It is not expected that such codes will be assigned for some time.

NUMBERING PLAN AREAS AND CODES - BY GEOGRAPHICAL LOCATION

SEPTEMBER 1956

Numbering Plan Area	Area Code	Numbering Plan Area	Area Code
Alabama	205	Kansas	316
		"	913
Arizona	602		
		Kentucky	502
Arkansas	501	"	606
California	213	Louisiana	318
"	415	"	504
"	714		
"	805	Maine	207
"	916	Maryland	301
Colorado	303	Massachusetts	413
		"	617
Connecticut	203		
		Michigan	313
Delaware	302	"	517
		"	616
District of Columbia	202		
		Minnesota	218
Florida	305	"	507
"	813	"	612
Georgia	404	Mississippi	601
"	912		
		Missouri	314
Idaho	208	"	417
		"	816
Illinois	217		
"	312	Montana	406
"	618		
"	815	Nebraska	308
		"	402
Indiana	219		
"	317	Nevada	702
"	812		
		New Hampshire	603
Iowa	319		
"	515	New Jersey	201
"	712	" "	609

Numbering Plan Area	Area Code	Numbering Plan Area	Area Code
New Mexico	505	Utah	801
New York	212	Vermont	802
" "	315		
" "	516	Virginia	703
" "	518		
" "	607		
" "	716	Washington	206
" "	914	"	509
North Carolina	704	West Virginia	304
" "	919		
		Wisconsin	414
North Dakota	701	"	608
		"	715
Ohio	216		
"	419	Wyoming	307
"	513	Canada	
"	614		
Oklahoma	405	Ontario	416
"	918	"	519
		"	613
Oregon	503	"	705
Pennsylvania	215	Quebec	418
"	412	"	514
"	717	"	819
"	814		
Rhode Island	401	British Columbia	604
South Carolina	803	Alberta	403
South Dakota	605	Saskatchewan	306
		Manitoba	204
Tennessee	615	The Maritimes	506
"	901	" "	902
Texas	214		
"	512		
"	713		
"	817		
"	915		

LIST OF SUITABLE CENTRAL OFFICE NAMES
With ( ) Directory Abbreviations

22 Series

Academy (ACdmy)
Baldwin (BAldwn)
Canal (CAnl)
Capital (CAptl)
Castle (CAstl)

23 Series

Adams (ADms)
Belmont (BElmnt)
Beverly (BEvrly)
Cedar (CEdr)
Center (CEntr)
  Central (CEntrl)

24 Series

Chapel (CHapl)
Cherry (CHery)
Chestnut (CHstnt)
Churchill (CHrchl)
Circle (CIrcl)

25 Series

Alpine (ALpin)
Blackburn (BLakbrn)
Clearbrook (CLerbrk)
  Clearwater (CLerwtr)
Clifford (CLifrd)
Clinton (CLintn)

26 Series

Amherst (AMhrst)
Andrew (ANdrw)
  Andrews (ANdrw)
Colfax (COlfx)
Colony (COlny)
Congress (COngrss)

27 Series

Bridge (BRidg)
Broad (BRoad)
  Broadway (BRdwy)
Brown (BRown)
  Browning (BRowng)
Crestview (CRstvw)
  Crestwood (CRstwd)

28 Series

Atlantic (ATlntc)
Atlas (ATlas)
Atwater (ATwtr)
Avenue (AVenu)
Butler (BUtlr)

29 Series

Axminster (AXmnstr)
Axtel (AXtel)
Cypress (CYprss)

32 Series

Davenport (DAvnprt)
Davis (DAvis)
East (EAst)
  Eastgate (EAstgat)
Faculty (FAclty)
Fairfax (FAirfx)
  Fairview (FAirvw)

33 Series

Deerfield (DErfld)
Dewey (DEwy)
Edgewater (EDwtr)
  Edgewood (EDgwd)
Edison (EDisn)
Federal (FEdrl)

34 Series

Diamond (DImnd)
Dickens (DIkns)
Fieldbrook (FIeldbrk)
  Fieldstone (FIeldstn)
Fillmore (FIlmor)
Fireside (FIresd)

35 Series

Elgin (ELgn)
Elliot (ELiot)
Elmwood (ELmwd)
Flanders (FLandrs)
Fleetwood (FLetwd)

36 Series

Emerson (EMrsn)
Empire (EMpir)
Endicott (ENdicot)
Forest (FOrest)
Foxcroft (FOxcrft)

37 Series

Drake (DRake)
Drexel (DRexl)
Essex (ESex)
Franklin (FRnkln)
Frontier (FRntir)

38 Series

Dudley (DUdly)
Dunkirk (DUnkrk)
Dupont (DUpnt)
Evergreen (EVrgrn)
Fulton (FUltn)

39 Series

Exbrook (EXbrk)
Exeter (EXetr)
Export (EXprt)
Express (EXprss)

42 Series

Garden (GArdn)
Garfield (GArfld)
Hamilton (HAmltn)
Harrison (HArisn)
Hazel (HAzl)

43 Series

General (GEnrl)
Geneva (GEneva)
Hemlock (HEmlok)
Hempstead (HEmstd)
Idlewood (IDlwd)

44 Series

Gibson (GIbsn)
Gilbert (GIlbrt)
Hickman (HIckmn)
Hickory (HIkry)
Hillcrest (HIlcrst)
  Hilltop (HIltp)

45 Series

Gladstone (GLadstn)
Glencourt (GLencrt)
  Glendale (GLendl)
  Glenview (GLenvw)
Globe (GLobe)

46 Series

Hobart (HObrt)
Homestead (HOmstd)
Hopkins (HOpkn)
Howard (HOwrd)
Ingersoll (INgrsl)

47 Series

Granite (GRnit)
Greenwood (GRnwd)
  Greenfield (GRnfld)
  Greenleaf (GRnlf)
Grover (GRovr)
Gridley (GRidly)

48 Series

Hubbard (HUbbrd)
Hudson (HUdsn)
Hunter (HUntr)
  Huntley (HUntly)
Huxley (HUxly)
Ivanhoe (IVnho)

49 Series

Gypsy (GYpsy)
Hyacinth (HYcnth)
Hyatt (HYat)

52 Series

Jackson (JAksn)
Lafayette (LAfayet)
Lakeside (LAksd)
  Lakeview (LAkvw)
Lambert (LAmbrt)
Lawrence (LAwrnc)

53 Series

Jefferson (JEfrsn)
Kellogg (KElog)
Keystone (KEystn)
Lehigh (LEhi)
Lenox (LEnox)

54 Series

Kimball (KImbl)
Kingsdale (KIngdl)
  Kingswood (KIngwd)
Liberty (LIbrty)
Lincoln (LIncn)
Linden (LIndn)

55 Series

Reserved for
Radiotelephone

56 Series

John (JOhn)
Jordan (JOrdn)
Locust (LOcst)
Logan (LOgn)
Lowell (LOwel)

57 Series

Reserved for
Radiotelephone

58 Series

Juniper (JUnipr)
Juno (JUno)
Justice (JUstce)
Ludlow (LUdlo)
Luther (LUthr)

59 Series

Lyceum (LYceum)
Lyndhurst (LYnhrst)
Lynwood (LYnwd)
Lyric (LYric)

62 Series

Madison (MAdsn)
Main (MAin)
Market (MArkt)
Mayfair (MAyfr)
National (NAtl)

63 Series

Medford (MEdfrd)
Melrose (MElros)
Mercury (MErcry)
Neptune (NEptn)
Newton (NEwtn)
  Newtown (NEwtn)

64 Series

Midway (MIdwy)
Milton (MIltn)
Mission (MIssn)
Mitchell (MItchl)
Niagara (NIagra)

65 Series

Oldfield (OLdfld)
Olive (OLiv)
  Oliver (OLivr)
Olympia (OLmpia)
  Olympic (OLmpic)

66 Series

Mohawk (MOhwk)
Montrose (MOntrse)
Morris (MOris)
Normandy (NOrmdy)
North (NOrth)
  Northfield (NOrfld)

67 Series

Orange (ORnge)
Orchard (ORchrd)
Oriole (ORiol)
Orleans (ORlns)
Osborne (OSbrn)

68 Series

Murdock (MUrdk)
Murray (MUrry)
Museum (MUseum)
Mutual (MUtual)
Overbrook (OVrbrk)
  Overland (OVrlnd)

69 Series

Myrtle (MYrtl)
Owen (OWen)
Oxbow (OXbo)
Oxford (OXfrd)

72 Series

Palace (PAlace)
Park (PArk)
  Parkview (PArkvw)
  Parkway (PArkwy)
Randolph (RAndlf)
Raymond (RAymd)
Saratoga (SArtoga)

73 Series

Pershing (PErshng)
Redfield (REdfld)
  Redwood (REdwd)
Regent (REgnt)
Republic (REpblc)

74 Series

Pilgrim (PIlgrm)
Pioneer (PIoner)
Riverside (RIvrsd)
  Riverview (RIvrvw)
Shadyside (SHadysd)
Sherwood (SHerwd)

75 Series

Plateau (PLato)
Plaza (PLaza)
Pleasant (PLsnt)
Plymouth (PLymth)
Skyline (SKyln)

76 Series

Poplar (POplr)
Porter (POrtr)
Rockwell (ROckwl)
Roger (ROgr)
  Rogers (ROgr)
South (SOuth)
  Southfield (SOthfld)

77 Series

Prescott (PRscot)
President (PRsdnt)
Prospect (PRspct)
Spring (SPrng)
Spruce (SPrce)

78 Series

State (STate)
Sterling (STrlng)
Stillwell (STilwl)
Story (STory)
Sunset (SUnst)

79 Series

Pyramid (PYrmid)
Swarthmore (SWthmor)
Swift (SWift)
Swinburne (SWinbrn)
Sycamore (SYcmor)

82 Series

Talbot (TAlbt)
Talmadge (TAlmdg)
Taylor (TAylr)
Valley (VAlly)
Vandyke (VAndyk)

83 Series

Temple (TEmpl)
Tennyson (TEnysn)
Terminal (TErmnl)
Terrace (TErace)
Vernon (VErnon)

84 Series

Thornwall (THrnwl)
Tilden (TIldn)
Victor (VIctr)
  Victoria (VIctria)
Viking (VIkng)
Vinewood (VInwd)

85 Series

Ulrick (ULrik)
Ulster (ULstr)
Ulysses (ULyses)

86 Series

Townsend (TOwnsnd)
Underhill (UNdrhl)
Union (UNion)
University (UNvrsty)
Volunteer (VOlntr)

87 Series

Tremont (TRemnt)
Triangle (TRiangl)
Trinity (TRnity)
Trojan (TRojn)
Uptown (UPtwn)

88 Series

Tucker (TUckr)
Tulip (TUlip)
Turner (TUrnr)
Tuxedo (TUxedo)

89 Series

Twilight (TWilght)
Twinbrook (TWinbrk)
  Twinoaks (TWinoks)
Twining (TWing)

92 Series

Wabash (WAbsh)
Walker (WAlkr)
Walnut (WAlnut)
Warwick (WArwk)
Waverly (WAvrly)

93 Series

Webster (WEbstr)
Wells (WElls)
  Wellington (WElngtn)
West (WEst)
  Westmore (WEstmor)
Yellowstone (YElowstn)

94 Series

Whitehall (WHitehl)
Whitney (WHitny)
William (WIliam)
  Williams (WIliam)
Wilson (WIlsn)
Windsor (WIndsr)

95 Series

Reserved for
Radiotelephone

96 Series

Woodland (WOodlnd)
  Woodlawn (WOodlwn)
Woodward (WOodwrd)
Worth (WOrth)
Yorktown (YOrktn)

97 Series

Reserved for
Radiotelephone

98 Series

Yukon (YUkon)

99 Series

Wyandotte (WYndot)
Wydown (WYdown)
Wyman (WYman)

SWITCHING PLAN FOR DISTANCE DIALING

CONTENTS PAGE

1. GENERAL

1.01 The Telephone Systems in the United States and Canada handle more than eight million toll calls a day. These are routed over a comprehensive network of more than 140,000 long haul intertoll trunks which interconnect approximately 2,600 toll switching offices and, with few exceptions, all of the telephones in these two countries, and provide in part for establishing connections to many other parts of the world.

1.02 Large volumes of traffic between toll offices are generally routed economically over direct intertoll trunks. When the volume of traffic is small, however, the use of direct trunks is usually not economical. In these cases the traffic is then handled by connecting together, by means of switching equipment at intermediate toll offices, two or more intertoll trunks to "build up" the required circuit. The places where the interconnections are made are generally known as intertoll switching points and the process is referred to as a "switch." "Built-up" connections may involve several intertoll switching points if the originating and terminating points are a great distance apart and the traffic volume is small. Although this multi-switched traffic constitutes only a small portion of the total, it is important that telephone plant be designed to care for it as well as for the greater volume that is handled via the less complex direct and single switch routes.

1.03 The basic routing arrangements that make possible systematic and efficient handling of manually switched long distance calls will, with some modification, serve the needs of operator and direct distance dialing with automatic switching. These arrangements, called the "General Toll Switching Plan", are discussed herein as modified for distance dialing.

1.04 The conditions under which toll traffic will be automatically switched on a nationwide scale are quite similar to those found in large cities with large volumes of traffic between many separate switching centers. Therefore, experience gained in these places was applied to the nationwide distance dialing job.

1.05 The needs of multi-office exchange areas are met by switching and trunking plans that employ the principle of automatic alternate routing to provide rapid and accurate connections with few occasions for repeated attempts. With this principle, a call which encounters an all trunks busy condition on the first route tested is automatically and rapidly "route advanced" and offered to one or more alternate routes, in sequence, for completion. Appendix A, "Alternate Routing" at the end of this section discusses what alternate routing is and why it is used.

2. THE GENERAL TOLL SWITCHING PLAN

2.01 Definitions: In the general toll switching plan the central office, where customers' telephone lines are terminated for purpose of interconnection, is called an End Office and for convenient reference has been assigned the classification "5" That is, the End Office is a Class 5 office. A Class 5 office may be physically located in the same building that houses an office of higher classification and in some cases the End Office and the toll office functions are performed by one machine. However, the offices will be considered as separate entities, and customers' lines will be terminated at the Class 5 office only. Chart 1 shows how a number of Class 5 offices are grouped on or homed at, a Toll Center or a Toll Point. A Toll Center (Class 4C) is defined as a toll switching location where operators are present to handle inward toll traffic in addition to other normal traffic operating functions. A Toll Point (Class 4P) is defined as a toll switching location where operators, if present, will not handle inward traffic. A Class 4P office may or may not have operators handling other traffic items such as outward, delayed outward (TX), assistance, information, etc. Both the Class 4C and 4P offices have the same importance and rank in the toll switching plan as regards transmission considerations. Class 4 offices are grouped upon, and served over final routes from, a higher rank toll switching location designated as a Primary Center or Class 3 office. Class 3 offices "home" at Sectional Centers (Class 2) and the latter have final routes to Class 1 offices known as Regional Centers. Present plans call for nine Regional Centers in the United States and two in Canada. Collectively, the Class 1, 2 and 3 offices (Regional Centers, Sectional

Centers, and Primary Centers) will constitute the Control Switching Points (CSP's) for nationwide dialing. A Control Switching Point is a key location in the nationwide automatic switching network for which the basic requirements are shown on Chart 2. The major switching centers that have tentatively selected as CSP's are shown on Charts 3, 4 and 5 together with the proposed classification of each. These are subject to change as further studies of the switching plan are made.

2.02 Switching Areas: The systematic grouping of switching centers results in a similar grouping of the areas they serve. Each of the Regional Centers (RC) serves a very large area known as a Region. (Tentative regional area boundaries in the United States are shown on Chart 6.) The Region is subdivided into smaller areas known as Sections; the principal switching facility in the section is the Sectional Center (SC). The Section is still a rather large area, and it, too, is further divided into smaller parts known as Primary Areas, each of which is served by a Primary Center (PC). The remaining toll offices that do not fall into the above categories are the Toll Centers (TC) and Toll Points (TP).

(A) Homing Arrangements and the Interconnecting Network

2.03 It is not necessary that Class 5, 4 or 3 offices home on the next higher ranking (lower class number) office: the complete intermediate final route chain is not necessary. For example, Class 5 offices may be served directly from any of the higher ranking CSP's. The several possible homing arrangements for each class of office are shown in Table 1, following and illustrated on Chart 1.

Table 1

Homing Arrangements

Class of Office	May Home at Offices of the Following Classes
Class 5	Class 4, Class 3, Class 2, Class 1
Class 4	Class 3, Class 2, or Class 1
Class 3	Class 2 or Class 1
Class 2	Class 1

2.04 Chart 7 shows, for the general case, the backbone network of "final" intertoll trunk groups, or final route chain, interconnecting the several classes of offices. One final circuit group will always be provided from each office to an office of a higher rank. That one higher ranking switching point to which an office is connected over a final group is called its "home" office; the dependent office is spoken of as "homing" at it. The network of final trunk groups will be engineered on a low delay basis so that, on the average, not more than three calls in each hundred that are offered to such a trunk group in the busy hour will find all circuits busy.

2.05 Final circuit groups will also be provided between each pair of regional centers in the United States, between the two regional centers in Canada, and between each of the regional centers in Canada and certain regional centers in the United States. (It may be economical to provide final groups between each of the Canadian regional centers and other regional centers in the United States.) These inter-regional center final trunk groups will be the last choice groups for all inter-region traffic between the pairs of regions involved. In the case of the groups between each of the Canadian regional centers and the regional centers in the United States, these groups may be the last choice groups for all interchange traffic between the Canadian regions and the entire United States. This will result in RC-RC-RC routings which will involve no more than eight intertoll links on any call between the two countries.

2.06 In addition to the final network, direct high usage circuits may be provided between offices of any class, wherever the volume of traffic and costs warrant. These high usage trunk groups will not be engineered to care for all the offered traffic since, as discussed in Appendix A, the overflow traffic will be offered to an alternate route. The proportion of the offered traffic that is carried on the direct high usage trunk group in each case will be determined by the relative costs of the direct route and the alternate route (including the additional switching costs on the alternate route). High usage groups will be provided only when they are shown by appropriate studies to be economically desirable.

2.07 Intertoll trunk groups, both high usage and final, are usually two-way because, with the usual volumes of toll traffic, they are more economical than two groups of one-way trunks.

2.08 Routing Patterns: In the standard switching pattern (Chart 7) all locations are arranged in a final route chain. Referring to Chart 1, a call originating in one final route chain which enters a second chain at a Class 2 office, for example, and progresses down the second chain to a Class 3 or 4 office is within the standard pattern. A call originating in one final route chain which enters a second chain and progresses up the second chain or crosses to a third chain violates the standard pattern. Appendix B with Charts B-1 and B-2 illustrate typical routing patterns that are within this general toll switching plan. It should be noted that the maximum number of intertoll "links" in the final route chains from Class 4 office to Class 4 office cannot exceed seven for intra-country calls or eight for inter-country calls. (These, plus the two toll connecting trunks to the end offices, result in a maximum over-all total of nine links for intra-country calls and ten links for inter-country calls.) However, the probability of a call traversing all links of the final route chains is estimated to be only a few calls in a million. Most calls will be completed on direct trunks; relatively few will encounter multiple switches and then only during periods of heavy traffic. In addition, as traffic growth occurs a relatively larger proportion of the traffic will be carried on the direct trunks.

(B) Selection of Control Switching Points

2.09 Increasing the number of CSP's will decrease the cost of toll trunk plant because the CSP may be moved closer to the Toll Centers or Toll Points it serves. Thus, Plan II shown on Chart 8 will affect savings in toll transmission facilities as compared to Plan I. However, a CSP requires more expensive switching equipment and other features that would not ordinarily be required if the switching point were used as a Class 4 office (Toll Center or Toll Point). This tends to offset, and may even exceed the toll transmission facility saving. It is necessary to weigh these related factors to determine the number and location of CSP's that will result in the most economical over-all toll plant layout.

2.10 Through switching center studies (CSP location studies) have been made by each of the Bell System Operating Companies and the Long Lines Department of the AT&TCo. These studies are reviewed from time to time as required by changed conditions. The last review compiled on a Bell Systemwide basis was completed in 1952. The results of all studies and reviews to date are shown by the locations indicated on Charts 3, 4 and 5.

2.11 Future studies may result in requirements for additional CSP's. Such studies will reflect the relative costs of toll transmission facilities and switching equipment that will then be available to do the CSP job. They will also recognize the change in traffic flow, including growth, that will develop with the passage of time. The combined effects of these influences may be to increase the number of CSP's that should be provided and to change the classification of existing CSP's.

(C) Effects on Toll Plant Layout

2.12 Since the general toll switching plan will make extensive use of alternate routing, the flow of traffic, in many instances, will be different from what it would be if present routing methods were continued. The present layout of intertoll trunks may not then be the most advantageous. As can be seen on Chart 8, in a particular cross section of a toll route, the number of intertoll trunks between given terminations is likely to be changed appreciably. Furthermore, it is probable that the number of intertoll trunks terminated at a toll center designated as a CSP will be considerably different under the nationwide distance dialing plan from what it would be if the present trunk estimates were projected assuming continuation of the present method of operation.

2.13 Chart 9 is a comparison of intertoll trunk networks theoretically required (a) with the limited switching under ringdown operation (where engineering was on the basis of many inefficient direct groups), and (b) with operator and direct distance dialing utilizing common control equipment and full automatic alternate routing at the principal switching centers. It is apparent that there are possiblilities for substantially reducing the number of inefficient intertoll trunk groups. Alternate routing tends to eliminate small inefficient direct groups and to concentrate the intertoll trunks in larger and more efficient groups which generally can be provided at lower cost per trunk mile.

2.14 It is essential that these factors be taken into consideration when engineering toll plant additions. By so doing, the most advantageous toll plant layout for distance dialing employing alternate routing may be obtained and at the same time the interim needs during the transition period will be provided for adequately.

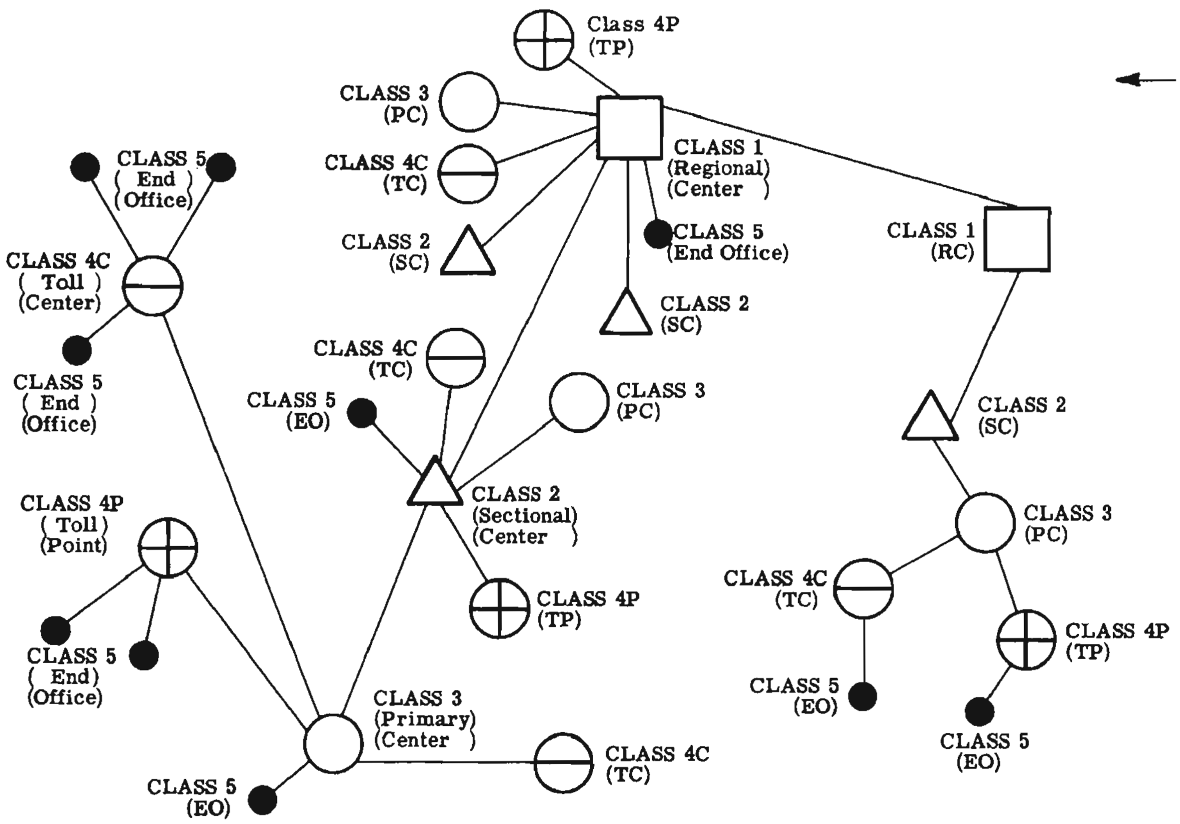
2.15 It is recommended for operator and direct distance dialing that a toll connecting trunk group engineered for low delay (not more than five and preferably not more than three delayed calls in each 100 busy hour calls) be provided between each end office (Class 5) and its home toll office. (In the Bell System such trunk groups are usually engineered for not more than one delayed call in each 100 busy hour calls, particularly the groups to the larger end offices and elsewhere when it is economically feasible.) Service needs, trunk costs and need for access to an operator for assistance are factors that should be considered in determining the basis upon which the trunk group should be engineered.

2.16 The ultimate general toll switching plan does not provide for tandem operation of community dial offices for completion of toll calls: each Class 5 office will have direct trunks to its home toll office. In the interim, the connection between any Toll Center or Toll Point and its most remote Class 5 office should not have a transmission loss exceeding 4 db. Tandem community dial office operation should be avoided for transmission, equipment, traffic operating, and numbering plan reasons. In general, calls to an end office that can be reached only through a tandem end office require that numbering plan arrangements must be selected with considerable care, because as discussed in Section II, it must be possible to reach the most remote office from anywhere in the United States or Canada by sending into the toll switching network a maximum of ten digits. If the number of digits required to switch beyond the last CSP in the final route chain exceeds the out pulsing capabilities of the CSP equipment, direct distance dialing will not be possible and it will be necessary to call in an operator at the terminating toll center to establish the connection. A preferred arrangement is to provide trunks that will bypass one or more tandem switching points following the last CSP.

Attached:

Charts 1 through 9
Appendix A — Alternate Routing (with Chart A-1)
Appendix B — Routing Patterns under the Toll Switching Plan for Distance Dialing (with Charts B-1 and B-2)

GENERAL TOLL SWITCHING PLAN
(Basic Principle)



Legend

Symbol	Class	Name	Abbreviation	Symbol	Class	Name	Abbreviation
□	1	Regional Center	RC	⊖	4C	Toll Center	TC
△	2	Sectional Center	SC	⊕	4P	Toll Point	TP
○	3	Primary Center	PC	●	5	End Office	EO

—— Final Trunk Group

BASIC REQUIREMENTS FOR CSP'S
(All Class 1, 2 and 3 Offices)

1. Transmission Requirements

a. An objective of 27 db average office balance on two-wire connections for intertoll to intertoll through switched traffic.

b. Via net loss (VNL) operation of intertoll trunks for intertoll to intertoll through switched traffic.

c. An objective of via net loss operation of intertoll trunks for intertoll originating and terminating traffic. This involves meeting a VNL + 2 db transmission design objective for toll connecting trunks.

2. Equipment Requirements

Automatic switching of intertoll trunk to intertoll trunk connections, sometimes called through switching.

When destination code routing is employed for traffic which is to be switched through a Class 3 step-by-step office, an office having a trunk group to the Class 3 step-by-step office must be provided with:

(1) Code conversion and/or digit prefixing.

(2) Six-digit (foreign area) translation when the Class 3 step-by-step office is in a foreign numbering plan area in order that code conversion may be performed.

3. Homing Arrangements

There must be at least one office of the next lower rank homing at it, i.e., a Class 1 office must have at least one Class 2 office which homes at it, etc.

If a given office meets Requirements 1 and 2 and long range plans call for an office of next lower rank to eventually home at it, Requirement 3 may be considered to be met even though it is not currently being met.

4. Other Features Provided at CSP's with Common Control Equipment

a. Storing of digits.

b. Variable spilling - deletion of certain digits when not required for outpulsing.

c. Prefixing of digits when required.

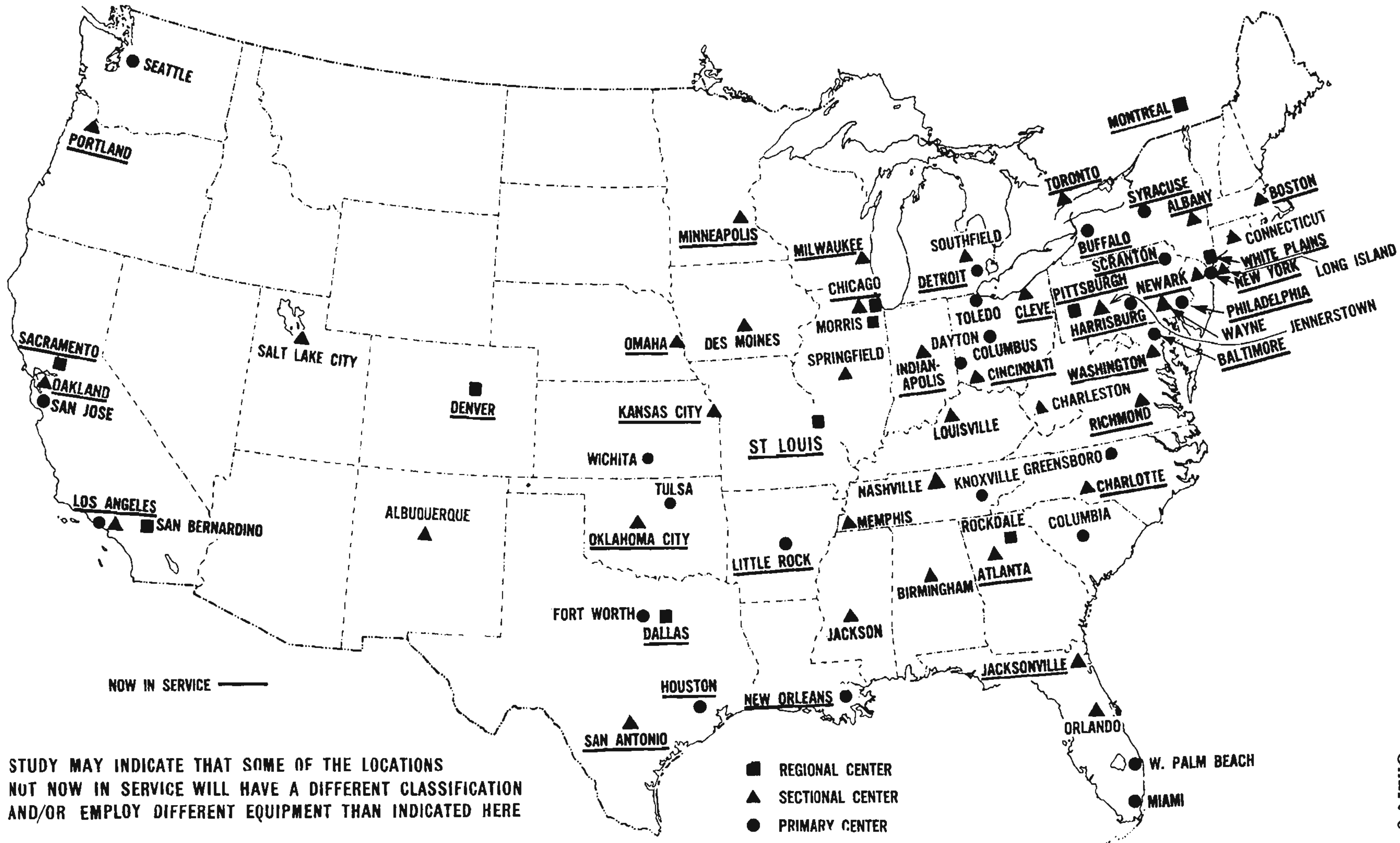
d. Code conversion - a combination of digit deletion and prefixing (also termed substitution).

e. Translation of 3 or 6 digits. (Also translation of 4 or 5 digits for TX calls.)

f. Automatic alternate routing.

CSP's WITH No. 4 TYPE EQUIPMENT

TENTATIVE SEPTEMBER 1956 VIEW OF 1965 ARRANGEMENTS



STUDY MAY INDICATE THAT SOME OF THE LOCATIONS
NOT NOW IN SERVICE WILL HAVE A DIFFERENT CLASSIFICATION
AND/OR EMPLOY DIFFERENT EQUIPMENT THAN INDICATED HERE

Revised
September 1956

SECTION III
Chart 3

CSP's IN THE UNITED STATES WITH EQUIPMENT OTHER THAN No. 4 TYPE

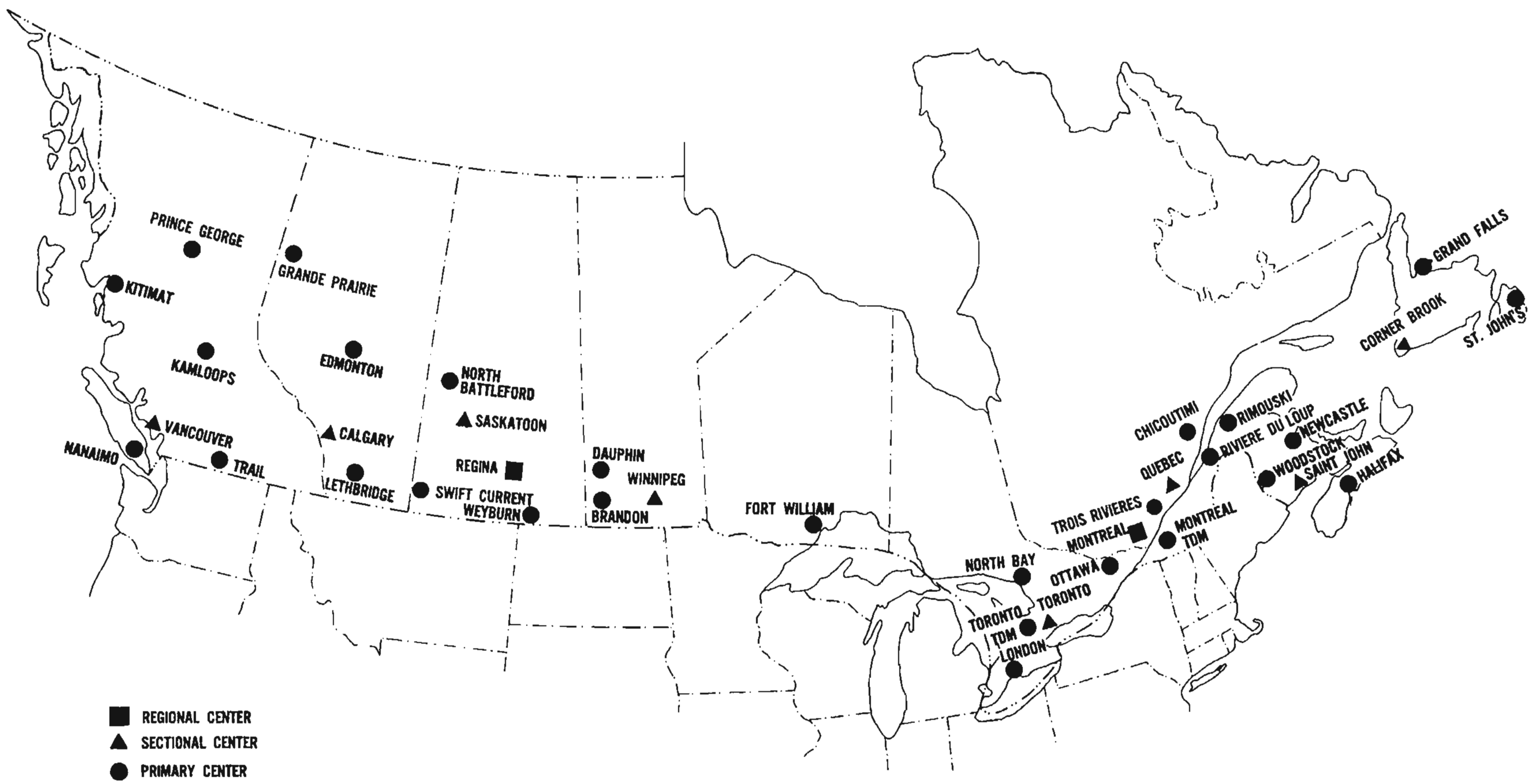
TENTATIVE SEPTEMBER 1956 VIEW OF 1965 ARRANGEMENTS

Revised
September 1956

SECTION III
Chart 4

CSP's IN CANADA

TENTATIVE SEPTEMBER 1956 VIEW OF 1965 ARRANGEMENTS

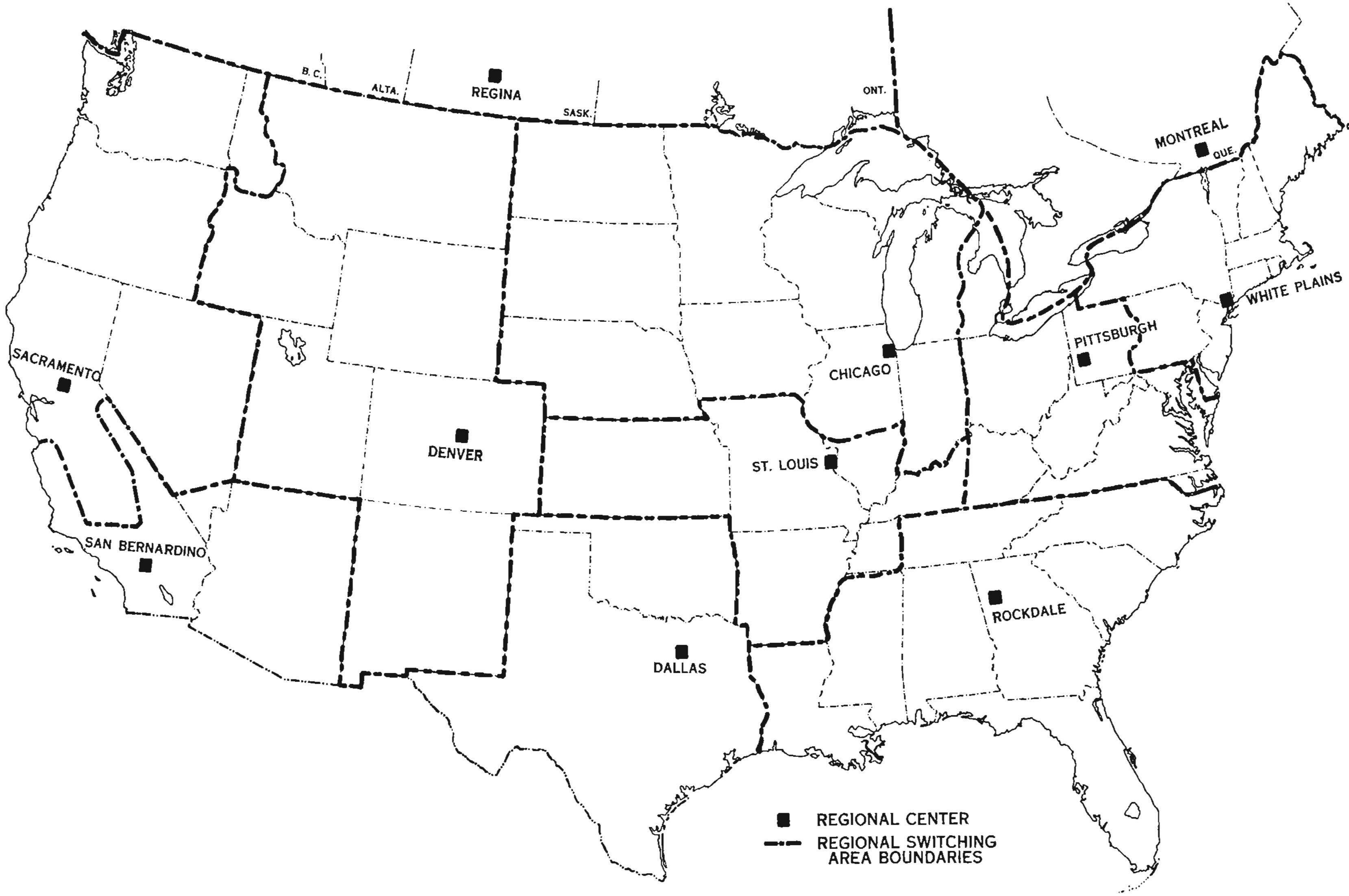


NOTE: It is expected that only MONTREAL and TORONTO CSP's will have No. 4 Type Equipment.

Revised
September 1956

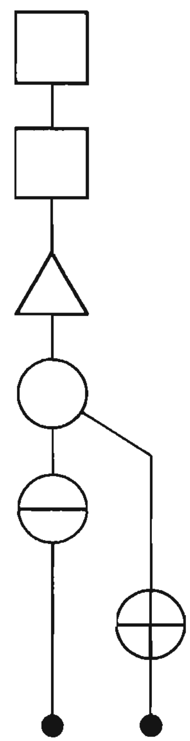
SECTION III
Chart 5

REGIONAL AREA BOUNDARIES
Tentative September 1956 View of 1965 Arrangements



Revised September 1956

STANDARD SWITCHING PATTERN



Class No.	Names	Abbrev.	Equip.	Final Route Trunks (Transmission Design Objectives)	Average Office Balance Requirements-db Between Intermediate Links (Transmission Design Objectives)
1	Regional Center	RC	4X		27
				0.5 db (Intermediate Links)	
1	Regional Center	RC	4X		27
				VNL (Intermediate Links)	
2	Sectional Center	SC	4X, XT, 5X		27
				VNL (Intermediate Links)	
3	Primary Center	PC	4X, XT, 5X, SS		27
				VNL (Intermediate Links)	
4 (4C)	Toll Center	TC	XT, 5X, SS		Notes 1 & 2
4 (4P)	Toll Point	TP		VNL+2 to maximum of 4 db (Terminal Link)	
5	End Office	EO			——

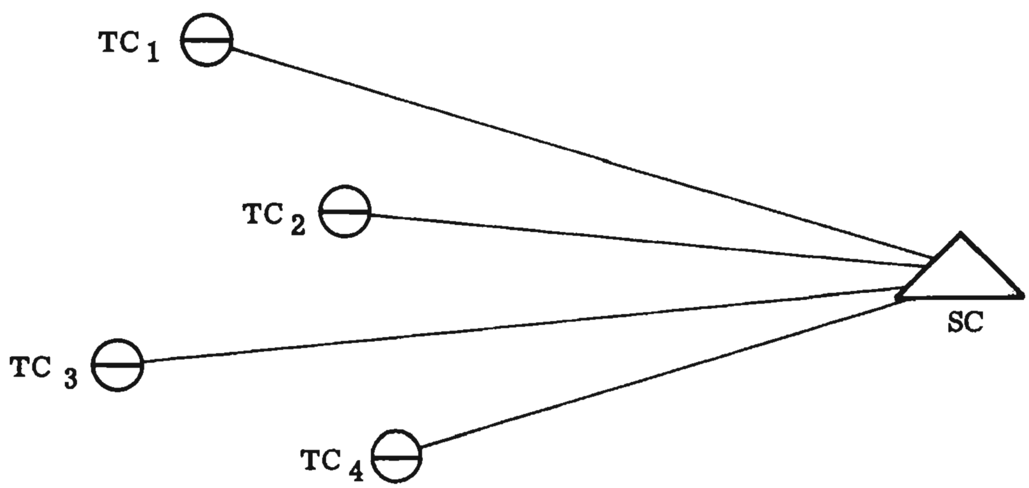
Bell System Type Equipment: 4X-4A or 4M Crossbar; XT-Crossbar Tandem; 5X-No. 5 Crossbar; SS-Step-by-Step

Equipment Manufactured by Independent Suppliers with all of the necessary comparable features may also be employed.

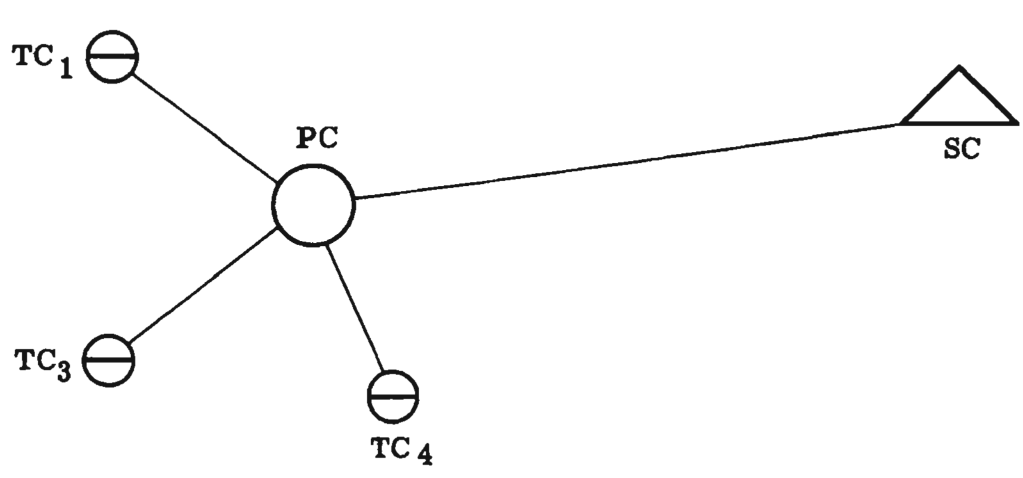
Note: 1. No Through Switching Requirement.
2. Terminal Requirement of 11 or 15 db Depending on 2 db Pad Arrangement.

EFFECT OF ESTABLISHMENT OF A CSP

PLAN I

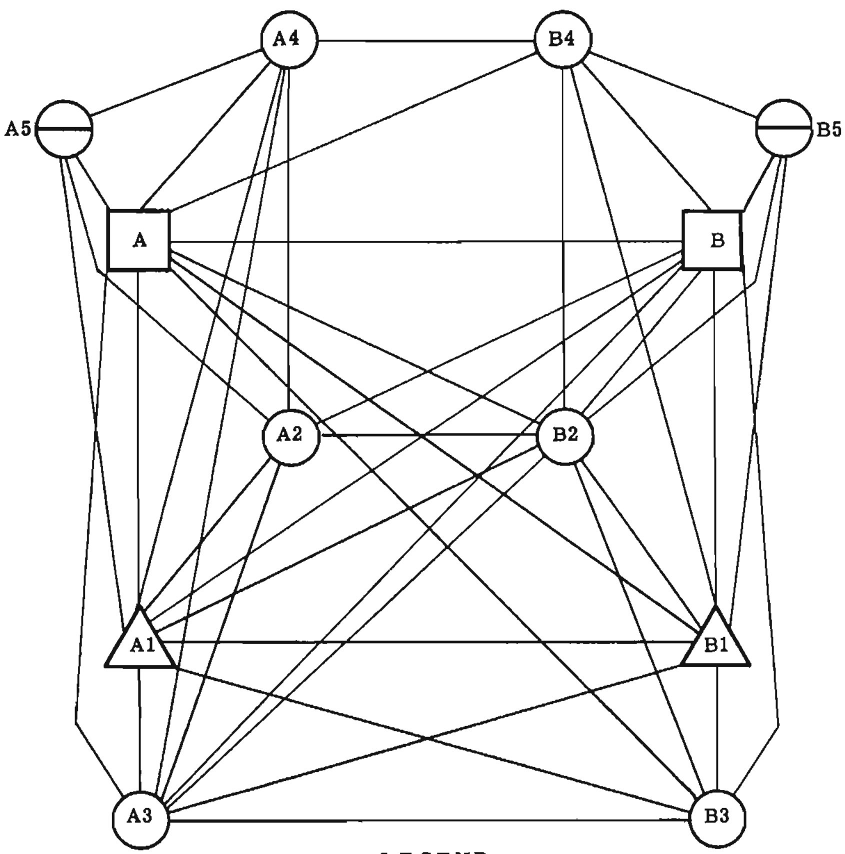


PLAN II



INTERTOLL TRUNK NETWORK

RINGDOWN OPERATION



LEGEND:

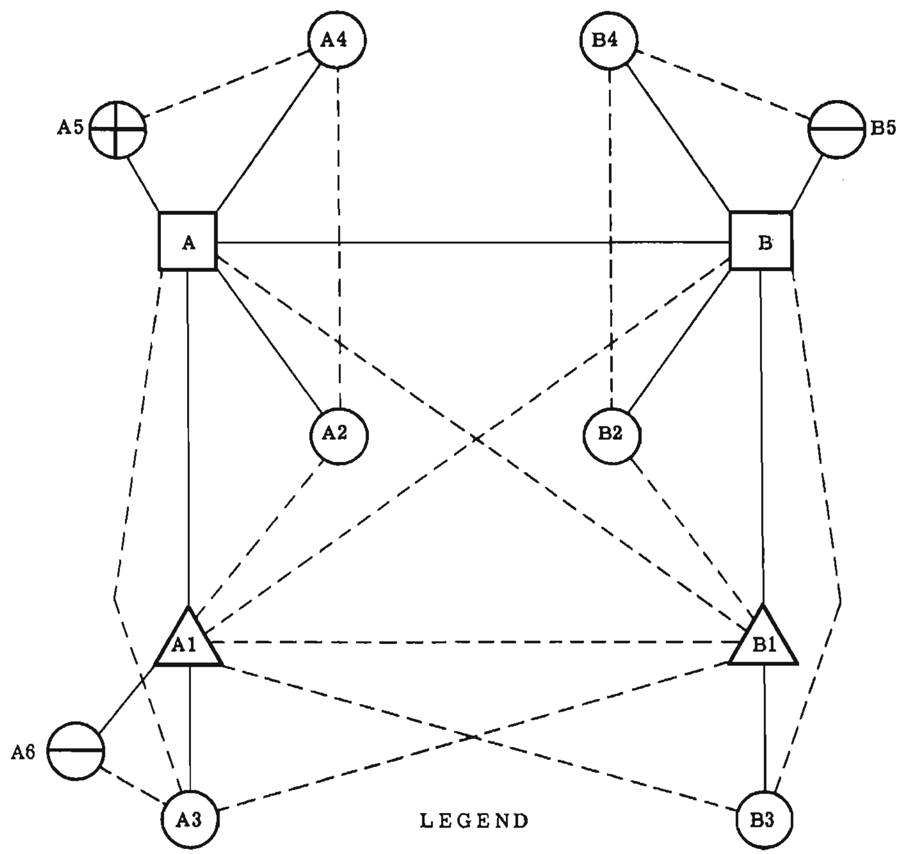
Regional Center

Primary Outlet

Primary Center

Toll Center

NATIONWIDE DISTANCE DIALING



LEGEND

Final Groups

HU Groups

Regional Center

Sectional Center

Primary Center

Toll Center

Toll Point

ALTERNATE ROUTING

1. GENERAL

1.01 The successful dialing of nationwide long distance traffic, by both operators and customers, depends on a high speed intertoll network so that "all trunks busy" conditions will rarely be encountered, even during the average busy season, busy hour. Alternate routing is one of the techniques that makes this possible. It is the purpose of this appendix to tell what alternate routing is and why it is employed.

1.02 Definitions:

(a) Alternate Routing - A method of advancing a call at a switching point by diverting it to a trunk group, other than the first choice group, when the first choice group is busy.

(b) Multi-alternate Routing - Alternate routing with provision for more than one alternate route.

(c) High Usage Group - A group of trunks for which an alternate route is provided and for which the number of trunks is determined by economic considerations.

(d) Final Group - A group of trunks which has no alternate route and in which the number of trunks provided will result in a low probability of lost calls for the traffic offered to the group.

2. THEORY OF ALTERNATE ROUTING

2.01 The theory of alternate routing is comparable to a man's transportation to work in the morning. If normally the man uses his automobile for this purpose, and on a particular morning his wife is using the car, he will then take a bus or a taxi. He practices alternate routing.

2.02 Under alternate routing calls are first offered to individual high usage groups and failing to find an idle trunk they are then offered to another group.

Fundamentals

2.03 Alternate routing is based on two fundamentals, - irregularities in the flow of traffic and diminishing returns from the provision of additional trunks.

Irregularities in the Flow of Traffic

2.04 The volume of traffic reaches peaks in certain hours: facilities are usually provided to care for the average busy season, busy hour (see Chart A-1). Traffic volume also peaks for shorter intervals within the busy hour, but it is not practical nor economical to provide facilities for the busiest five or ten minutes.

2.05 With only one outlet (i.e., one group) these shorter peaks are reflected in slower service (or lost calls). If more than one route can be made available, there is a good possibility that the shorter surges of traffic to which each group is subject, and sometimes even the longer busy hour peaks, will not coincide and that a peak on one route may be fitted into a valley on another route.

Diminishing Returns from the Provision of Additional Trunks

2.06 This principle may be illustrated by assuming the case of a dial switch offering calls to a group of ten trunks. Tested in order, trunk No. 1 will be selected first, reselected when idle, and thus be kept busy most of the time; trunk No. 2 will be slightly less busy; trunk No. 3 will be used less than No. 2; and so on to the tenth trunk, which is only called into use during short surges of traffic. If the tenth trunk were removed, some of the calls would be delayed (or lost) but considerably less than one-tenth of the calls would be affected because this last trunk does not carry its proportionate share of the load. If the offered load is relatively low for ten trunks, the service will be good but the tenth trunk will be lazy. It is a low usage trunk. Conversely, if the offered load is very high for ten trunks the last trunk is kept very busy and unless some other route is provided the service will be poor.

2.07 Advantages of alternate routing are a combination of the two fundamentals, fitting the peaks into the valleys and maintaining a higher average usage of all trunks without service impairment.

3. ECONOMIC FACTORS

3.01 The number of high usage or direct trunks to be provided and the consequent amount of traffic allowed to seek an alternate route depends upon the ratio of cost (cost ratio) of the two routes.

3.02 A call from Newark to Norfolk can readily be rerouted from Newark to Richmond to Norfolk. The mileage is approximately the same; the type of facility used is the same; the same; the additional cost is in switching the call at Richmond. This represents a low cost ratio. To reroute the same call from Newark via Pittsburgh and Richmond to Norfolk obviously introduces many more circuit miles as well as the cost of additional switching. This case represents a high cost ratio.

3.03 Similarly an alternate route involving open wire facilities would involve a higher cost ratio than an alternate route in cable for the same mileage, because open wire costs more per circuit mile than cable.

3.04 If the alternate route is almost as cheap as the first route (low cost ratio) fewer trunks will be provided on the first route, they will be kept very busy, and more traffic will overflow. If the alternate route is very much more expensive (high cost ratio) more trunks will be provided on the first route and fewer calls forced to take the expensive alternate route.

3.05 The following example illustrates this principle using load figures from standard alternate routing trunk tables.

		First Route				
a	b	c=30 CCS÷b	d	e	f=e÷d	g
Offered Load	Cost Ratio	Economical CCS Carried by Last Trunk	No. of Trunks	Load Carried	Average Load per Trunk	Overflow to Alternate Route
300 CCS	1.1	27	6	178 CCS	30 CCS	122 CCS
300 CCS	1.5	20	8	224 CCS	28 CCS	76 CCS
300 CCS	2.0	15	10	259 CCS	26 CCS	41 CCS

Notes: (1) a and b are assumed data for this example.

(2) 30 CCS is the approximate load carried per trunk added to the alternate route.

(3) d, e and g are obtained from standard alternate routing trunk tables.

3.06 Sometimes there are two or more potential alternate routes and where this is the case the one having the lowest cost ratio should be used.

4. APPLICATION OF ALTERNATE ROUTING

Local Dial Trunking (Crossbar Offices Only)

4.01 In large multi-office cities, direct trunks are provided from each office to every office where there is sufficient traffic to justify economically such trunks. Also each office has trunks to and from a common tandem point. Calls between offices not directly connected are completed through this tandem center. Since every office is connected to tandem, the tandem network may be used to provide an alternate route for each of the direct groups. Therefore, fewer direct trunks need be provided. Furthermore, because of the existence of this tandem overflow, it becomes economical to establish new efficient direct groups of small size between offices not previously served by direct groups.

4.02 Because the alternate routing can be done automatically and quickly it can be used extensively. Calls may be offered in succession to a series of alternate routes via two or more mechanical tandem centers or their equivalent. Each time the traffic overflowing from several groups is combined and offered to a new group there is a gain in efficiency because of the meshing of short surges of traffic - peaks filling up the valleys.

4.03 In an emergency situation such as a cable failure, the ability to use an alternate route protects the service. However, if there is a heavy surge of traffic over the entire area (as in a major disaster such as a hurricane) there are fewer lazy trunks available to take up the slack and the service is not as good as it would have been with more direct trunks.

Intertoll Trunking - Automatic Selection of Alternate Route

4.04 The principle of alternate routing is basic in the design of the nationwide intertoll dialing network. The equipment seeks out the alternate routes without any action on the part of the toll operator. The field of application to intertoll trunking is more extensive than in the case of local trunking, since a call may be subject to rerouting through more switching centers.

4.05 At each switching center, all of the groups to which a call is offered, except the last, are kept very busy (high usage) and a high proportion of traffic overflows to other routes. The final groups, which are fewer in number, are low usage groups, so that service will be good. The over-all chance of completing a call is improved by the fact that it has previously been offered to several high usage groups. The switching equipment operates rapidly and there is no objectionable penalty in speed of service.

4.06 At some toll switching points where trunks appear in the multiple before operators, alternate routing can also be done by operators' testing high usage and final groups in a prescribed order.

4.07 In addition to the direct final groups which will connect offices to their home switch points, direct high usage groups will also be provided wherever it is economical to do so. There will remain, however, many items of traffic for which there will be no direct group. The first route for such items will be a switched route over two or more links of the existing network using the cheapest combination of links available and permissible under the General Toll Switching Plan.

4.08 Since the entire United States and Canada are to be integrated into the plan, the employment of an overflow system on such a grand scale requires an orderly and prearranged routing plan. This routing plan is described under "Homing Arrangements and the Interconnecting Network" in the main text of Section III.

4.09 Appendix B to Section III, entitled "Routing Patterns under the Toll Switching Plan for Distance Dialing" gives in detail an example of how alternate routing is employed in distance dialing.

TYPICAL TRAFFIC DISTRIBUTION

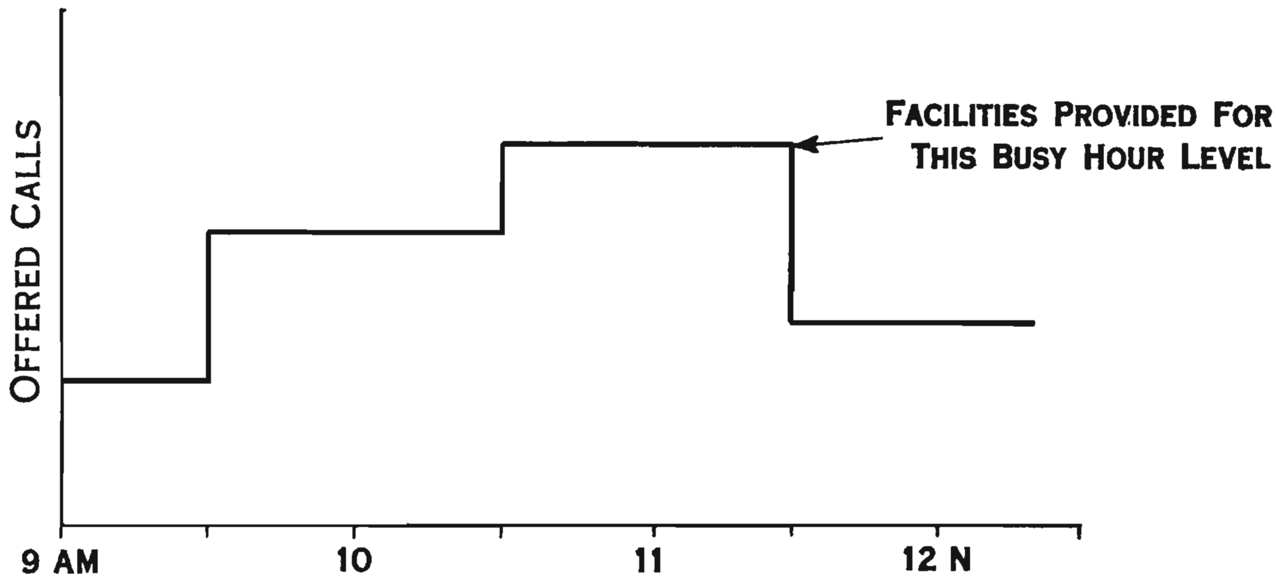


FIGURE A. - AVERAGE HOURLY TRAFFIC DISTRIBUTION

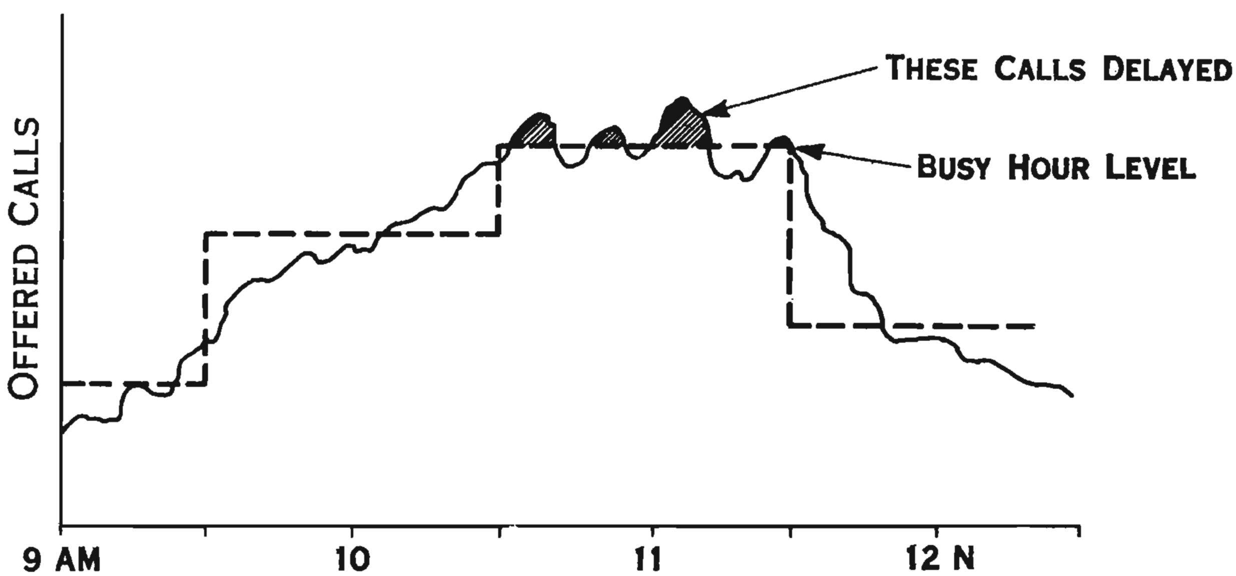


FIGURE B. - INSTANTANEOUS TRAFFIC DISTRIBUTION

ROUTING PATTERNS UNDER THE TOLL SWITCHING PLAN FOR DISTANCE DIALING

1. GENERAL

1.01 This appendix discusses a typical routing pattern that is theoretically possible within the framework of the general toll switching plan for distance dialing. Since economic and other considerations will require various other patterns, an example of one such variation is also included.

2. TYPICAL ROUTING PATTERN

2.01 Chart B-1 and the following discussion illustrate a routing pattern that could be employed to complete a call that appears at toll center TC_1 destined for an end office served from toll center TC_2. In this example, TC_1 has intertoll trunks to PC_1 only, hence the call is routed to this Primary Center.

2.02 At PC_1 the call would be offered first to the high usage group to PC_2. At PC_2 the switching equipment would select an idle trunk in the final group to TC_2 and the call would be routed to the called customer via TC_2.

2.03 If, however, all the trunks in the first high usage group (between PC_1 and PC_2) had been busy, the call would next be offered to the high usage group between PC_1 and SC_2 (if PC_1-SC_2-PC_2 is the cheapest alternate route). At SC_2 the call would have a choice of two routings; (1) via direct high usage trunks to TC_2, or if they were all busy, (2) over the two final trunk groups SC_2-PC_2 and PC_2-TC_2.

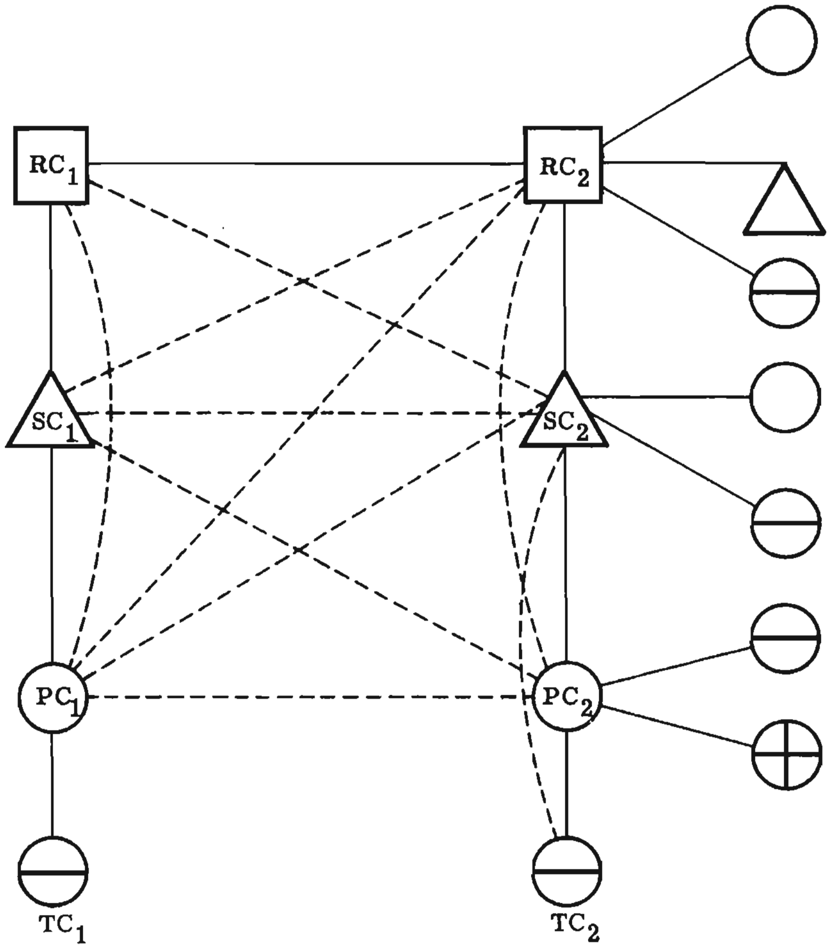
2.04 In the event all the trunks in the group between PC_1 and SC_2 had been busy, the call might next be offered to the high usage group between PC_1 and RC_2. At RC_2 there are two possibilities for completion; (1) via the RC_2-PC_2 high usage group, or when all these are busy, (2) downward via the final group in the chain from RC_2.

2.05 Similarly, if all the trunks in the group between PC_1 and RC_2 had been busy, the call would next be offered to the high usage group between PC_1 and RC_1. At RC_1 the call would have a choice of two routings in succession: (1) via the RC_1-SC_2 high usage group, and (2) via the RC_1-RC_2 final group. Subsequent routing would be as noted above.

2.06 Lastly, if all the trunks in the group between PC_1 and RC_1 had been busy, the call would be offered, as a last choice from PC_1, to the final group between PC_1 and SC_1. Since this is a final group there would be a very low probability of all the trunks being found busy. At SC_1 the call would have a choice of four routings in the following sequence; (1) via the SC_1-PC_2 high usage group, (2) via the SC_1-SC_2 high usage group, (3) via the SC_1-RC_2 high usage group, and lastly (4) via the final group from SC_1 to RC_1.

2.07 The routing described above is for one set of assumed conditions and could be different in actual practice to the extent that economics and plant layout would dictate different high usage trunk groups. For example, PC_1 might have only one high usage group, PC_1-PC_2, with overflow traffic route advanced at once to the final group to SC_1. This is illustrated on Chart B-2 which shows the alternate routes available for a call from Geneva, New York to Minneapolis. It will be noted that there are no high usage groups from Syracuse to Minneapolis (comparable to the PC_1-SC_2 group of Chart B-1) nor from Albany to Minneapolis (comparable to the SC_1-SC_2 group of Chart B-1).

GENERAL TOLL SWITCHING PLAN
(Routing Pattern)



LEGEND

C S P'S:
- RC - Regional Center
- SC - Sectional Center
- PC - Primary Center

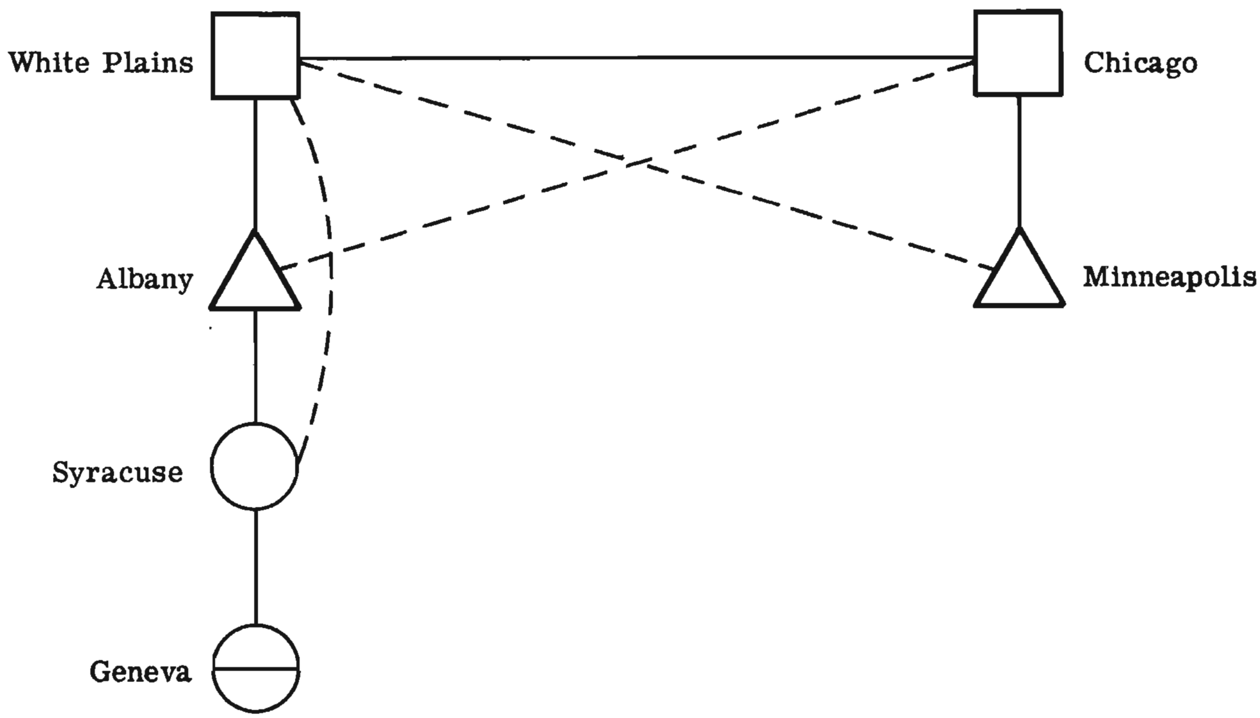
TC - Toll Center

TP - Toll Point

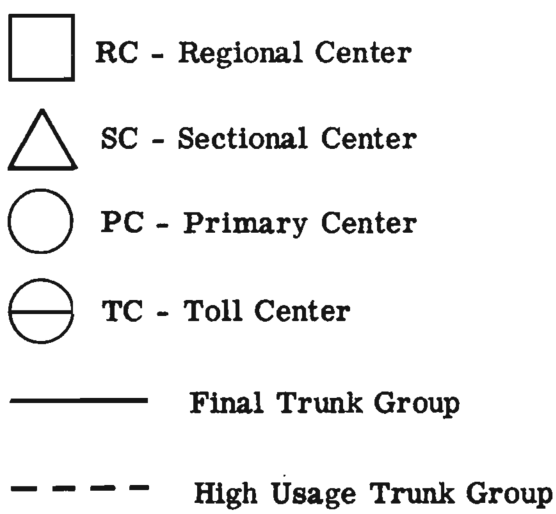
——— Final Group

– – – – Possible High Usage Group

EXAMPLE OF ALTERNATE ROUTING
Call from Geneva, New York to Minneapolis



Legend



INTEROFFICE SIGNALS

CONTENTS PAGE

1. INTRODUCTION

1.01 The interoffice signals required for operator and direct distance dialing are described in this section. Full dial operation is assumed; therefore, ringdown and straight-forward methods are not discussed. Only those signals currently in use or about to be put into use are included. Some of these signals, such as revertive pulsing, PCI (panel call indicator) pulsing, and call announcer, are not discussed since nationwide distance dialing raises no special problems in respect to them nor extends their field of use.

1.02 It will be helpful to consider interoffice signals from two viewpoints — the functional and the technical. The function or use of signals is a basic consideration for everyone concerned. The technical composition of signals is of particular importance to the engineering, manufacturing, and maintenance personnel. The functional aspects of signals may be explained more simply and clearly by discussing them separately and prior to consideration of the technical aspects. Accordingly, in Part 2, the signals are listed and described simply from the standpoint of their function or use.

1.03 Part 3 describes the same signals from the technical viewpoint and states the more important technical requirements.

1.04 The digit capacities of the various interconnecting switching systems are also of fundamental importance to the subject of signaling. These are summarized in Part 4.

1.05 The effect of sender and register timing in the various switching systems is to impose timing requirements on digit pulsing in the calling office, and on the function of attaching a sender, register, or link in the called office. These requirements are summarized in Part 5.

1.06 The signaling, carrier, and switching systems referred to in this section are of Bell System manufacture. There are many systems of other manufacture in use throughout the industry. Some of these differ appreciably in design but for distance dialing should be compatible with the equipment herein described.

2. SIGNALS REQUIRED FOR DISTANCE DIALING

2.01 Chart 1 at the back of this section lists the signals required for distance dialing and explains the use of each signal. The names of the signals given are those which are well established by general use. A few alternative terms, also having considerable usage, are shown in parentheses. The direction of each signal, the indication given to the customer or operator, and where applicable, the on-hook or off-hook classification of the signal are also shown.

2.02 Chart 2 shows the application of the signals listed in Chart 1 to a direct distance dialed connection switched through three toll offices in addition to the originating and terminating local offices. Calls can, of course, be switched through more or fewer offices. However, the number of offices shown should suffice to illustrate the use of the signals.

3. TECHNICAL DESCRIPTION OF SIGNALS

ON-HOOK AND OFF-HOOK SIGNALS (INCLUDES DIAL PULSING)

3.01 A number of interoffice signals are classified technically as on-hook, off-hook, or a combination of these. These terms are derived from the signals received from a customer's station by the local central office (Class 5 end office). If the station is on-hook, the loop is open to dc. If the station is off-hook, there is a dc bridge (shunt) across the line.

3.02 These terms, on-hook and off-hook, have also been found convenient to designate the two signaling conditions of an interoffice or intertoll trunk. If a trunk is not in use it is signaling on-hook towards the other end. Seizure of the trunk at the calling end signals off-hook to the called end. Also, if a trunk is in the condition of awaiting an answer from the called end, the called end is signaling on-hook toward the calling end. Answer of the call results in the sending of off-hook back towards the calling end.

3.03 The signals which are technically on-hook or off-hook or a combination of both are indicated in Chart 1. The direction of each of these is also shown. Besides these conditions one or more of the following factors help in determining their significance.

(1) Duration: For example, the on-hook of a dial pulse is relatively short and is thus distinguished from a disconnect signal which is in the same direction.

(2) Relative Time of Occurrence: A delay dialing off-hook signal occurs before any digits have been sent, while the answer off-hook signal occurs after all digits have been sent. Although both signals are off-hook they are distinguished in a particular office by the relative time of their occurrence.

(3) Frequency of Repetition: Examples are: No Circuit (NC), 30 IPM; Line Busy, 60 IPM; and Reorder, 120 IPM.

(4) Position in the Connection: It is possible for a delay dialing off-hook signal to be returned to an intermediate switching office when the originating office is waiting for the answer signal which is also off-hook. However, the trunk circuit in the intermediate office is split (not cut through) and, because of its position in the connection, the delay dialing signal will not get through to the originating office but instead is steered to the intermediate office sender.

3.04 In discussing the technical aspects of each signal mention will be made of the above factors which apply.

3.05 Discussion of the technical aspects of on-hook and off-hook signals falls naturally into two categories. In the first category, titled "Detailed Description," the signals are considered apart from the various (and sometimes mixed) means used for their transmission. In the second category, titled "Arrangements for Transmitting On-Hook and Off-Hook Signals," the various means or systems of transmission are described. These discussions follow.

(A) Detailed Description

Connect and Disconnect

3.06 A connect signal is a sustained off-hook signal toward the called end of a trunk following its seizure. It continues as long as the connection is held. Momentary interruptions in the connect signal caused by dial pulses or the ring forward (rering) signal are ignored as far as the connect and disconnect functions are concerned. A connect signal should be sent immediately upon seizure of a 2-way trunk in order to make it busy at the other end.

3.07 A disconnect signal is an on-hook signal toward the called end exceeding a minimum of about 0.750 second. Incoming trunks which may be reached by operators must not release on maximum length of ring forward (rering) pulse of 0.130 second plus 0.010 second safety margin or a total of 0.140 second. This is to insure that rering signals do not cause false disconnections.

3.08 Generally two methods are used to guarantee the minimum disconnect interval necessary between calls. In the first method the outgoing trunk is guarded by holding it busy for an interval after its release. This prevents a new connect signal from being sent forward until sufficient time has elapsed to effect release of the equipment at the called end. The second method permits the trunk to be reseized immediately, but the sending of the connect signal is delayed by the common control equipment for a measured interval or until a test of the trunk indicates that disconnect has taken effect. The second method saves trunk circuit equipment, but can not be used for 2-way trunks because, as explained above, on these the connect signal must be sent immediately.

Off-Hook and On-Hook

3.09 When the called customer answers, the off-hook signal is transmitted backward toward the calling end (usually repeated by relays) to the outward operator's calling cord or to the office where automatic charging control takes place. For charging purposes the answer off-hook signal is distinguished from off-hook signals of shorter duration (such as reorder and line busy) by the requirement that it must be continuous for a minimum interval which ranges from two to five seconds.

3.10 The condition of a trunk when awaiting the customer's answer is on-hook from the called station transmitted to the calling end. The term on-hook, as used functionally, applies to the technical on-hook condition of a trunk after all pulsing has been completed and the connection is cut through for ringing the called station. It applies again when the called station hangs up. Both off-hook and on-hook are often referred to as supervisory signals or simply as "supervision."

Delay Dialing (Delay Pulsing)

3.11 Description of Delay Dialing: Trunk groups employing common receiving equipment (such as senders or registers) at the called end may operate on one of two bases in respect to their readiness to receive digits. As one basis of operation, they may be equipped at the called end with fast links (or by-links), with both the links and the common receiving equipment engineered to minimize delays. Such groups are normally ready to receive pulsing in approximately one-tenth of a second after trunk seizure. This type of operation is employed for direct dialed traffic (CAMA) to avoid the use of second dial tone. With the second basis of operation, for pulsing originated in senders or by operators, economy is obtained by the use of slower links and by the engineering of these links and the common equipment at the called office for longer delays. With these more economical arrangements, variable short delays are encountered sufficiently often to require a signal which indicates non-readiness to receive digits. The delay dialing (delay pulsing) signal accomplishes this function. This signal is off-hook toward the sending office indicating that the receiving office is not ready to accept digits. It continues until the receiving end is ready. This signal is steered by the trunk-splitting relays in the calling office to the sender and thus does not affect charging control. One-way loop signaling trunks may be arranged to signal off-hook toward the calling end when idle. However, the wink start pulsing arrangement described later has been used in some applications because it affords extra protection against false charging, the trunks being in the on-hook (non-charge) condition when idle. Other types of one-way trunks arranged for delay dialing, and all 2-way trunks, signal on-hook toward each end when in the idle condition. As soon as a connect signal is received from the calling end, an off-hook signal is returned to indicate that the called end is not ready for digits. The time from the sending of the connect signal to the receipt of the delay dialing signal (round trip transit time) should not exceed 300 milliseconds. Either delay pulsing or wink start pulsing must be employed for multifrequency pulsing into distant senders or registers. However, dial pulsing trunks to direct control switching systems which are ready to accept digits immediately after seizure do not employ either the delay dialing signal or the wink start pulsing signal. These situations may be summarized as follows:

Delay Dialing (or Wink Start Pulsing*)

Required	Not Required
1. Dial pulsing by operators* or senders into distant senders or registers.	1. Dial pulsing by customers into distant senders or registers through by-links (CAMA).
2. Multi-frequency pulsing by operators* or senders.	2. Dial pulsing by customers, operators, or senders into direct control switches.

*Wink start pulsing is not suitable for trunks having switchboard multiple appearances.

3.12 Sender Operation with Delay Dialing: Bell System senders are designed to operate, in respect to delay dialing, with one (some with either) of two methods arbitrarily designated here as Method A and Method B. Method A is used in Crossbar Tandem and No. 5 Crossbar; Method B is used in No. 4-type and No. 5 Crossbar. A description of these two methods follows:

(a) Method A: With this method the sender requires detection of an off-hook signal followed by an on-hook signal when the called end is ready for digits. This method, illustrated in Fig. 1, is applicable for calls on which the connect signal is initiated under control of the sender and in which the delay dialing signal is always of sufficient duration to be recognized by the sender. A delay dialing signal exceeding 0.075 second meets this requirement. Method A is also applicable on calls where the connect signal is generated as soon as the trunk is seized if the outgoing trunk circuit is arranged to lock in a memory of the delay dialing signal until the sender recognizes it.

(b) Method B: With this method the sender recognizes on-hook as a start dialing signal only after sufficient time has elapsed from trunk seizure for the return of the delay dialing off-hook signal. Method B is used on calls to trunks which generate a connect signal as soon as they are seized and which are not equipped to lock in a memory of the delay dialing signal for the sender. This method of operation is necessary with these trunks because, under certain traffic conditions, the sender may not be connected in time to "see" the delay dialing signal (Fig. 2) and under other conditions, the sender may be connected before the delay dialing signal has returned (Fig. 3). Method B is also used on calls to trunks which do not always return a delay dialing signal of sufficient duration to be recognized by the sender.

3.13 With Method B the sender does not check that the signaling circuit is operative. Since certain signaling systems can signal on-hook with signaling leads open, it is important that tests be provided to check the signaling circuit operations. Automatic self-checking of the signaling circuit in connection with the delay dialing signal is under development. It will be applied to the common control circuit which seizes the trunk.

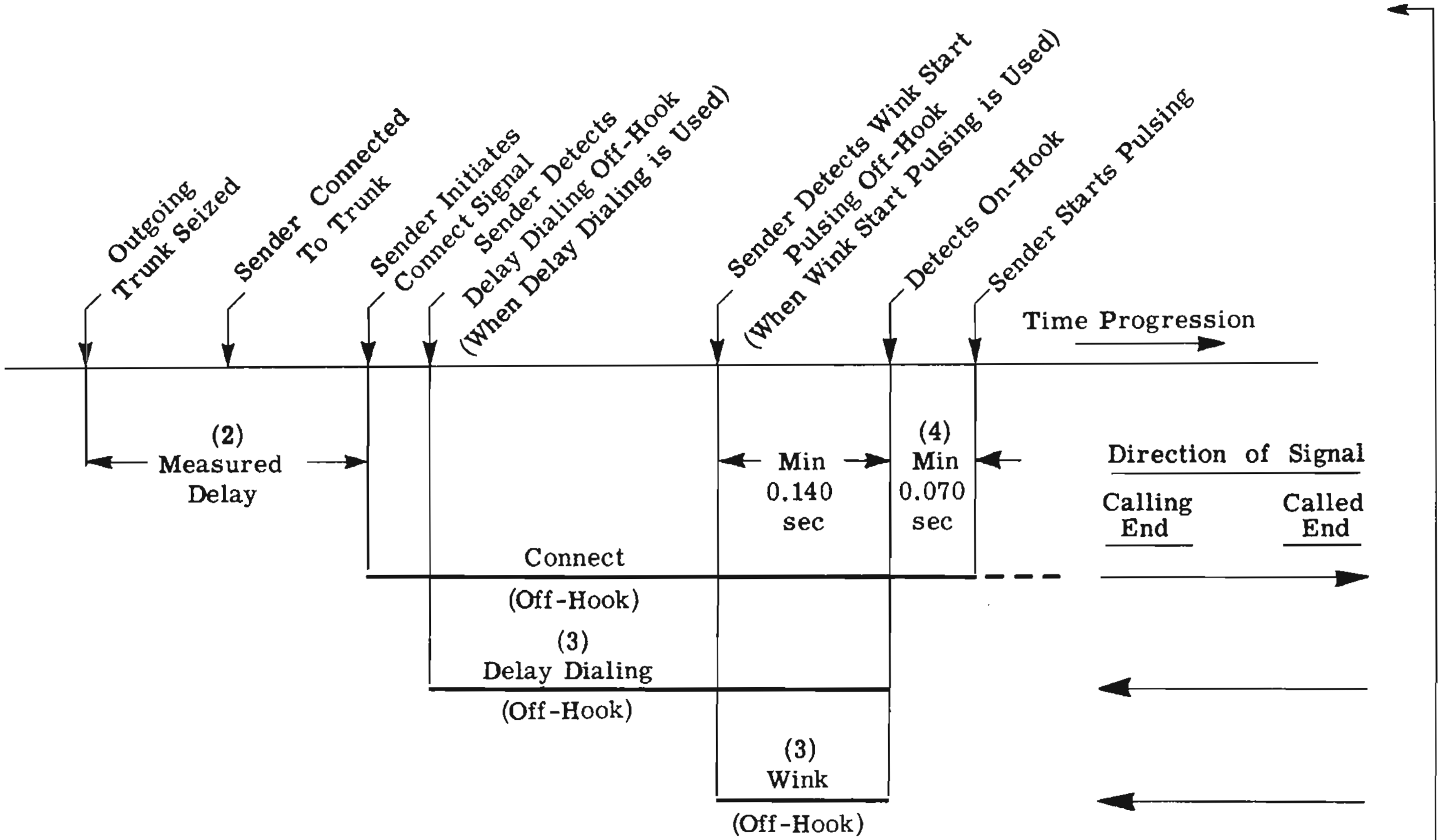
Start Dialing (Start Pulsing)

3.14 Start dialing is on-hook occurring when the receiving office is ready to accept digits. However, a momentary delay of a minimum of 0.070 second should be introduced before dial pulsing is started (Figs. 1, 2, and 3). This delay is necessary because dial pulsing receiving circuits are sometimes momentarily disabled at the instant of the sending of the start dialing signal to prevent the registration of a false reflected pulse.

3.15 Most trunks to direct control switching systems are ready to receive digits without delay and so are normally in the start dialing on-hook condition. However, senders should delay the first dial pulse a minimum of 0.070 second to allow time for operating the A relay and soaking the B relay of the distant selector or equivalent circuit. Senders are informed by class marks whether they are operating with this class of trunks or with trunks requiring delay dialing.

Wink Start Pulsing (Wink)

3.16 This signal is a momentary off-hook pulse, nominally 0.200 second (0.140 second minimum) transmitted toward the calling end when the called end is ready to receive pulsing. As shown in Fig. 1, pulsing should not be started until a minimum of 0.070 second after receipt of the following on-hook signal. Sender operation is similar to operation with Delay Dialing — Method A. The wink start pulsing signal, like the Delay Dialing — Method A, is applicable only



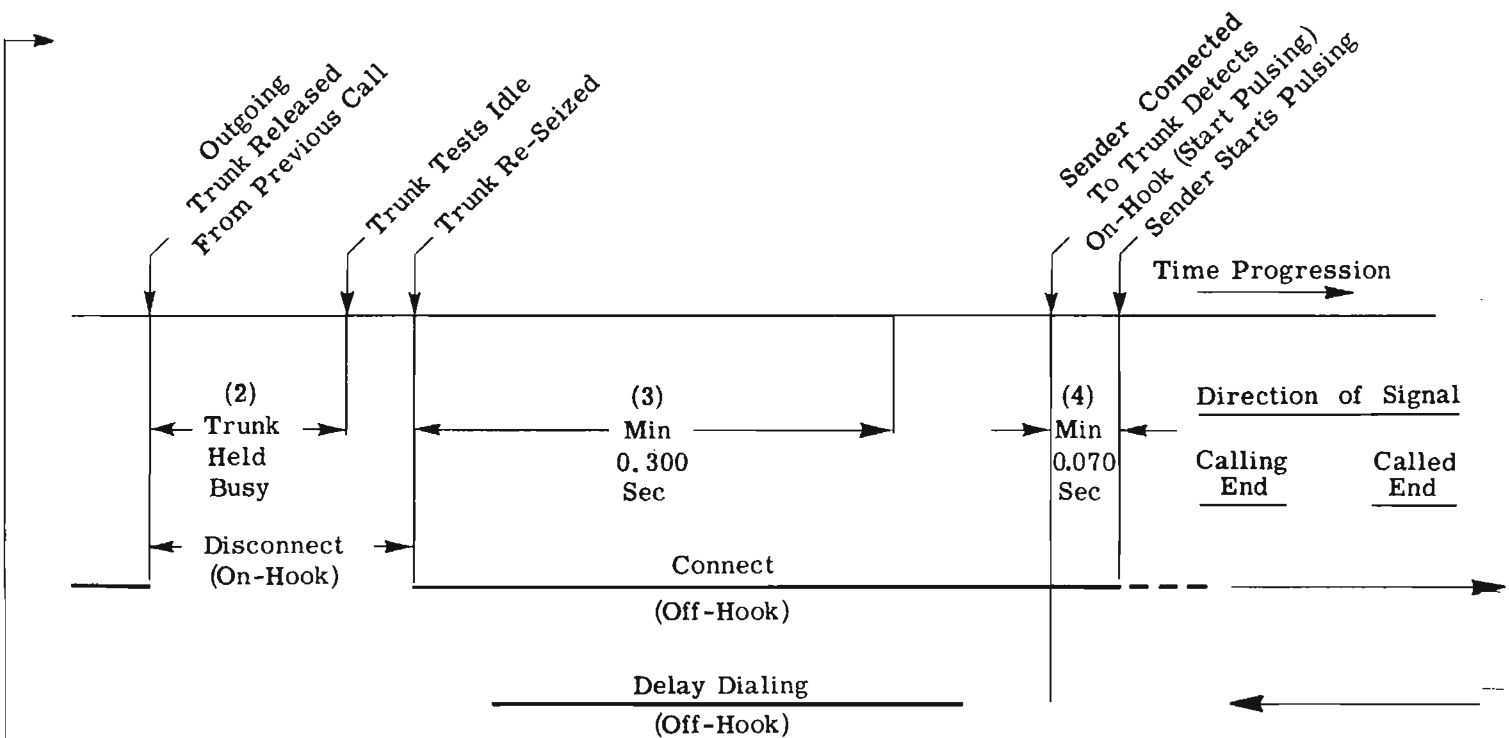
(1) The sender indicated is in the sending office.

(2) This measured delay is provided to insure the minimum interval of 0.750 second required for disconnection.

(3) The sender operations for Delay Dialing Method A and Wink Start Pulsing are similar except that with the latter the off-hook is a nominal 0.2 second (minimum 0.140 sec) timed pulse received just before the start dialing on-hook.

(4) This delay is necessary when dial pulsing because dial pulsing receiving circuits under certain conditions are momentarily disabled to prevent the registration of a false reflected pulse caused by the sending of the start dialing on-hook.

Fig. 1 - Delay Dialing Method A
(Wink Start Pulsing also Illustrated)



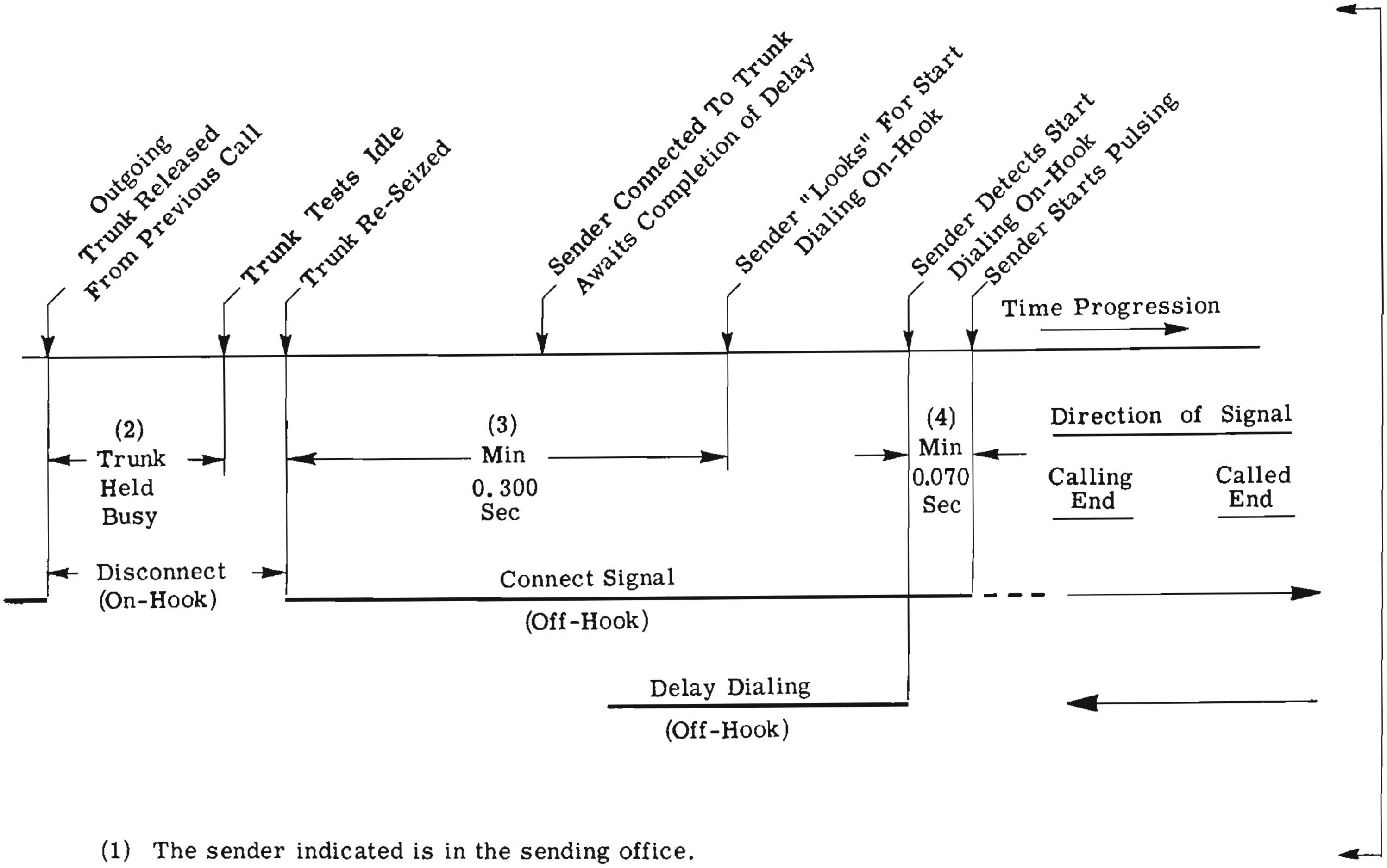
(1) The sender indicated is in the sending office.

(2) The minimum interval required for disconnection of all 2-way and some one-way trunks is obtained by holding the trunk busy after disconnection for a minimum of 0.750 second.

(3) This interval must elapse before the sender tests for on-hook as the start dialing signal. It insures sufficient time for sending forward the connect signal and the return of the delay dialing signal.

(4) This delay is necessary when dial pulsing because dial pulsing receiving circuits under certain conditions are momentarily disabled to prevent the registration of a false reflected pulse caused by the sending of the start dialing on-hook.

Fig. 2 - Delay Dialing Method B - Sender Connected
After Delay Dialing Signal



(1) The sender indicated is in the sending office.

(2) The minimum interval required for disconnection of all 2-way and some one-way trunks is obtained by holding the trunk busy after disconnection for a minimum of 0.750 second.

(3) This interval must elapse before the sender tests for on-hook as the start dialing signal. It insures sufficient time for sending forward the connect signal and the return of the delay dialing signal.

(4) This delay is necessary when dial pulsing because dial pulsing receiving circuits under certain conditions are momentarily disabled to prevent the registration of a false reflected pulse caused by the sending of the start dialing on-hook.

Fig. 3 - Delay Dialing Method B - Sender Connected Before Delay Dialing Signal

when the connect signal is initiated by the sender or when the trunk circuit is arranged to lock in a memory of the wink start pulsing off-hook signal. It is not suitable for trunks having switchboard multiple appearances, nor is it used on intertoll trunks. Also, the wink start pulsing signal can not be used when a common control switching system reaches another common control switching system through an intermediate direct control switching system.

Stop

3.17 A stop signal is an off-hook toward the calling end which occurs after some but not all digits have been received and which indicates that the called end is not yet ready to receive the remaining digits. It is required on dial pulsing calls which are directed, after some digits have been outpulsed, to trunks terminating in (1) link type CDO's, (2) line circuits of step-by-step offices, or (3) common control offices. It is not used on MF pulsing calls.

Go

3.18 A go signal is an on-hook toward the calling end following a stop. It indicates that the called end is ready to receive further digits. It continues until pulsing is completed or until it is interrupted by an apparent second stop, which actually is not a stop but rather is the off-hook flash of a reorder or no circuit signal which causes the sender to cut the trunk through or set the call to reorder. After receipt of a go signal, senders should delay the first pulse a minimum of 0.070 second.

Dial Pulsing (DP)

3.19 Dial pulsing represents each digit by the number of on-hook intervals in a train of pulses. The on-hook intervals of each digit are separated by short off-hook intervals while the digits themselves are separated by relatively long off-hook intervals. The on-hook signals will not interfere with the function of the connect signal since they fall much below the minimum disconnect times given above under Connect and Disconnect. The off-hook between digits is distinguished from the off-hook between pulses by the timing of a slow release relay. In step-by-step systems, the end of a digit is recognized when the off-hook signal exceeds 0.100 to 0.295 second. In common control systems, the range is of the order of 0.075 to 0.210 second. After the end of a digit is recognized, additional operations must be performed before the next digit can be received. (See "Interdigital Time" Paragraphs 3.26-3.30.)

3.20 Three important requirements for dial pulsing are (1) pulsing speed, (2) per cent break (sometimes per cent make is used), and (3) interdigital time. The requirements for pulsing speed and per cent break must be considered in relation to (1) the various dial pulse generators, (2) the various signaling, trunk, and repeater circuits used to transmit or regenerate dial pulses, and (3) the receiving circuits such as step-by-step selectors, links, and senders or registers. Per cent break is defined as:

$$100\text{x} \frac{\text{on-hook interval}}{\text{on-hook + off-hook interval}}.$$

3.21 The Bell System readjust requirements for pulsing speed in pulses per second (pps), and per cent break of typical dial pulse generators are shown in Table 1.

Table 1

Dial Pulse Generators	Speed PPS	Per Cent Break
Earlier Type Customer Dial	8.5-10.5	59.5-67.5
Later Type Customer Dial (Present Standard)	9.5-10.5	60-64
4A Toll System Sender (Loop Signaling)	9.5-10.5	59.5-67.5
4A Toll System Sender (E&M Lead Signaling)	9.5-10.5	59-63*
Earlier Operator Dial (10 pps)	9.5-10.5	59.5-67.5
Earlier Operator Dial (20 pps)**	16-20	62-70
Later Operator Dial (10 pps)	9.5-10.5	61-67
Later Operator Dial (20 pps)**	19-21	61-67

*This is converted to 58 per cent nominal in the outgoing intertoll trunk circuit for application to the signaling circuit M lead.

**20 pulses per second dialing is limited to panel and crossbar areas.

3.22 The nominal requirements for pulsing speed in the various signaling, trunk, and pulse repeater circuits used in intertoll signaling is 9 to 11 pulses per second. The exact requirements for per cent break vary since the per cent break may be shifted in passing through various circuits.

3.23 Signaling and trunk circuits are designed to obtain optimum over-all pulsing results in transmitting the pulses from the dial or sender to the receiving equipment at the incoming office. Each circuit is designed to provide an average or nominal shift in per cent break to deliver pulses best suited to the connecting equipment. As a typical example, in the Bell System, switchboard dials have a nominal 64 per cent break, whereas with intertoll signaling equipment it is desirable to have 58 per cent imput on the M lead. This transformation usually occurs in the trunk circuit. For example, the optimum input to a CX signaling circuit is 58 per cent break at the sending end as received from a trunk circuit. The CX signal at the receiving end (E lead) is optimum 59 per cent break and may be delivered to a variety of circuits as required by the switching conditions. As an example, if switched to an AB toll transmission selector, an incoming trunk circuit is required between the CX signaling circuit and the AB toll selector. The A relay of this trunk responds to the CX signals and delivers an output pulse in the order of 62 per cent break. The A relay and its associated circuitry are designed to provide this pulse characteristic. Further examples of the per cent break signal and the typical shifts in per cent break taking place into and through the intertoll train are given in Table 2.

Table 2

Type of Trunk (Bell System)	Average Per Cent Break Tested at 12 PPS Input	Output	Shift
Outgoing intertoll trunks from switchboard	64*	58	-6
CX signaling circuit	58	59	+1
Four-wire trunk to toll intermediate selector or intertoll transmission selector	59	59	0
Trunk to AB train	59	62	+3
Trunk to loop toll train	59	64	+5
Operator office trunk - loop signaling **	59	62	+3
Operator office trunk - CX signaling **	59	58	-1
Selector appearance of intertoll trunk	59	58	-1

* From 10 pps operator dial.

** Repeating relay used from intertoll selector appearance.

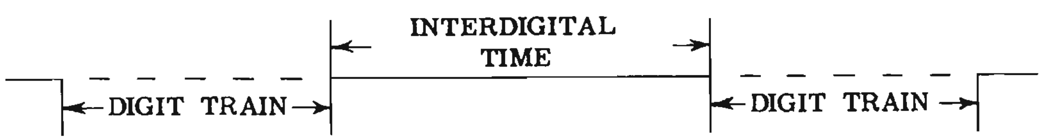
Single frequency signaling systems operate on a pulse correcting basis with a median 58 per cent break at 10 pulses per second.

3.24 Optimum toll dial pulsing speed may be considered as 10 pulses per second. In view of the shifts in per cent break through the train, no single per cent break value can be considered as optimum. Where per cent break limits apply, they are specified on the drawing. These limits provide a band on either side of the optimum or average value to guarantee that pulses will be delivered to a connecting circuit within a similar band specified for that circuit.

3.25 In general, the various dial pulse receivers, such as step-by-step selectors and senders or registers, must have capabilities broader than the requirements of the dial pulse generators and the transmitting and repeating devices. This provides a margin for satisfactory service.

Interdigital Time

3.26 The interdigital time is the interval from the end of the last on-hook pulse of one digit train to the beginning of the first on-hook pulse of the next digit train.



3.27 The interdigital time delivered by a sender depends on the availability of the succeeding digit. When the next digit is immediately available the sender must control the minimum interdigital interval by timing. The requirements for the minimum interval are:

(1) 0.300 second when pulsing into senders or registers of the crossbar or panel type.

(2) 0.600 second when pulsing into step-by-step selectors or the equivalent. This can be, and generally is, used for pulsing into senders or registers.

3.28 An accuracy of 5 per cent is considered satisfactory for timing this interval. In step-by-step offices three functions must be completed during the interdigital interval as follows:

(1) Recognition of end of digit by the release of the pulse train detector C (or equivalent) slow relay.

(2) Trunk hunting over as many as nine terminals.

(3) Test idle terminal, cut through, operate A relay, and soak B relay of next switch or equivalent relay circuit.

3.29 The off-hook portion of either the 120 IPM reorder signal or the 30 IPM no circuit signal which results from finding all trunks busy may not be returned during the interdigital interval if, during this interval, the interrupter furnishing the signal happens to be in the open (or on-hook) portion of its cycle. When this occurs, the off-hook may be returned during pulsing of the succeeding digit. Since continued pulsing against off-hook might cause false disconnections in SF (single frequency) signaling systems, means should be provided, where practicable, to stop pulsing immediately, without completing the digit, when off-hook is received from the called end of intertoll trunks.

3.30 A stop dial signal must be received 0.065 second before the termination of the interdigital interval to allow time for the sender to recognize the signal and stop outpulsing. Improper adjustment of the digit train detecting, slow release relay (C relay, or equivalent) in a step-by-step selector can, of course, reduce the time available for other interdigital functions.

Line Busy, Reorder, and No Circuit

3.31 Three supervisory flashes and tones presently employed in the Bell System plant are shown in Table 3. It is planned to limit the flashing signals indicating some form of blockage to these three signals.

3.32 Tone for 30 and 120 IPM, shown in parentheses in Table 3, has not been provided in certain toll systems in the past. Flashes with accompanying tone should be provided at Class 5 offices for 60 and 120 IPM; flashes should be provided at Class 4 and higher ranking offices for 30 and 120 IPM, and it is desirable that tones accompany these flashes where they can be furnished more economically than by the use of tone appliers. Tone appliers (discussed in Section V, Paragraph 3.22) will be used to supply tones to customers encountering flashes without tone or where the tone has been impaired in transmission.

Table 3

	Line Busy 60 IPM	Reorder 120 IPM Local	Reorder 120 IPM Toll	No Circuit 30 IPM
Flash				
Off-hook interval	0.5 sec.	0.3 sec.	0.2 sec.	0.3 sec.
On-hook interval	0.5 sec.	0.2 sec.	0.3 sec.	1.7 sec.
Tone (Low Tone)				
Tone on	0.5 sec.	0.3 sec.	(0.2 sec.)	(0.3 sec.)
Tone off	0.5 sec.	0.2 sec.	(0.3 sec.)	(1.7 sec.)
Cord Lamp Response				
Dark	0.5 sec.	0.3 sec.	0.2 sec.	0.3 sec.
Light	0.5 sec.	0.2 sec.	0.3 sec.	1.7 sec.

Ring Forward (Rering)

3.33 As applied to distance dialing circuits, ring forward is a momentary on-hook of 0.100 second ±0.030 second toward the called end. It is converted from the signal supplied by the operator's key to this timed on-hook interval by a timing element in the trunk circuit. It is again converted at the destination office to a recall signal on the operator's answering cord. At intermediate offices it may be regenerated to the proper interval.

Ringback

3.34 Ringback is reversed supervision backward to the originating operator, usually on-hook, lighting the operator's cord lamp. It results from the operation of the called operator's ringing key and continues until the key is released.

Flashing

3.35 A flashing signal is simply successive on-hook and off-hook intervals. These may be irregular and manually generated, but the term is also used to describe regular machine generated flashes including reorder, line busy, and no circuit signals.

(B) Arrangements for Transmitting On-Hook and Off-Hook Signals

Direct Current Methods

Loop Signaling Methods

3.36 Signaling methods which use the metallic loop formed by the trunk conductors and terminating bridges are known as loop signaling. Loop signals are transmitted by one or more of the following basic methods:

(1) Opening and closing the direct current path through the loop.

(2) Reversing polarity of current.

(3) Changing value of bridged resistance.

The principal loop methods are described in the succeeding paragraphs.

3.37 Reverse Battery Signaling: Reverse battery signaling employs basic methods (1) and (2) described above but takes its name from the fact that battery and ground are reversed on the tip and ring to change the signal toward the calling end from on-hook to off-hook. This is the preferred and most widely used of loop signaling methods. Fig. 4 shows a typical application. Note that the principal elements directly concerned in reverse battery signaling are the CS, T, and A relays and the SW2 switching contacts. On-hook forward (disconnect signal) is an open trunk loop at unoperated SW2 contacts. Off-hook forward (connect signal) is a closed trunk loop by operated SW2 contacts. The backward signals cannot be defined in absolute terms of polarity because of the many variations in practice, but it is always true that on-hook is the polarity existing when awaiting the customer's answer while off-hook is the polarity when the called customer has answered. Trunks not requiring the delay dialing signal are in the on-hook condition when idle whereas trunks requiring the delay dialing signal may be in the off-hook condition when idle. Trunks arranged for "wink" start dialing signal are in the on-hook condition when idle.

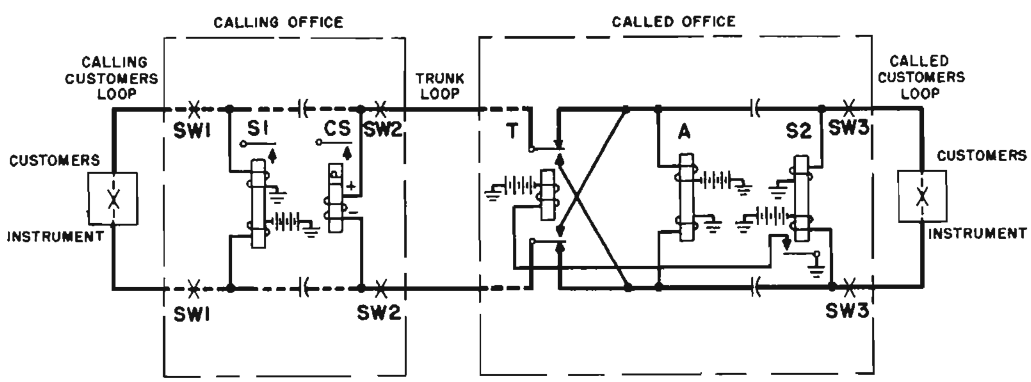


Fig. 4 - Reverse Battery Supervision

3.38 Fig. 5 illustrates repeated reverse battery supervision at a tandem office. The slow release D relay is used to hold the connection through the tandem switches.

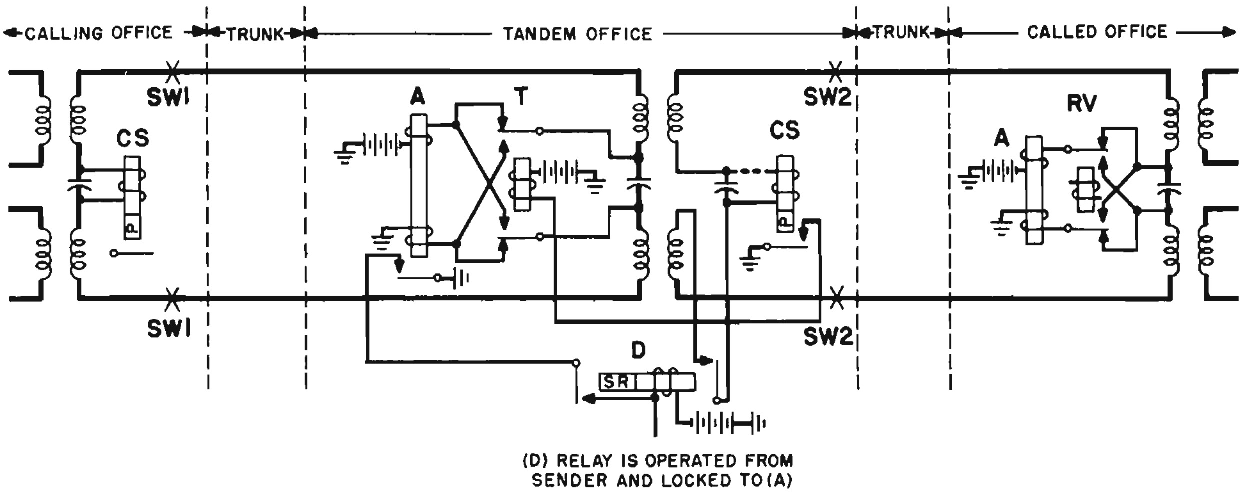


FIG.5 – REPEATED REVERSE BATTERY SUPERVISION

3.39 High-Low Signaling: High-low signaling employs basic methods (1) and (3) described above but takes its name from the fact that high resistance on-hook is changed to low resistance for off-hook. The basic high-low principle long used in straightforward local manual systems between A and B boards is illustrated in Fig. 6.

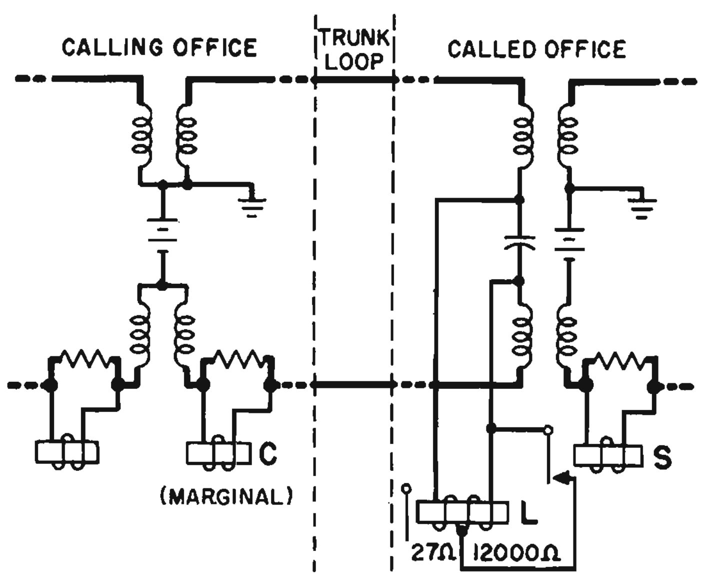


FIG. 6 – HIGH-LOW SIGNALING

3.40 Wet-Dry Signaling: Wet-dry signaling employs basic methods (1) and (2) described above. It is so named because of the following commonly used terminology. A trunk is "wet" when battery and ground are connected to the loop at the called end. It is "dry" when battery and ground are removed. "Wet" is on-hook and "dry" is off-hook. A connect signal (off-hook) forward is a dc bridge across the trunk loop at the calling office. A disconnect is an open trunk loop at the calling end. However, release of the connection will not take place until the called end is on-hook (wet) and the calling end has disconnected. This is called joint control of release. A reversed battery signal is sometimes superimposed on the "wet" or on-hook condition to indicate to the calling end that line seizure has taken place.

3.41 Battery and Ground Signaling: The range of loop signaling can be increased by employment of battery and ground signaling. This is simply the device of having battery on one conductor and ground on the other at the originating end meeting ground and battery, respecttively, at the terminating end. This approximately doubles the current available for signaling on long trunks. Means are provided to open and close both conductors at the originating end to furnish forward on-hook and off-hook signals. Reverse battery is generally used for supervisory signals from the called end (backward signals). Between digits and at the completion of pulsing, a bridged supervisory relay may be substituted for the pulsing battery and ground to detect the backward signals and to hold the connection regardless of the polarity of these signals. This widely used arrangement is sometimes called "Battery and Ground Pulsing, Loop Holding." When maximum range is required, "Battery and Ground Pulsing, Battery and Ground Holding" may be employed.

E & M Lead Control

3.42 Most signaling systems other than loop signaling are independent of the trunk circuit, and functionally are located between the trunk circuit and the line. The trunk circuit connects with the signaling circuit over two leads designated, traditionally, the "E" and "M" leads. The E lead is used to receive open or ground signals from, and the M lead is used to send ground or battery (-48 volts) signals to, the signaling circuit.

3.43 By segregating certain functions in the trunk circuits and others in the signaling system, the particular kind of trunk circuit necessary for a job and the particular E and M lead signaling system required can be selected independently with assurance that they will work together. Similar signaling circuits should be used at both ends of a signaling section.

3.44 The input and output signals of E and M lead signaling systems are uniform and are shown in Fig. 7.

3.45 Note that the operation of these systems is "duplex"; that is, simultaneous signals can be sent in both directions without interference with the exception noted in 3.29.

Signal A to B	Signal B to A	Condition at A M Lead	Condition at A E Lead	Condition at B M Lead	Condition at B E Lead
on-hook	on-hook	GRD	Open	GRD	Open
off "	on "	BAT	Open	GRD	GRD
on "	off "	GRD	GRD	BAT	Open
off "	off "	BAT	GRD	BAT	GRD

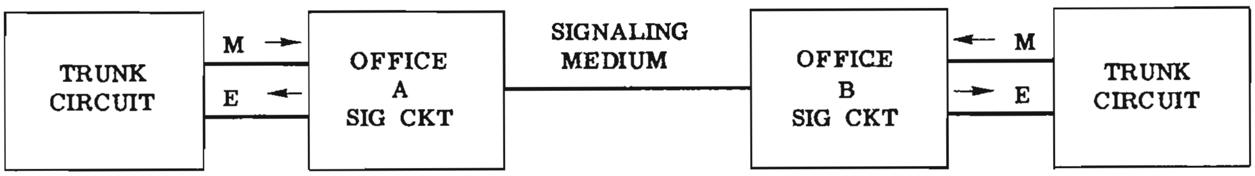


Fig. 7 - E and M Lead Control

Pulse Links and Converters

3.46 A trunk may be made up of two signaling sections connected in tandem, each section having its own signaling system. If the sections have similar signaling arrangements an auxiliary pulse link is provided to repeat the signals. If the signaling arrangements are different, converters are provided. For example, one section of a trunk may employ loop signaling and another section employ signaling with E and M lead control. At the junction of the two systems (intermediate office) a signaling converter is used to connect the two systems. Converters are also required at the terminals of a trunk when the signaling system to which it connects differs in signaling arrangements from that of the trunk circuit.

Composite (CX) Signaling

3.47 Composite (CX) signaling employs a single line conductor for each signaling channel. A balanced polar relay is used at each end of the signaling section as shown in Figure 8 in a symmetrical arrangement which permits full duplex operation. Higher frequency voice currents are separated from lower frequency currents by a filter arrangement called a CX set. The crossover frequency is about 100 cycles. Two CX legs can be derived from a pair of wires, and four from a phantom group. These can be used independently, with a ground return, for signaling, but in most cases one is used as an earth potential compensation path. If the fourth leg is not required for earth potential compensation, or for telephone signaling, it can be used for telegraph service. The signaling channels can be assigned independently of the voice channels with which they are physically associated.

3.48 CX Sets (Filters): Three types of CX sets are used for signaling. As coded in the Bell System they are:

(1) Type C — used for CX signaling on open wire and cable. It can be used at intermediate and terminal points.

(2) Type D – used for CX signaling on open wire and cable but only at terminal points and can not be used for intertoll dialing. It is similar to Type C but less expensive.

(3) Type E – used for CX signaling on cable circuits only. It can be used at intermediate and terminal points like Type C but uses less expensive components.

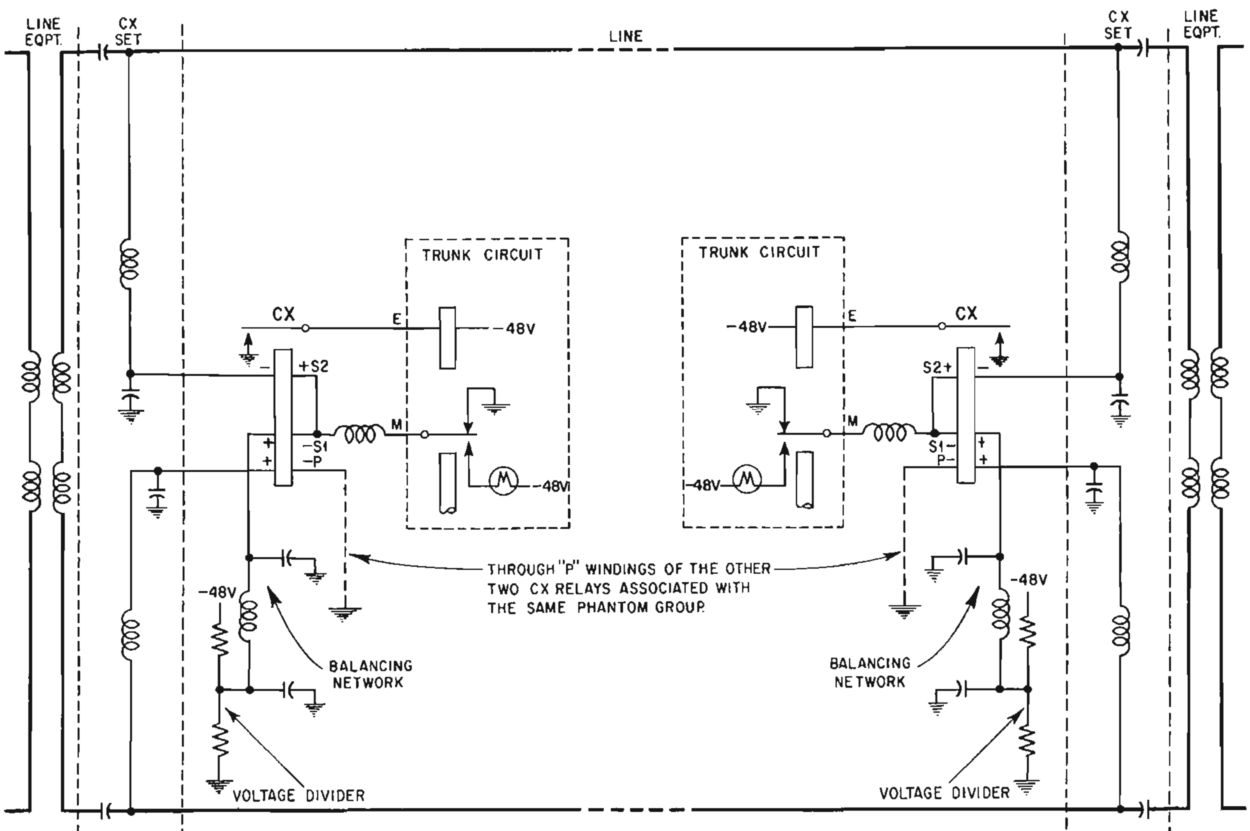


FIG. 8 – COMPOSITE SIGNALING FOR ONE VOICE CHANNEL

3.49 Signaling Equipment: CX signaling equipment is duplex in operation: it provides simultaneous 2-way signaling paths. The circuit techniques are those used in polarential telegraph and teletype. A sensitive 3-winding polar relay at each end of the line receives from the distant end. Balancing networks must be adjusted for each circuit according to the impedance of the line conductors. Compensation for earth potential differences is optional.

3.50 A number of CX signaling equipment units are available. They may be classified as short haul and long haul, with the following broad applications:

(1) Short haul: Maximum of 4800 ohms loop resistance on cable circuits or 90-100 miles of open wire.

(2) Long haul: Maximum of 12,000 ohms loop resistance, including one bypassed voice repeater.

3.51 Earth potential compensation is essential to proper performance where earth potential conditions indicate its use. It is applied in the Bell System where variations beyond the specified limits are considered likely to occur. As an example, the Long Lines Department of the American Telephone and Telegraph Company applies compensation to practically all CX circuits under its administration.

Signaling Distortion

3.52 Dial pulsing on CX signaling circuits is normally at a rate of from 9 to 11 pulses per second. Tests for dial pulse distortion, however, are made at 12 pulses per second and typical limits for adjusting, testing, and performance, in terms of per cent break at this speed, are as follows:

	Per Cent Break		Pulsing Speed
	Input	Output	(PPS)
Adjust	58	59	12
Test	58	57-61	12
Expected Performance	58	55-63	12

The input is at the M lead of one end of a signaling section and the output is at the E lead of the other end.

3.53 The input to CX signaling equipment should be limited to the range 47 to 67 per cent break or a narrower range under unfavorable conditions. When testing at 12 pulses per second the output limits into a step-by-step selector are 44 to 72 per cent break.

3.54 Dialing without intermediate senders or registers is not expected to be transmitted through more than four trunks connected in tandem. This limitation applies to all types of toll line signaling.

3.55 Range: Economic factors limit CX signaling to a range of about 200 miles. The longer ranges of CX signaling are obtained by connecting signaling circuits in tandem with pulse links.

DX Signaling

3.56 DX signaling is a dc signaling method so named to simplify its identification among trunk signaling methods. It can be operated by E and M control as shown in Fig. 9 or it can be incorporated into the trunk circuit design.

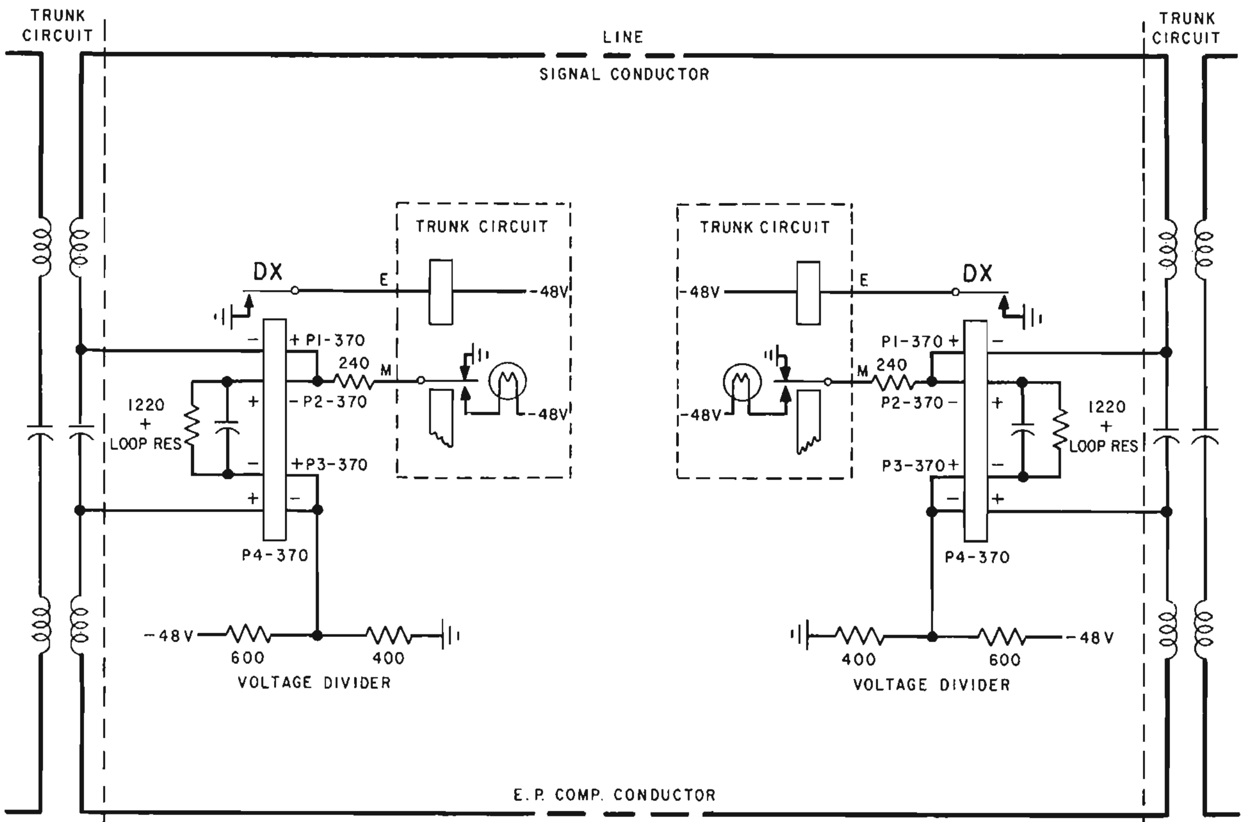


FIG. 9 - DX SIGNALING CIRCUIT

3.57 DX signaling is similar to CX in that it is balanced and symmetrical. However, it differs from CX in that it requires a physical cable pair per circuit. The signaling circuit should use the same cable pair as the talking path, and therefore no filter is required to separate the signaling from the voice transmission. One wire of the pair is used for signaling and the other to compensate for differences in ground potential and partially for variations in battery voltages.

3.58 At each end of the line a polar relay with four equal windings is connected to the trunk conductors at the midpoints of a repeating coil. A balancing network consisting of resistance and capacitance is provided at each terminal between the P2 and P3 windings. The resistance of this network is adjusted to equal the conductor loop resistance plus 1220 ohms.

3.59 When the trunk is idle both M leads are grounded and both DX relays are electrically biased to the non-operated position by the P2 and P3 windings from the negative potential of the voltage divider. Assuming no earth potential difference, there is no current flowing over either trunk conductor.

3.60 When one end is off-hook, battery is placed on the M lead thus causing the distant DX relay to be operated to ground on its M lead. At the near end, current in the P2 and P3 windings is reversed tending to operate the polar relay but the signal current through the P1 winding more than offsets this effect and holds the relay non-operated.

3.61 When both ends are off-hook, both M leads are connected to battery and each DX relay holds operated to ground on the voltage divider. As in the case of on-hook at both ends there is no current over either trunk conductor if no earth potential difference is assumed. However, when earth potential differences do exist they produce opposite and approximately equal effects in the P1 and P4 windings at each end of the trunk and so are neutralized.

3.62 DX signaling transmits nominal 10 or 20 pps dial pulsing with little signal distortion. No pulse repeating adjustments are required.

3.63 A single DX signaling section is limited to a maximum loop resistance of 5000 ohms. However, this range can be doubled by using two sections in tandem.

3.64 DX signaling is expected to be used instead of loop signaling on longer local and tandem trunks and instead of SX and CX on short intertoll trunks except where open wire or non-physical circuits preclude its use. It can be operated without impairment through E type (negative impedance) repeaters.

Simplex (SX) Signaling

3.65 Simplex (SX) signaling requires the use of both trunk conductors for a signal channel. A center tapped coil or its equivalent is used at both ends of the trunk for this purpose. The arrangement may be a one-way signaling scheme suitable for intraoffice use as illustrated in Fig. 10, or the simplex legs may be connected to full duplex signaling circuits which function like the CX signaling circuits with E and M lead control.

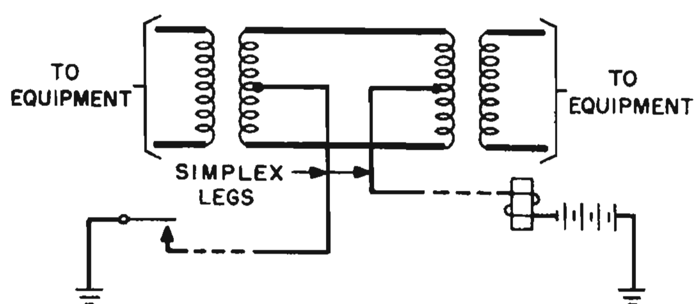


Fig. 10 - Simplex Signaling

3.66 Earth potential compensation requires the use of the conductors of an additional trunk for each five signal channels. Thus, only five SX signaling circuits are derived from six physical circuits. The signaling currents in the line side induce no voltage in the equipment side because they flow in opposite directions and conversely voice currents in the equipment side cause no current flow in the simplex leg. Because a phantom can not be derived when the simplex leg is used for signaling, SX systems are seldom used on long trunks.

Alternating Current Methods

Single Frequency Signaling Systems

3.67 Three single frequency (SF) signaling systems are used in the Bell System; two employing frequencies in the voice band and the third, used on N and O carrier, employing a frequency outside but adjacent to the voice band. The in-band single frequency signaling systems are free from range and other limitations imposed by dc signaling methods and so have made a major contribution to the feasibility of distance dialing. They use alternating currents within the voice band as the signaling medium and, therefore, can be used with any trunk which meets voice transmission requirements.

3.68 The earlier, 1600-cycle, SF system employs 1600 cycles in both directions on 4-wire trunks and 1600 cycles in one direction and 2000 cycles in the other for 2-wire trunks. The later, 2600-cycle, SF system employs 2600 cycles for 4-wire trunks and 2600 and 2400 cycles for 2-wire trunks. The 2600-cycle system provides all of the features of the 1600-cycle system at lower first cost and with more economical maintenance. However, it can not be used on narrow band facilities such as EB channel banks or H-172 loaded lines. It can be used on 4-wire broadband J, K, and L carrier and TD-2 radio systems, C5 carrier systems, and 2-wire or 4-wire H-88 or lighter loaded cable facilities.

3.69 The 1600- and 2600-cycle SF systems operate alike basically. Speech and the single frequency are not on the line simultaneously except on calls to the intercepting operators, as discussed later. The single frequency is applied and removed at each trunk terminal to operate and release a relay at the other end. One SF unit is required at each end of a trunk. Each unit is connected to a trunk circuit by E and M leads. It is placed in series with the line circuit on a 4-wire transmission basis.

3.70 The on-hook and off-hook conditions for all three SF signaling systems are as follows:

SIGNAL	TONE	OPERATION	LEAD	CONDITION
ON-HOOK	ON	SENDING	M	GROUND
		RECEIVING	E	OPEN
OFF-HOOK	OFF	SENDING	M	BATTERY
		RECEIVING	E	GROUND

3.71 The major features of the 2600-cycle SF system are illustrated in the simplified schematic of Fig. 11.

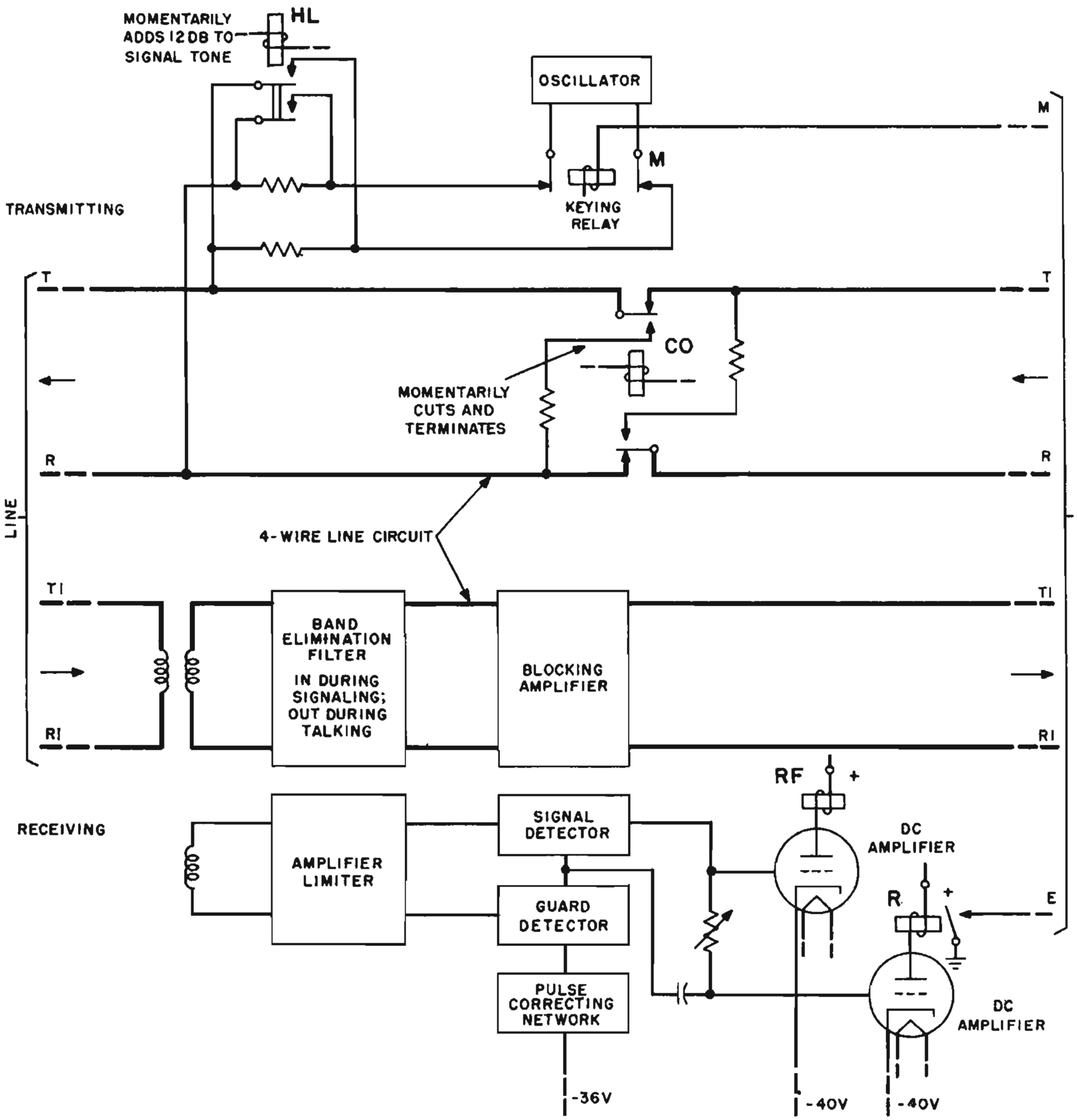


FIG.11 — SIMPLIFIED SCHEMATIC DRAWING OF THE SF CIRCUITS AS CONNECTED TO A FOUR-WIRE TRANSMISSION CHANNEL

3.72 Receiving: An incoming signal is separated into signal and guard components by the signal and guard detectors. The signal component is a band about 100 cycles wide centering on the signal frequency. The guard component is made up of other frequencies in the voice band. These components produce opposing voltage adding to net voltage on the grids of the dc amplifiers. In the talking condition (tone off in both directions) the guard detector sensitivity is such that almost a pure tone is required to operate the receiver since other than signal frequencies will produce a voltage opposing its operation. The guard feature prevents false operation of the receiver from speech signals. This guard action continues for about 230 milliseconds after the receiver operates at which time the receiver responds to all voice frequencies. This broad response during the idle period guards against momentary E lead closures due to bursts of noise. When tone disappears for 15 to 20 milliseconds, guard action is reinserted and the receiver again becomes selective to signal frequency.

3.73 An important reason for removing the frequency selectivity along with guard sensitivity when in the receiving on-hook condition for more than 230 milliseconds is the necessity for talking to intercept operators under such conditions. Thus, the operator's speech will not interfere with the tone signal reception. In addition, the band elimination filter, which is inserted under any on-hook condition, will prevent the tone from interfering with voice transmission.

3.74 Volume limiting in the receiving amplifier limiter helps prevent false operation on high levels of speech.

3.75 The pulse correcting network keeps pulses close to the ideal break interval of 60 milliseconds. Badly distorted pulses are only partially corrected in the SF unit.

3.76 Reorder and busy tones accompanying flashing signals are not transmitted satisfactorily. Tone appliers will be provided at originating local offices or outward toll centers to regenerate tones from flashes whenever tones are impaired by transmission through SF signaling systems.

3.77 Sending: Sending is under control of the M relay. Ground on the M lead releases the M relay and sends tone momentarily at 12 db higher than, and then at, normal level. The higher level is also used when sending dial pulses.

Carrier Systems — Adjacent Band (SF) Signaling

3.78 The N, the O, and the ON carrier systems have adjacent band signaling which employs 3700 cycles. These are short haul systems for trunks ranging from 15 or 20 up to about 200 miles in length. It is expected that under favorable conditions the range of the N system can be extended to more than double this length. The N system employs a cable pair in each direction and provides 12 channels per system. The O system provides from 4 to 16 channels (in groups of 4) in both directions on one open wire pair. The ON system will provide up to 24 channels on combinations of open wire and cable.

3.79 Speech and signaling frequencies are separated by low-pass and band-elimination filters. A time delay feature is provided in the signal detector circuit to minimize registration of false pulses of short duration due to noise bursts and hits on the line. Means are provided to disconnect called customers, in the event of a carrier failure, to prevent their being held out of service. In addition, in such cases, the trunks using the carrier facilities are made busy to prevent lost calls. In-band SF signaling is also used on these carrier systems in some cases where two or more types of line facilities are used in a particular intertoll trunk.

MULTIFREQUENCY PULSING

3.80 The multifrequency pulsing system provides transmitting and receiving equipment for transferring called number information over telephone trunks. It uses voice frequency pulses that can pass through any line facility suitable for voice. MF receivers detect the pulses and transfer the information to control equipment which establishes connections through the switches.

3.81 The principal advantages of MF pulsing are speed, accuracy, and range. Keysets are faster than switchboard dials, and similarly, MF senders transmit more rapidly than dial senders. Consequently, receiving equipment requires less holding time per call. Accuracy is obtained by the use of self-checking features. An additional advantage is the provision of an end of pulsing signal.

3.82 Since MF pulses are in the voice frequency band, the range of this pulsing system is restricted only by the transmission limits of the toll line facility. Routing information can be directly transmitted to an office thousands of miles away. MF is thus readily adaptable to the requirements of nationwide toll switching.

3.83 The MF system transmits only digital information; hence another signaling system, such as CX, SF, or loop, must be provided for supervision.

3.84 Six voice frequencies, used in combinations of two, form the MF pulses. Twelve combinations, as shown in Table 4, are used: ten for the digits from 0 to 9 and two for auxiliary control signals.

3.85 The auxiliary signals indicate the beginning and end of pulsing to the MF receiver. They are called KP and ST signals, respectively.

3.86 In Table 4, the frequencies 700, 900, 1100, 1300, 1500, and 1700 are represented by the "additive" code designations 0, 1, 2, 4, 7, and 10. Any digit to be pulsed, with the exception of 0, is equal to the sum of the code designations which represent the two frequencies required for that digit. The additive plan has been adopted to assist in identifying the combinations.

Table 4

Frequencies and Digit Codes for MF Pulsing

Digit	Code	Frequencies
1	0 + 1	700 + 900
2	0 + 2	700 + 1100
3	1 + 2	900 + 1100
4	0 + 4	700 + 1300
5	1 + 4	900 + 1300
6	2 + 4	1100 + 1300
7	0 + 7	700 + 1500
8	1 + 7	900 + 1500
9	2 + 7	1100 + 1500
0	4 + 7	1300 + 1500
KP	2 + 10	1100 + 1700
ST	7 + 10	1500 + 1700

MF Pulsing From Switchboards

3.87 The plan of MF pulsing from a switchboard position to a crossbar office is shown in Fig. 12. In such an arrangement, MF pulses are transmitted manually by an operator using a keyset. The operator can key about two digits per second. In completing a call, the operator first connects the calling cord to the outgoing trunk. By depressing the front KP button the cord connection is split and the front cord is transferred from the operator's telephone set to the keyset; the KP lamp is lighted; and the keyset circuit is prepared to send the KP signal over the trunk when the distant end signals to start pulsing. Connecting the cord to the trunk gives a connect signal to the distant end which returns off-hook supervision to delay pulsing until a sender or register is found. When the sender has been found and the pulsing path completed to an idle receiver, the supervision changes to on-hook as a start pulsing signal. The KP pulse is then sent automatically and the positional S (sender) lamp lights (with some switchboards the KP pulse is not sent automatically and the KP key is, therefore, not operated until the sender lamp lights). At the distant end, the KP signal prepares the MF receiver for pulses. The operator now presses a button corresponding to each digit and then the ST key to indicate the end of pulsing. Besides informing the distant sender that no more pulses are to be expected, operating the ST key disconnects the keyset from the cord, reconnects the telephone set under control of the TALK key, restores the connection between the cord pair, and extinguishes the KP and S (sender) lamps.

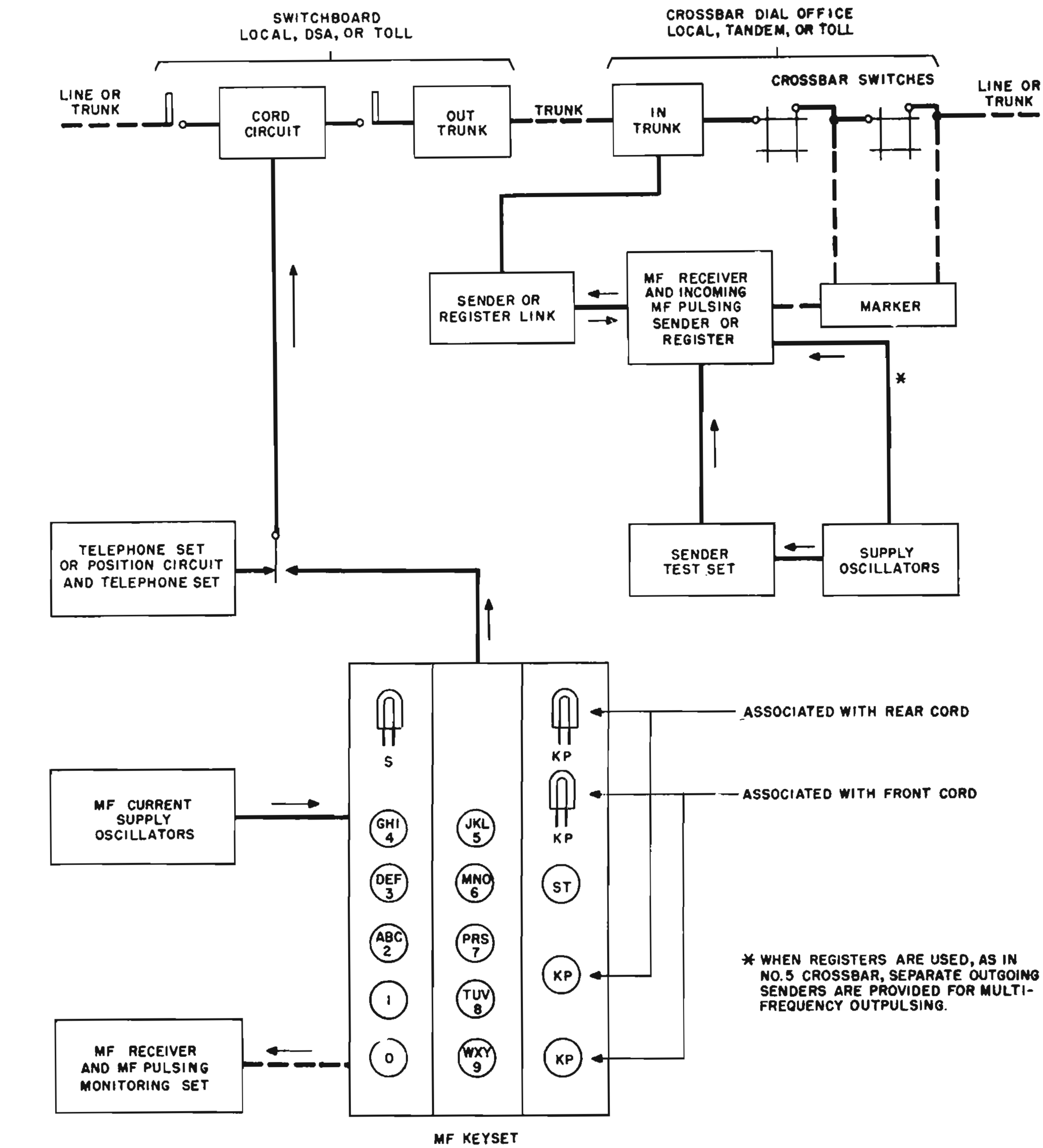


FIG. 12-PLAN OF MF PULSING SYSTEM

MF Pulsing From Senders

3.88 MF pulses are also transmitted by senders. The senders receive numbers from subscribers (on a dial pulsing basis) or from operators or other senders (on a dial pulsing, multifrequency pulsing, or other pulsing basis) and transmit these numbers as MF pulses. MF senders are arranged to pulse at a rate of approximately 7 digits per second.

MF Receivers

3.89 The receiver is connected to a trunk as part of a sender or register as required. It does not respond to voice frequency currents until it receives the KP signal. The unit then can receive and pass on the number codes and the ST signal to its associated sender or other connected equipment.

3.90 Fig. 13 shows the major features of a later type receiver which includes an input circuit, a volume-limiting amplifier, a biasing circuit, a signal present and unlocking circuit and the receiving channel circuits.

3.91 A check circuit in the receiver verifies that only two relays operate for each digit. Pressing two keys simultaneously and other errors are detected and a reorder signal returned to the sending end flashes the cord lamp. The operator must then release and start over.

Applications of MF Pulsing

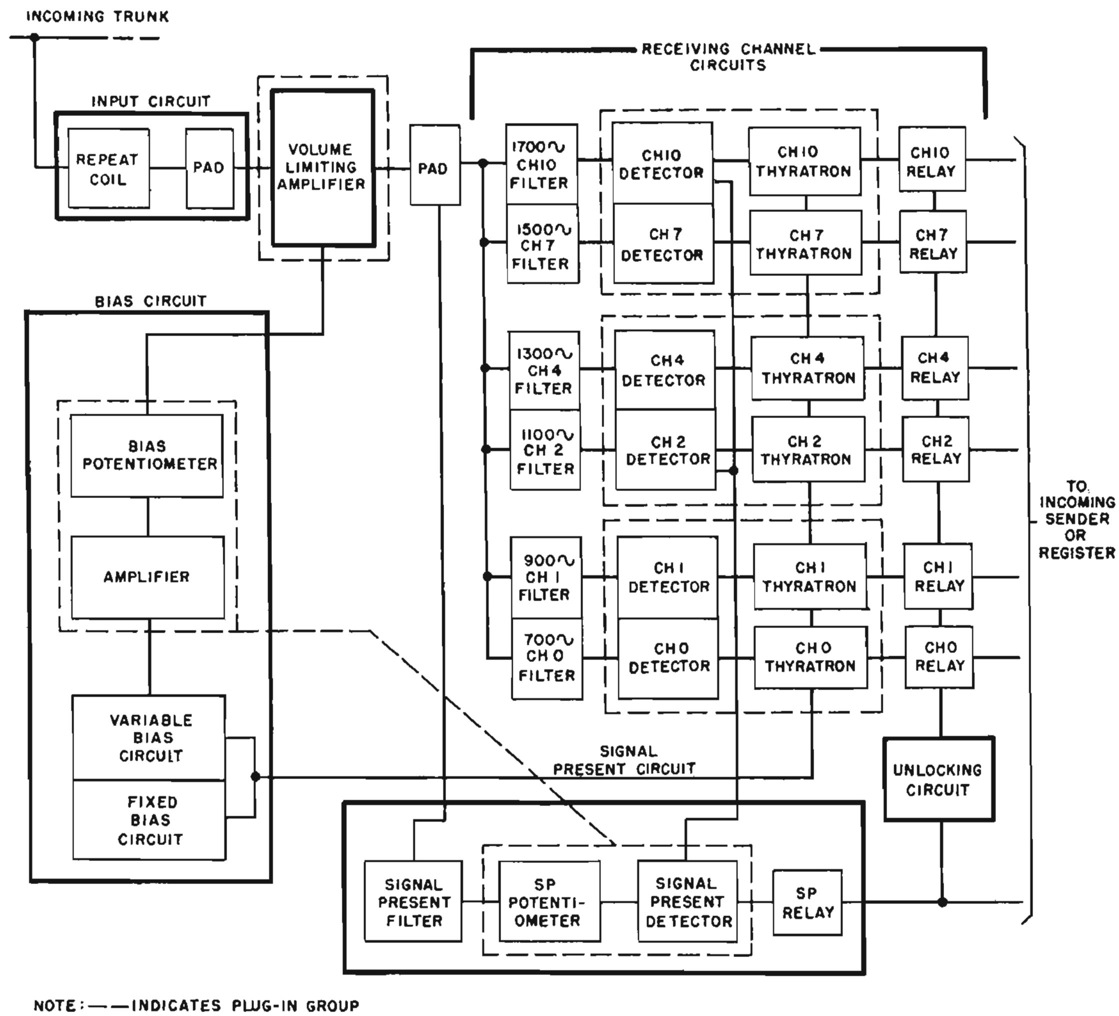
3.92 The general plan of MF pulsing is illustrated in Fig. 14. Crossbar offices receive MF pulses from senders at other dial offices and from keysets at switchboards.

3.93 Fig. 14 illustrates toll switchboard equipment for MF pulsing and having senders associated with outgoing trunks to step-by-step offices. These senders receive MF pulses from the operator keysets, and transmit dial pulses. This permits operators at positions equipped for MF pulsing to establish calls through step-by-step as well as crossbar offices.

Requirements of MF Pulsing

3.94 The normal power output of MF transmitters in toll, combined toll and DSA switchboards, toll testboards, test frames, and senders is -3 dbm per frequency at zero transmission level. On some local calls, the MF tones are heard by the calling subscribers, and to avoid being objectionable, the sending power from local manual switchboards is -6 dbm per frequency. The frequencies of the supply oscillators should be within ± one per cent of nominal.

3.95 The engineering limit for operate sensitivity of the receiver is -22 dbm per frequency. These margins permit the use of MF pulsing on trunks having maximum over-all losses of 19 db including allowances for trunk variations, etc., when connected to toll and DSA



→ FIG.13 – MF RECEIVER PLAN

switchboards, testboards, and senders, or 16 db when connected to local manual switchboards. Little interference from crosstalk, noise, and echoes on the line is encountered.

→ 3.96 Senders pulse at a rate of approximately 7 digits per second with 50 per cent open interval, as long as succeeding digits are available.

→ 3.97 Toll receivers are tested for slow pulsing at approximately 2 digits per second with 230 milliseconds open and 260 milliseconds closed intervals. Fast pulsing is tested at 10 digits per second with intervals of 35 milliseconds closed and 65 milliseconds open. This test is also made with the open and closed intervals interchanged. Receivers are also tested for

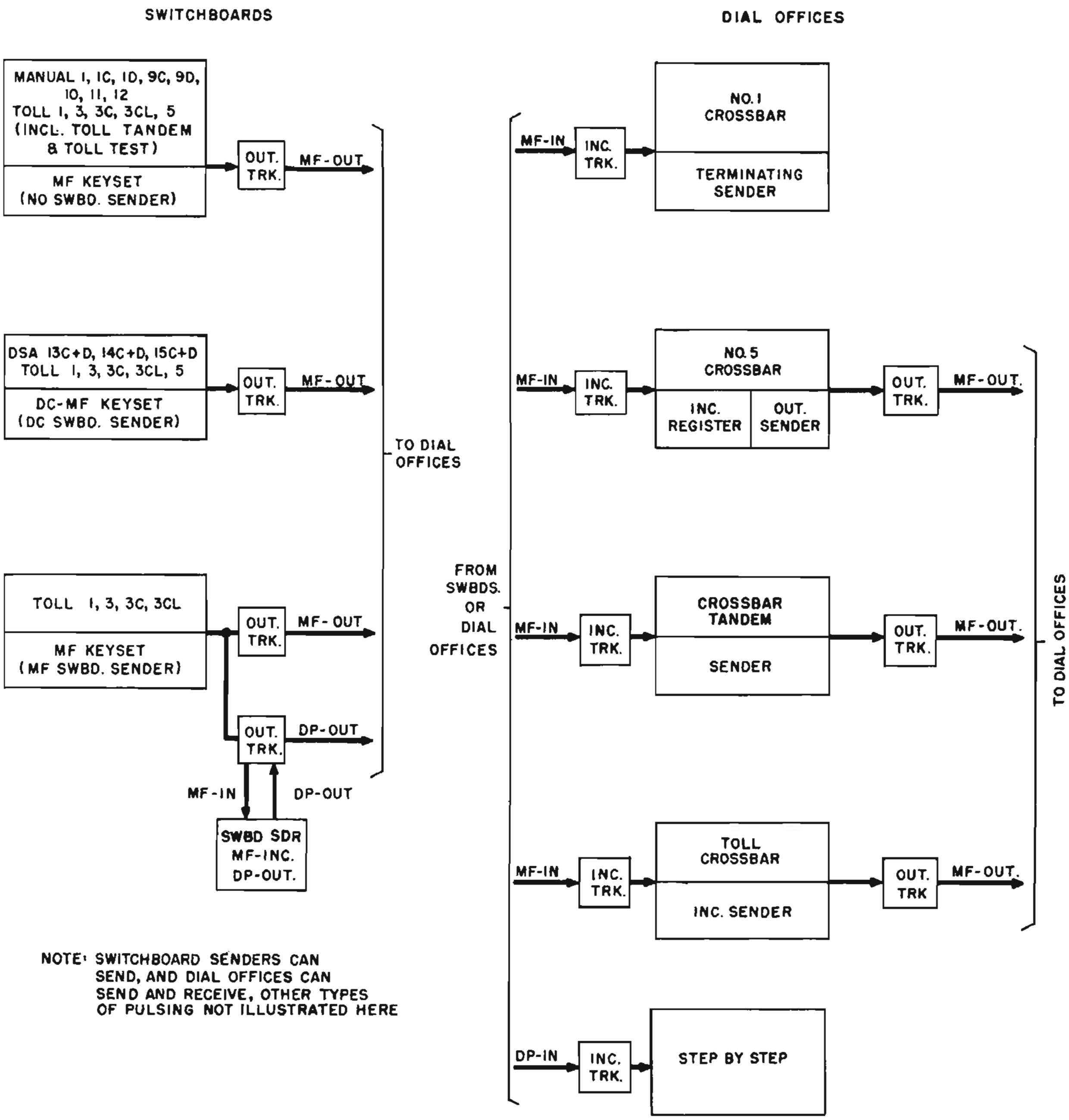


FIG. 14—APPLICATION PLAN OF MF PULSING SYSTEM

sensitivity range and for their ability to operate with the maximum allowable twist in transmission of frequencies of 8.5 db (6.5 db for early type receivers). Tests are also made at high input values to check that false operation of a channel does not result from modulation products.

→ 3.98 The nominal **KP** signal interval is 100 milliseconds. The receivers are designed to accept a **KP** pulse of 55 milliseconds minimum, but it is considered good practice for senders to deliver 85 milliseconds minimum to allow a margin for service insurance and for testing both receivers and senders.

→ 3.99 Delay pulsing and start pulsing signals are always required in connection with multifrequency pulsing since **MF** signals are received on a common control basis by senders or registers. However, after pulsing has started all digits are accepted without delay from the called end. For this reason, stop and go signals are not required.

TONE SIGNALS

→ 3.100 No industry standards for the levels of tones have as yet been established. However, it has been experienced that tone levels in the range of 60 to 70 dba (**F1A** line weighting) as measured with a 2B noise measuring set on the subscriber's line or on the trunk will provide satisfactory performance and cause no annoyance to the subscriber. (See Paragraph 3.109)

Dial Tone and Low Tone

→ 3.101 These are 600 cps modulated by 120 cps when supplied by a tone alternator or by 133 cps when supplied by an interrupter. The modulation frequency gives this tone its low-pitched sound. Interrupted low tone is used for line busy, reorder, and no circuit signals reached by the customer.

High Tone

→ 3.102 High tone is nominally 500 cps from a tone alternator or 400 cps from an interrupter.

Coin Collect Tone

→ 3.103 Coin collect tone is low tone used to inform the originating operator that the B operator or coin control circuit has collected the coin.

Coin Return Tone

→ 3.104 Coin return tone is high tone used to inform the originating operator that the B operator or coin control circuit has returned the coin.

Coin Denomination Tones and Signal

3.105 These tones are produced by two gongs in a coin telephone as nickels, dimes and quarters are deposited. The tones are introduced to the line by a transmitter in the coin box and enable the operator to check the amount deposited. Also, a dc signal is sent to the central office showing coins have been deposited.

Class-of-Service Tones

3.106 Used at a toll board operating as an A board to indicate class of service of the calling subscriber. Class of service may be indicated by a high tone, low tone, or absence of tone.

One Milliwatt Test Tone

3.107 This is tone at 1000 cps for transmission test purposes.

No Such Number Tone

3.108 No such number tone is low tone alternately ascending and descending in pitch at the rate of 1 cycle per second shut off every 6 seconds for one-half second.

Audible Ringing

3.109 420 cps modulated with 40 cps is a typical audible ringing signal. This signal is usually interpreted to mean the called line has been reached and ringing has started. It has been experienced that a maximum level of audible ringing tone, including harmonics, of about 65 dba (F1A line weighting) measured with a 2B noise measuring set at the source will provide satisfactory performance.

OTHER SIGNALS

Ringing

3.110 The technical aspects of ringing signals for customers' lines are not discussed since they are not an interoffice signaling problem.

Ringing Start

3.111 Switching trains designed for controlled ringing require a ringing start signal. These trains, when used for distance dialing, must operate on an automatic ringing basis. To accomplish this, some trunk circuits and senders are arranged to generate a ringing start signal when required. Two types of ringing start signals are employed, SX and 20 cycle. SX is +130V applied on a simplex basis to both conductors for a minimum of 0.1 second; 20 cycle is 105V AC ringing current applied on a loop basis for a minimum of 0.35 second. The SX ringing start signal can be applied after the first digit has been sent, as in trunk circuit design: or after all digits have been sent, as in sender design. The 20 cycle ringing start signal, however, cannot be sent until the off-hook line seizure signal has been received.

Coin Collect and Coin Return

3.112 Coin collect is +110 volts (or +130 volts in some systems) negative grounded potential and coin return is -110 volts (or -130 volts in some systems) positive grounded potential. The circuit (in simplified form) for collecting and returning coins over a customer's line is shown in Fig. 15.

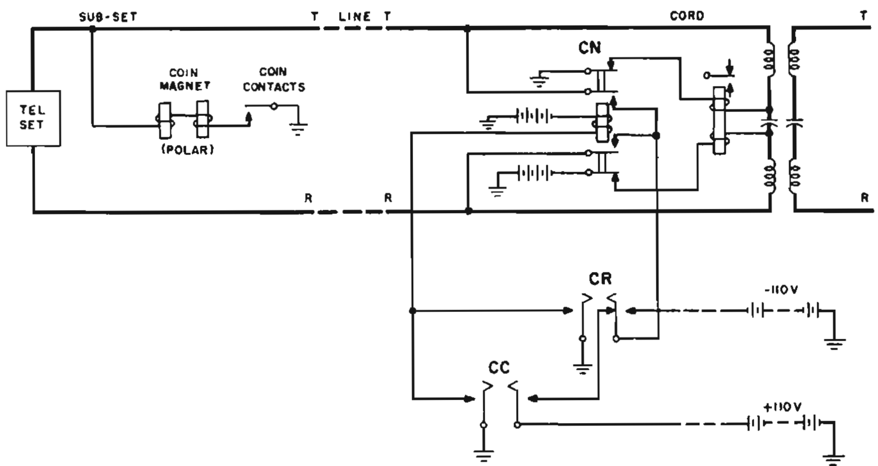


FIG. 15 - COIN COLLECT AND RETURN CIRCUIT

3.113 The coin magnet is polarized and tips an armature in one direction to collect and in the other to return. Coin contacts connect the coin magnets to ground when a coin is deposited. Operation of the coin return CR key operates the CN relay which disconnects talking battery and connects T and R together and to -110 volts. The CC key connects +110 volts to T and R. The parallel wires provide a low resistance path. (In some cases it is not possible to use the parallel connection and the T lead only is used.)

Announcements and Announcement Machines

3.114 Machines are currently being employed in the Bell System to provide recorded announcements. The primary use of the recorded announcement machines to date has been to provide an intercepting message to calls reaching vacant or disconnected customer numbers.

3.115 One such machine provides a single channel with an announcement interval which is usually fixed for a particular installation. It may be set to one of six intervals ranging from eleven to thirty-six seconds. Means are provided to connect a trunk at the beginning of an announcement interval and repeat from one to nine announcements (two or three is the usual number) and then to connect to an intercepting operator. Two machines are usually provided — one for service and one for standby. If the voice output of the machine in service fails, the standby machine is automatically placed in service. In multioffice cities the machines are provided in a central location and intercepting trunks may be brought into the center or to sub-centers to which the announcements are transmitted.

3.116 A smaller machine is now being made available for use in small dial offices where neither operator intercepting nor the larger intercepting machines can be economically justified. In this use, changed numbers, vacant thousands and hundreds levels, as well as all vacant or disconnected numbers will be connected to the machine. Normally only one machine will be provided. This machine will have an announcement interval that may be varied up to a maximum of thirty seconds. The machine will operate on a stop-start basis. When once started, all subsequent calls requiring intercept in the announcement interval will be cut in immediately to the machine at any stage of the announcement cycle. No provision has been made for subsequent transfer to an operator.

3.117 Direct distance dialed calls will reach these facilities. The announcements will be so worded that the customer can understand the proper action to be taken. Also it is desirable to inform the customer that the announcement is recorded. Connections to announcement machines should not return off-hook (answer) supervision.

3.118 In the past, a delay quotation announcement machine has been employed in No. 4 type crossbar systems to give posted delays to outward operators. This use will be changed as direct distance traffic is routed through the toll switching systems. Modifications, including the provision of a longer announcement interval, are underway to reuse this machine for the following purposes:

(1) Announcements for calls to vacant area or office codes in crossbar tandem, 4A, and 4M systems,

(2) Announcements at crossbar tandem, 4A, and 4M systems for calls which may not be completed because of overload conditions (where for some of these conditions on the 4A systems posted delays would formerly have been given),

(3) Emergency announcements in 4A and 4M systems, and

(4) Announcements for calls misdirected by customers to CAMA equipment in 4A and 4M systems.

4. DIGIT CAPACITIES

4.01 Chart 3 is a summary of digit capacities for the crossbar systems used in toll switching. The capacities listed are system capacities for both dial pulsing and multifrequency pulsing. A particular installation may not be equipped for the full capacity. Also, early Crossbar Tandem sender designs do not provide all of the listed features. For these reasons it is recommended that inquiry be made locally to determine the capacities of particular offices.

4.02 The capacities of step-by-step systems are not included as they are not fixed and will vary from one installation to another.

4.03 For operator distance dialing a minimum capacity of 11 digits is presently required in all systems for completion to manual offices in panel and crossbar areas having party line letters or numbers over 9999. However, equipment now under development for direct distance dialing will be limited to 10 digits (requires 2L-5N local numbers).

4.04 Six digit translation is used when a foreign area can be reached directly or indirectly by more than one route. It is the means for determining which route is to be used.

Digit Deletion

4.05 The number of digits which can be deleted is independent of the number of digits translated for routing. Any equipped combination of digits translated and digits deleted may be used. Digit deletion always begins with the first digit received.

4.06 Some of the more important uses of the digit deletion feature are:

(1) Send forward all digits received when they are required in the next office (Delete 0).

(2) Drop an area code when pulsing into that area (Delete 3).

(3) Drop an office code when pulsing into that office (Delete 3).

(4) Drop both area and office code when pulsing into that office and both were received (Delete 6).

(5) Drop an area and/or office code when other digits are to be substituted for them (Delete 3 or 6). This is called code conversion.

(6) Drop part of an office code when the remaining code digits are all that is required to route the call to that office (Delete 1 or 2).

4.07 The function of (6) above is accomplished in the 4A and 4M toll systems by deleting 3 and putting back the 1 or 2 code digits required for routing.

Prefixing and Code Conversion

4.08 One, two, or three digits may be prefixed to the routing digits. An example is the prefixing of the extra digits required for switching through a step-by-step primary center. Another example is the prefixing of the home area code to the office code and numericals received. This latter is necessary, when a call is switched through an office located in an adjacent foreign area, to bring the call back to the home area.

4.09 One, two, or three digits may be substituted for some or all of the routing digits received. This feature, which is called code conversion, accommodates the nationwide numbering plan to the particular requirements of certain systems for routing digits. For example, an established step-by-step train may require routing digits which differ from those provided by the 2-5 numbering plan. The last preceding CSP can delete some of the 2-5 digits and furnish instead digits which fit the switching train.

Outpulsing Capacities

4.10 Chart 4 lists the outpulsing capacities of the various crossbar systems for toll calls. The permissible combinations of digit deletion and prefixing are indicated for each system. For each combination the digits outpulsed are shown in order left to right. Some of the possible combinations may not yet have practical applications.

4.11 The terminology and mechanics for digit deletion and prefixing vary somewhat among the systems. For this reason the compromise terminology used here may not agree with the specific terms of a systems literature, and no inferences should be made from these data as to the mechanics of performing these functions.

5. SENDER AND REGISTER TIMING AND EFFECT ON SIGNALING

5.01 The senders and registers in toll switching are equipped with timing functions to prevent their being held too long. The intervals allowed for the registration of digits, and for a distant sender, register, or link to be attached, have an effect on signaling. If any of the intervals allowed for digit registration are exceeded, the sender or register at the called end will route the call to reorder and release. If the interval allowed for the attachment of a distant sender, register, or link is exceeded the call may be routed at the calling end to a mechanical announcement or reorder.

5.02 The requirements for digit pulsing which result from digit registration timing are given for the several systems in Chart 5. It must not be assumed that delays exceeding these intervals will always result in reorder routing since these limits are necessarily based on minimum timing in the senders and registers. In the No. 5 system, as shown in the chart, some of the intervals are automatically reduced in periods of heavy traffic in order to conserve common control equipment.

5.03 The requirements for the speed of attachment of a sender, register, or link, following receipt of a connect signal from the calling office, are shown in Chart 6. It will be observed that in periods of heavy traffic some of the intervals are automatically reduced. This measure is designed to prevent delays in one office from unduly affecting other offices. Such mutual effects in periods of heavy traffic could pyramid and seriously impair service.

Attached:

Charts 1 through 6

INTEROFFICE SIGNALS REQUIRED IN DISTANCE DIALING

Name of Signal	On-Hook	Off-Hook	Direction: Calling End → Called End	Use or Meaning	Indication: To Customer	Indication: To Operator	See Note
Connect (Seizure)		√	→	Request service and hold connection	—	—	
Disconnect	√		→	No service is desired - Message is completed - Release connection	—	Answering cord lamp lighted	
Off-Hook (Answer)		√	←	Called party has answered - Charge timing begins and depends on this signal	—	Calling cord lamp dark	
On-Hook (Hang Up)	√		←	Called party has not answered - Line idle - Message is completed	—	Calling cord lamp lighted	
Delay Dialing (Delay Pulsing)		√	←	Called end not ready for digits	—	Start dial lamp dark	1
Start Dialing (Start Pulsing)	√		←	Called end ready for digits	—	Start dial lamp lighted	1
Stop		√	←	Some digits received - Called end not ready for further digits	—	Start dial lamp changes to dark	1
Go	√		←	Called end ready for further digits	—	Start dial lamp changes to lighted	1
Dial Pulsing (DP)	√	√	→	Indicates called number	—	—	
Multifrequency Pulsing (MFP)					—	—	
Key Pulse (KP)			→	Prepare receiving circuit for digits -			
Digits			→	Indicates called number	—	—	
Start Pulse (ST)			→	Indicates that all necessary digits have been sent			
Line Busy	√	√	←	Called line is busy	60 IPM tone	60 IPM flash of calling cord lamp	
Reorder	√	√	←	All paths busy All local trunks busy All toll connecting trunks busy All NC trunks busy Blockage in equipment Incomplete registration of digits	120 IPM tone	120 IPM flash of calling cord lamp	2
No Circuit (NC)	√	√	←	All intertoll trunks busy	30 IPM tone	30 IPM flash of calling cord lamp	
Ringing			→	Alerts called customer to an incoming call	Bell rings	—	3
Audible Ringing (Ringing Induction)			←	Called station is being rung or Awaiting operator answer	Ringing induction tone		

Name of Signal	On-Hook	Off-Hook	Direction: Calling End	Direction: Called End	Use or Meaning	Indication: To Customer	Indication: To Operator	See Note
Ring Forward (Rering)	√		→		Recall operator forward to the connection	———	Steady or flashing cord lamp	
Ringback	√		←		Recall operator backward to the connection	———	Lighted cord lamp for duration of ring	
Ringing Start			→		Starts ringing when terminating equipment is of controlled ringing type	———	———	
Flashing	√	√	→ ←		Manually recall operator to the connection	———	Flashing cord supervisory lamp	
Coin Collect			← →		To collect coins deposited in coin box	———	———	
Coin Collect Tone			→ ←		Indicates that coin collect signal is being sent to coin box	———	Low tone	
Coin Return			← →		To return coins deposited in coin box	———	———	
Coin Return Tone			→ ←		Indicates that coin return signal is being sent to coin box	———	High tone	
Coin Denomination Tones			→ ←		Indicate number and denomination of coins deposited in coin box	Tones from gongs in coin box		
Class of Service Tone			→		Indicate to operator the class of service of the calling customer's line	———	High, low or no tone	
Recorder Warning Tone			→ ←		Indicates telephone conversation is being recorded	1400 CPS "Beep" Tone of 0.1 second duration applied every 14 seconds	———	
Announcements Unassigned Code Unassigned Number Overload Emergency			←		Inform customer or operator of reason why call has not been completed	Verbal		
No-Such-Number Tone (To be replaced by announcements)			←		Indicates vacant selector level (local) or vacant code	Low tone alternately ascending and descending in pitch at rate of 1 CPS and shut off every 6 seconds for 1/2 second		

NOTES

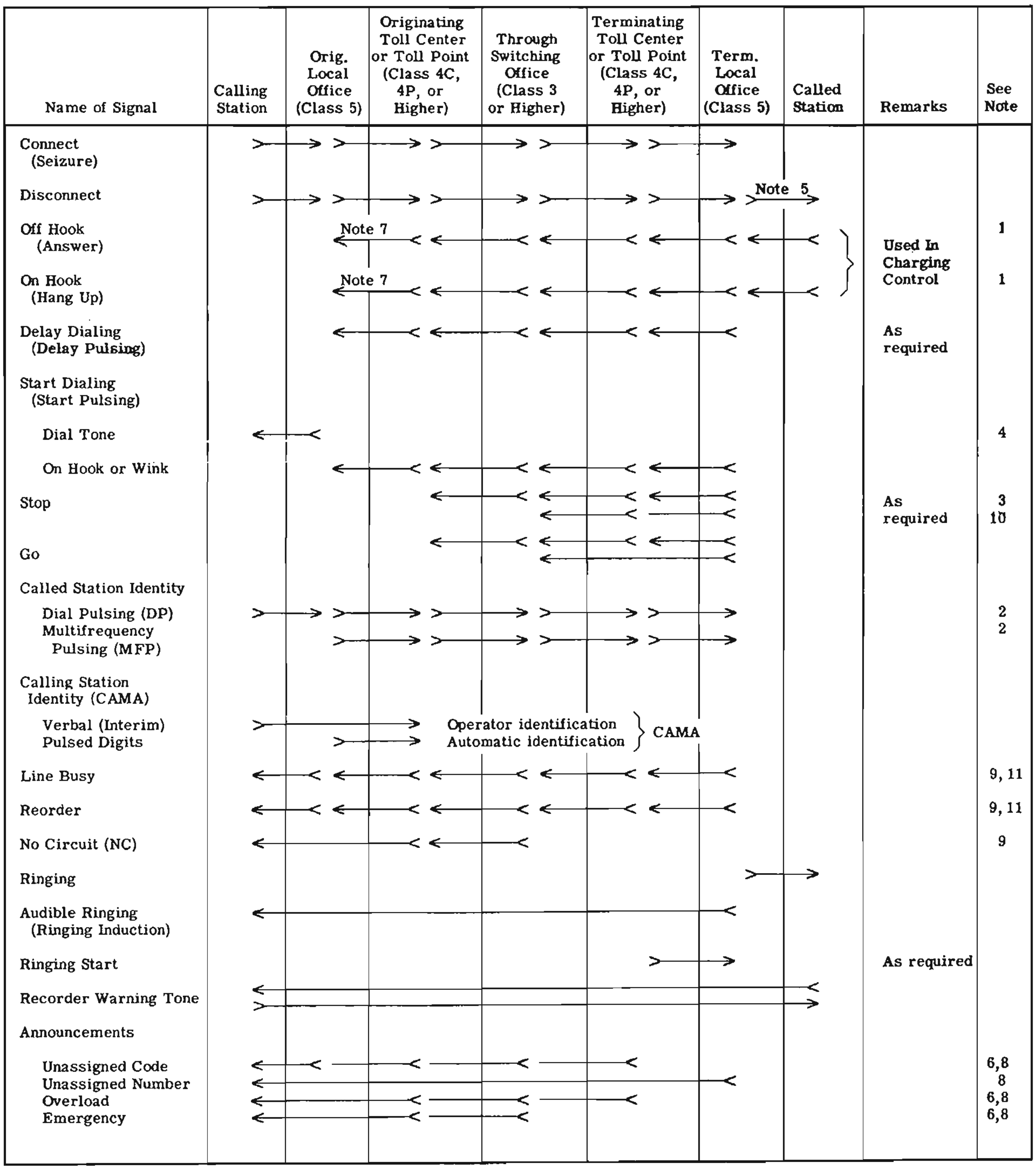
1. The start dialing, delay dialing, stop, and go signals are sometimes indicated to the operator on the calling cord lamp instead of the start dial lamp.

2. It will be observed that conditions producing a 120 IPM signal apply to facilities that are relatively liberally engineered and, hence, the probability of an immediate subsequent attempt succeeding is reasonably good.

   The use of the 120 IPM signal to indicate the dialing of an unassigned area or office code is to be discontinued.

3. Ringing of the called station should be started automatically upon seizure of the called terminal.

USE OF SIGNALS IN DIRECT DISTANCE DIALED CALLS



LEGEND

Calling Station	Class 5 Office	Class 4C or 4P Office	
> ——	—— >		Signal sent from calling station to Class 5 office
	< ——	—— <	Signal sent from Class 4C office to Class 5 office
< ——	—— < ——	—— <	Signal sent from Class 4C or Class 5 office to calling station
< ——	————	—— <	Signal sent from Class 4C office through Class 5 office to calling station
< ——	—— < < ——	—— <	Signal sent from Class 4C office to Class 5 office where it is detected and retransmitted to calling station

Notes

1. This signal is simply relayed from office to office.

2. Connection must be established before remaining or regenerated digits are sent ahead.

3. Second off-hook signal causes release of sender and cut through for talking or flashing.

4. Second dial tone is used in some cases but is not satisfactory in ultimate.

5. To stop answering service or to release a locked-in hold condition. This signal is delayed by a timed release feature for an interval of about thirteen to thirty-two seconds in some systems.

6. May originate at any one of the indicated offices.

7. Answer supervision must be returned to the office where charging control is centered. When charging control is centered at a toll center it may not be necessary to return answer supervision to a class 5 office, except for the timed disconnect function when provided.

8. Announcement may be by operator or by machine (recorded announcement).

9. Some offices may return tone in synchronism with flashes. Where such tone will not be transmitted satisfactorily to the calling station or where no tone is provided with flashes, tone appliers will be provided to furnish the tone at the originating local office or outward toll center (or toll point). The latter is assumed for this chart.

10. Stop is returned when selector reaches level having trunks which require this signal.

11. Flash is not provided in originating equipment of Class 5 offices since tone only can reach the calling customer. However, terminating equipment must be equipped with flash for the benefit of incoming calls.

DIGIT CAPACITIES OF CROSSBAR SYSTEMS
(TOLL SWITCHING)

	No. 4 Toll	A4A Toll	4A & 4M Toll	Crossbar Tandem	No. 5 Crossbar
Max. No. of Digits Received (Required Capacity)	14	11	11	11	11
Max. No. of Digits Outpulsed (Required Capacity)	11 (Note 1)	11	11 (Notes 1 & 2)	11 (Note 2)	14
No. of Digits Translated for Routing	3 (Note 3)	3 (Note 3)	3,4,5,6 (Note 4)	3 (6 Digit Under Development) (Note 3)	3,6 (Note 3)
No. of Digits Received Which Can Be Deleted	0,3	0,3	0,3,6 (Note 5)	0,1,2,3, 4,5,6	0,1,2,3, 4,5,6
No. of Digits Which Can Be Prefixed or Substituted for Routing Digits Received	0	1 (Note 6)	1,2,3	1,2,3 (Note 7)	1,2,3 (Note 8)

Notes:

1. Technically, these systems can outpulse a maximum of 14 digits. However, there is usually no need for outpulsing more than 11 digits.
2. See Chart 4.
3. Also translates 4 and 5 digits for TX calls
4. 4 and 5 digit translation, although fully flexible in these systems, is used at present principally for TX codes.
5. Equivalents for the deletion of 1,2,4 and 5 digits are shown in Chart 4.
6. A4A toll can prefix 1 arbitrary digit only to digits remaining after delete 3 has been applied.
7. Crossbar tandem can prefix digits only to digits remaining after either delete 3 or delete 6 has been applied. The combination of this feature with delete 0 is under development, primarily for 7 or fewer digits received.
8. See Note 6 in Chart 4

OUTPULSING CAPACITIES OF CROSSBAR SYSTEMS

Item No.	Number of Digits Deleted	Number of Digits Prefixed or Substituted	Digits Outpulsed: Digits Prefixed or Substituted (1)	Digits A-L Registered (2) ("I" Desig. Not Used): A	B	C	D	E	F	G	H	J	K	L	Systems: 4A & 4M Toll	A4A Toll	4 Toll	XB TDM	No. 5 XB	
1	0	0		X	X	X	X	X	X	X	X	X	X	X	#	#	#	#	#	
2	1	0		O	X	X	X	X	X	X	X	X	X	X	(3)			#	#	
3	2	0		O	O	X	X	X	X	X	X	X	X	X	(3)			#	#	
4	3	0		O	O	O	X	X	X	X	X	X	X	X	#	#	#	#	#	
5	4	0		O	O	O	O	X	X	X	X	X	X	X	(3)			#	#	
6	5	0		O	O	O	O	O	X	X	X	X	X	X	(3)			#	#	
7	6	0		O	O	O	O	O	O	X	X	X	X	X	#			#	#	
8	0	1	+	X	X	X	X	X	X	X	X	X	X	X	#			(4)	#	
9	1	1	+	O	X	X	X	X	X	X	X	X	X	X	#			(5)	#	
10	2	1	+	O	O	X	X	X	X	X	X	X	X	X	#			(5)	#	
11	3	1	+	O	O	O	X	X	X	X	X	X	X	X	#	#		#	#	
12	4	1	+	O	O	O	O	X	X	X	X	X	X	X	#			(5)	#	
13	5	1	+	O	O	O	O	O	X	X	X	X	X	X	#			(5)	#	
14	6	1	+	O	O	O	O	O	O	X	X	X	X	X	#			#	#	
15	0	2	+ +	X	X	X	X	X	X	X	X	X	X	X	#			(4)	#	
16	1	2	+ +	O	X	X	X	X	X	X	X	X	X	X					#	
17	2	2	+ +	O	O	X	X	X	X	X	X	X	X	X	#			(5)	#	
18	3	2	+ +	O	O	O	X	X	X	X	X	X	X	X	#			#	#	
19	4	2	+ +	O	O	O	O	X	X	X	X	X	X	X					#	
20	5	2	+ +	O	O	O	O	O	X	X	X	X	X	X	#			(5)	#	
21	6	2	+ +	O	O	O	O	O	O	X	X	X	X	X	#			#	#	(6)
22	0	3	+ + +	X	X	X	X	X	X	X	X	X	X	X	#			(4)	#	
23	1	3	+ + +	O	X	X	X	X	X	X	X	X	X	X					#	
24	2	3	+ + +	O	O	X	X	X	X	X	X	X	X	X					#	
25	3	3	+ + +	O	O	O	X	X	X	X	X	X	X	X	#			#	#	
26	4	3	+ + +	O	O	O	O	X	X	X	X	X	X	X					#	
27	5	3	+ + +	O	O	O	O	O	X	X	X	X	X	X					#	
28	6	3	+ + +	O	O	O	O	O	O	X	X	X	X	X	#			#	#	

Legend

- OOO Digits Deleted (Registered but not outpulsed)
- XXX Digits Registered and Outpulsed
- + + + Digits Prefixed or Substituted in accordance with instructions previously given to the machine

} Each digit may be any digit 0-9

- # System has capability for this item

Notes

1. Substituted digits may be identical to those that are deleted.
2. In every case the digits A, B, and C must be received. Digits in positions D through L are outpulsed only if they are registered. For example, when 7 digits are received, digits H, J, K, and L are not registered.
3. Items 2, 3, 5, and 6 are provided by the means used to obtain items 18, 11, 21, and 14, respectively.
4. Under development primarily for 7 or fewer digits received.
5. Items 9, 10, 12, 13, 17 and 20 are provided by the means used to obtain items 25, 18, 28, 21, 25, and 28 respectively.
6. All No. 5 XB systems may be equipped for items 15 through 28 for Dial Pulsing but only the later design may be so equipped for Multifrequency Pulsing. However, restricted 2 and 3 digit prefixing for MF pulsing is now available for the earlier design.

DIGIT TIMING REQUIREMENTS

	A4A, 4A & 4M Toll		No. 4 Toll		Crossbar Tandem (Incl. CAMA)		No. 5 Crossbar	
	DP	MF	DP	MF	DP	MF	DP	MF
1st digit must be received in less than ___ seconds from seizure	10	10	10				19 or 4.4*	
Both 2nd and 3rd digits must be received in less than ___ seconds from registration of 1st digit	10	10	10					
First 3 digits must be received in less than ___ seconds from seizure				10	20			
2nd and 3rd digits must each be received in less than ___ seconds from registration of previous digit							19 or 4.4*	
4th digit must be received in less than ___ seconds from registration of 3rd digit	**		**		20			
When total number of digits expected is indicated to register by class marks or translation of one or two initial digits, each digit after 3rd digit must be received in less than ___ seconds from registration of previous digit							19 or 4.4*	
When total number of digits expected is not indicated to register, each digit after 3rd digit must be received in less than ___ seconds from registration of previous digit							3	
Each digit after 4th digit must be received in less than ___ seconds from registration of previous digit	3		3		5***			
All digits must be received in less than ___ seconds from seizure				30		20		19
All remaining digits must be received in less than ___ seconds from registration of 3rd digit	30	30	30					

* Under overload conditions
** The receipt of the 4th digit is covered by the timing for all digits shown in last line of chart
*** 3.5 seconds for stations digit

SENDER, REGISTER, OR LINK ATTACHMENT TIMING REQUIREMENTS

		All No. 4 Type Toll	Crossbar Tandem (Incl. CAMA)	No. 5 Crossbar	
				DP	MF
Sender or register in distant office must be attached in less than ___seconds or originating sender in indicated system may time out.	Normal Traffic	30	20	19	13
	Heavy Traffic	5 (Note 1)	20 (Note 2)	4.4	4.4
Link or line finder in distant office must be attached in less than ___seconds or originating sender in indicated system may time out.	Normal Traffic	30 (Note 3)	20	19	
	Heavy Traffic	30 (Note 3)	20 (Note 2)	4.4	

Notes:

1. This is present nominal adjusted interval. The range of adjustment is 3-8 seconds.
2. Reduced intervals under heavy traffic conditions are under development for crossbar tandem.
3. 20 seconds in No. 4 and 4M Toll.

EQUIPMENT REQUIREMENTS

CONTENTS PAGE

1. GENERAL

1.01 This section summarizes miscellaneous equipment requirements for central offices that are to be connected to the nationwide distance dialing network. The signals needed for distance dialing are described in Section IV of these Notes. Central office equipment and circuits should be arranged to operate with these signals if connection to the distance dialing network is desired. Other miscellaneous items, some of them unrelated, that require discussion have been included in this section under the broad heading "Equipment Requirements." Most of these apply to all classes of offices; those that are confined to but a few classes have been appropriately noted.

1.02 The greater part of this section is devoted to equipment used for direct distance (customer) dialing. Operator-dialed calls will, in general, be handled by the same switching equipment and trunks. However, where operator dialed traffic requires different treatment, or where interim arrangements may be employed, this will be noted following the discussion of the customer dialing requirements.

1.03 Other items which may require attention when considering distance dialing also are included in this section; it is, therefore, divided into four parts.

(a) Station Equipment

(b) Central Office Switching Facilities

(c) Miscellaneous Central Office and Traffic Administration Facilities

(d) Automatic Recording of Message Billing Data for Direct Dialed Calls

2. STATION EQUIPMENT

2.01 Station equipment connected to offices arranged for direct distance dialing should have:

(a) 2-5 station number cards similar to that shown on Chart 1, Figure A.

(b) Dial number plates with letters and numerals arranged in the sequence shown on Chart 1, Figure B. (Required for outward direct distance dialing.)

(c) Switchhook (common battery) supervision.

3. CENTRAL OFFICE SWITCHING FACILITIES

3.01 Under this heading are included miscellaneous requirements for:

(a) Dial Switching Equipment

(b) Manual Toll Switching Equipment

(c) Trunk Circuits

(d) Signals

(A) Dial Switching Equipment

3.02 Nationwide distance dialing places no restriction on the type of dial switching system (SxS, XB, etc.) provided at Class 4, or 5 offices*; the facilities should, however, send, receive and be actuated by the signals discussed in Section IV. Common control equipment such as registers, senders, directors, etc., is not essential at these offices although it may be used in many instances to effect economies in switching traffic and to provide uniform dialing procedures. Class 1 and 2 and many Class 3 offices will employ common control switching facilities and have the control switching point (CSP) features described in Section III.

3.03 Outward direct distance dialing requires that the Class 5 (local) office be able to send the complete 7 or 10-digit called number to the toll switching system at which it homes. Common control switching equipment can be arranged to do this. If direct control equipment such as step-by-step without senders or directors is used at the Class 5 office, it will be necessary to prefix a toll access or transfer code (e.g., 112) to direct the call to the toll office. An alternate arrangement might provide for the simultaneous registration of digits at both the local and toll offices. At the toll office, common control equipment or its equivalent will store the digits and transmit them forward.

3.04 Some typical trunking plans for inward toll dialing in small and medium-sized exchanges are discussed in Appendix A. While the arrangements shown are those commonly used in the Bell System and are not necessarily the same as those employed in the Independent Industry, the fundamental principles involved in completing inward toll traffic are applicable. For simplicity, the step-by-step system has been used in the examples, but the principles are applicable to other types of switching systems.

3.05 Switching equipment at Class 5 offices should be arranged so that incoming terminating links (toll connecting trunks) will have access only to equipment arranged to return busy flashes and tones.

3.06 Chart 2 shows the minimum number of digits that Classes 3, 4C, 4P and 5 offices should be capable of receiving over incoming intertoll trunks or terminating links. It may be desirable for an office to receive more than this minimum number. Such situations should be studied jointly by the Companies involved to determine the trunking arrangements that best meet the needs of the industry as a whole. In general, the 2-5 number will be sent as far as the toll office at which the class 5 office "homes" so that machine switched traffic may be combined with operator dialed traffic received over direct trunk groups from distant toll switchboard positions (operators normally dial the full 2-5 listed numbers).

*Office class numbers are discussed in Section III of these Notes.

3.07 When non-common control switching equipment is used, it frequently is desirable on an incoming call to absorb some digits, either at the toll office or at the Class 5 office to avoid providing selector stages for all seven digits. Ordinarily, this is done at the toll office but occasionally it may be more economical overall to absorb at the Class 5 office than to provide an additional rank of switches at the toll office.

3.08 Inward calls may be either operator or direct dialed. Operator-dialed calls usually will be completed by fully automatic means, but certain calls such as collect to coin boxes, requests for busy line verification, assistance, etc., will require the services of an inward operator. Direct dialed calls will be completed by automatic equipment. (Calls dialed by either customers or distant operators should not have access to verification and coin control equipment.) Calls to manual offices equipped with call indicator positions may also be completed on an operator or direct dialed basis.

3.09 Neither called operators nor called customers should be signaled until the full complement of digits has been received.

(1) If calls to "operator codes" (see Section II, Part 7, Paragraph 7.03) or plant test codes (Section VII, Part 2) reach a terminating trunk circuit before the complete code has been dialed, provision should be made for the receipt of any remaining digits before the circuit is cut through. Otherwise off-hook supervision upon fast answers may cause out pulsing senders to "stick" and interfere with the operation of the automatic toll switching equipment at a preceding office.

(2) Level hunting connectors used on toll calls to reach P.B.X. terminals should be arranged not to trunk hunt until all digits have been received.

(3) Equipment arrangements should be such that selection of the called customer's line will not occur until all digits (including the ST signal on MF pulsing) have been received.

3.10 Primary centers (Class 3 offices), some of which will be Independent Company offices, may be equipped with either direct control or common control types of switching equipment. For example, direct control equipment such as step-by-step intertoll will be satisfactory, provided transmission requirements for office balance, etc., are met (see Section VI). Common control features at Class 3 offices may, however, effect economies in intertoll trunk facilities through automatic alternate routing, etc.

3.11 Outgoing trunks from selector levels that terminate on equipment arranged to return a "stop dial" signal present a special problem. The selector serving such trunks should return a "stop dial" signal before hunting for the outgoing trunk begins. This requirement is explained in more detail on Chart 3.

3.12 Overload Control Arrangements: The distance dialing system will be engineered to give a predetermined and satisfactory grade of service to traffic offered during the busy hour. However, it is expected that there will be occasional surges or peaks of traffic that are beyond the actual capacity of the facilities provided. The failure of a common facility, such as the loss of a trunk cable because of mechanical damage, may also create an overload condition. During these overloads the over-all toll switching system, as well as the individual switching machines of the system, need to maintain maximum call handling capacity even though the offered traffic is far in excess of the engineered capacity. Therefore, precautions should be taken to ensure that overloads, regardless of cause, do not spread throughout the network and temporarily reduce its call carrying capacity. Alert administration of the operating plant, early detection of overloads, and immediate application of corrective measures will do much to reduce the effects of isolated overloads. Most effective results, however, may be obtained by including overload control arrangements in the equipment design. Steps should be taken to provide circuit features that will prevent overloads from spreading to connecting offices. (See Section IV, Charts 5 and 6.) In addition, the office should be protected from overloads occurring in other places. For example, trunk circuits from key pulsing switchboards may be arranged to send the "connect" signal forward only after a switchboard sender is attached instead of immediately upon seizure by the operator.* Thus, an "all senders busy" condition in the sending office will not overload the incoming equipment in the receiving office; the latter will be called in only when a sender is available to send pulses to it.

(B) Manual Toll Switching Equipment

3.13 Toll switchboard positions should be arranged as follows:

(1) To ring forward and ring back over intertoll trunks.

(2) For pulsing, by means of either dials or keysets. Switchboard position and cord circuits should be arranged for pulsing on both front and rear cords, and for operation with "start dial" signals preferably by lighting a "start dial" lamp. (It is desirable that switchboards with MF pulsing do not send the MF tones back to the customers.)

(3) For switchhook supervision on both front and rear cords.

(C) Trunk Circuits

3.14 Intertoll trunk circuits should meet the following requirements for satisfactory operation with signaling facilities used on toll lines:

(1) The ring forward signal should result in a pulse, on the M lead from the intertoll trunk, with a duration of 0.100-second ± 0.030-second. (See Section IV, Paragraph 3.33.)

(2) When ringing over 2-wire intertoll trunks, the circuit at the originating end should:

(a) have the tip and ring of the voice path opened, and

(b) have an idle trunk termination connected to the line side of the open.

* The trunk, if two-way, is so arranged that an incoming call, received while awaiting a sender, will take preference.

(3) Intertoll trunk circuits should not disconnect on an E lead open of less than 0.140-second. (See Section IV, Paragraphs 3.07 and 3.08.)

(4) Switchboard intertoll trunks employing dial pulsing, other than loop pulsing, should be arranged to open the tip and ring conductors of the trunk and apply an idle trunk termination to the line side of the open prior to start of pulsing. This condition should be retained until pulsing is completed.

3.15 Offices receiving traffic over loop signaling trunks from Bell System Crossbar Tandem offices will need to have the incoming trunk circuits equipped with balanced windings on the pulse receiving relays to avoid false disconnect upon receipt of a ring forward signal. The ring forward on-hook pulse received over an incoming intertoll trunk is converted by the Crossbar Tandem office into a positive 130-volt signal simplexed on the outgoing trunk conductors. When the trunk outgoing from the crossbar tandem uses E&M lead signaling no problem exists; the simplex signal is merely converted to an on-hook pulse. However, when the outgoing trunk employs loop signaling, the simplexed pulse may cause false disconnect of the distant terminating equipment if windings of the pulse receiving relay are not balanced.

3.16 Terminating links incoming to Class 5 offices preferably should not be terminated on line circuits or links. However, if this type of termination is employed "stop-go" signals will need to be furnished.

In this connection, it is well to remember that trunking arrangements involving delay dialing and stop-go signals need to conform to the capabilities of dial pulse senders. Senders in No. 4-type and No. 5 crossbar systems, when connected to a particular dial outpulsing trunk group, can be set to expect only one of the following combinations of signals:

(1) No delay dialing and no stop-go.

(2) Both delay dialing and one stop-go.

(3) Only delay dialing.

(4) Only one stop-go.

Crossbar tandem senders presently in operation, on dial outpulsing calls to a particular trunk group, can be set to expect only one of the following combinations of signals:

(1) No delay dialing and one stop-go.

(2) Only delay dialing.

Arrangements have now been developed for crossbar tandem 11-digit senders that will permit operation with the following signals:

(1) No delay dialing and one stop-go.

(2) Both delay dialing and one stop-go.

3.17 Dial back operator office trunks provide facilities over which a calling customer in one community dial office (CDO) may reach the operator at the operator office, who, in turn, may dial back over the same trunk to connect the calling customer to a called customer served from the same or another CDO. Dial back operator office trunks may be used as toll connecting trunks for completing inward dialed calls provided they return the standard supervisory and control signals discussed in Section IV and conform to VNL + 2 db design as discussed in Section VI. If these trunks have other signaling characteristics, inward toll traffic to the CDO's should be handled through the inward operator, or separate toll completing trunk groups should be established to each CDO. It is contemplated that dial back type trunks will not be used for customers to gain access to Bell System CAMA equipment.

3.18 It is desirable that all operator trunks, except dial-automatic or multi-frequency-automatic, be arranged to return audible ringing signal to the calling end of the circuit. In addition, trunks to "121" (inward) operators should be arranged to ring back and to receive ring forward.

3.19 Joint Control Trunks: Although the nationwide distance dialing network operates on "calling party control" basis, it may sometimes be necessary, because of operating arrangements, to complete calls over toll connecting trunks which are arranged for joint control. This is permissible if the joint control trunks are arranged to:

(1) have the toll office end of the trunk release the toll switching equipment upon calling party disconnect, and then

(2) make the trunk appear busy until the called party hangs up (disconnects).

Note: Trunk busy should not be released if called party flashes.

3.20 Two-Way Trunks: If these trunks are not arranged for joint control, they should have the following operating characteristics:

(1) The calling end of a two-way trunk should be held busy a minimum of 0.750 second after sending the disconnect signal forward to the called end. During this "guard" interval, off-hook supervision from the called end should not start a new call at the calling end.

(2) The called end should recognize the disconnect signal by timing an interval not less than 0.140 second and not more than 0.750 second, at the end of which, switches should have been released and the trunk should test idle for a call in the opposite direction.

3.21 2-way trunks are subject to occasional simultaneous seizures at both ends because of the unguarded interval between the seizure of the trunk at one end and the consequent making busy of the trunk at the other end. These simultaneous seizures cause each end of the circuit to receive an immediate and sustained off-hook signal. Equipment at each end should be arranged to (1) prevent the off-hook signal from reaching the charging control equipment and (2) disengage from this mutually blocking condition. When delay dialing signals are used, the blocking condition is assumed to exist if the off-hook condition persists longer than the intervals shown on Chart 6 of Section IV. The above mentioned actions should then take place. When delay dialing signals are not used, the blocking condition can be detected immediately upon trunk seizure. To disengage from the blocking condition, No. 4-type equipment, for example, is arranged, at both ends, to flash forward at the reorder rate when the blocked condition is recognized. The flash is sent after the expiration of the intervals shown on Chart 6 of Section IV on MF pulsing calls; it is sent immediately on dial pulsing trunks which do not require delay dialing. The circuits are so arranged that the flash brings about the release of the connection at the distant end. The near-end is arranged to release and route to reorder. A satisfactory alternative arrangement is to complete the call over the same trunk after a 2 second pause (to insure disconnections at the distant end) and receipt of the start pulsing signal from the distant end.

3.22 Tone Appliers: As pointed out in Section IV, Paragraphs 3.31 and 3.32, when satisfactory tone can not be returned to the calling customer from the point at which a call is blocked a locally generated tone, synchronized with the flashing signal that is returned, will be supplied. The Bell System is arranging certain trunks incoming to the various toll switching systems to supply this locally generated tone toward the calling office. Any tone or tones that may appear at the trunk circuit along with flashes will be blocked so that they will not be confused with the locally applied tone. The following suggestions, illustrated on Chart 4, may serve as a guide for determining which trunk circuits should be arranged for tone application.

(a) In general, incoming trunk circuits with tone appliers should be provided at the first toll office encountered by trunks which carry customer dialed toll traffic. Included in this group will be the incoming trunk circuits at offices arranged for centralized recording of automatic message billing data.

(b) Provide tone appliers on trunks outgoing from Class 5 offices equipped with local automatic message billing data recording equipment if these trunks terminate on step-by-step intertoll selectors not arranged to return busy tones, or if single frequency (SF) signaling of the types found in the Bell System are used. (If tone appliers are provided at the Class 5 office on toll connecting trunks using SF signaling they will not be required with the incoming trunk circuits as noted above.)

(D) Signals

3.23 Certain operating and signaling features sometimes found in local central office equipment are not compatible with the requirements for distance dialing. These are tabulated on Chart 5.

4. MISCELLANEOUS CENTRAL OFFICE AND TRAFFIC ADMINISTRATION FACILITIES

(A) Intercepting Facilities

4.01 Adequate intercepting facilities should be provided for unassigned and non-working customer numbers as well as for unassigned central office codes (vacant levels in SxS offices). The general criteria for adequate intercepting service with distance dialing are as follows:

(a) Long range objective and most desirable intercepting service

Interception of all vacant codes, levels, and non-working numbers.

(b) Practical and acceptable interim minimum criteria

(1) Vacant codes and levels.

Interception of vacant numbering plan area and central office codes either in the originating office or at some other point in the toll switching network. Interception of vacant levels where practicable.

(2) Non-working numbers.

Interception of non-working numbers for which there are two or more incoming calls per week. If a count is not available, non-working numbers listed in the current directory to be intercepted until reassigned.

(c) Handling of intercepted calls

Intercepted calls to be directed to an operator or to a recorded announcement. (Where presently provided, "no-such-number" tone may be connected to vacant levels as an interim measure until standard arrangements can be provided. The use of busy or audible ring back tones for such purposes or the return of no tone at all is considered unsatisfactory.)

4.02 The Bell System plans to use recorded announcement systems to intercept disconnected and unassigned numbers and vacant codes in the larger offices while calls to changed numbers will be handled by operators. (In the smaller offices either recorded announcements or operator handling may be provided depending on service and economic considerations.) It also appears that calls to vacant levels may be satisfactorily intercepted by the same recorded announcement.

4.03 Operator intercepting should normally be provided when number changes are made. However, with large scale number change projects, such as changes to 2L + 5N numbers, where the change is uniform and easily explainable, recorded announcements may well be used. In many cases this may be the only practical method for handling the large volume of traffic. Most of the changes of this type are accomplished through the use of digit-absorbing selectors. Blocked levels of those step-by-step digit-absorbing selectors can be routed to an appropriate recorded announcement, rather than to paths busy signal (120 IPM) by temporarily rewiring the 11th rotary step springs or other appropriate wiring changes. Previously working selector levels, too, may be supplied with this announcement to provide better service during and immediately following the number change.

4.04 The transmission loss of intercepting trunks to either an announcement machine or to manual positions at a centralized location should not exceed 2.5 db including equipment losses at both ends. The volume level of the output from the announcement machine should be adjusted so that the level at the incoming (customers') side of the bridging trunk circuit is about -8 VU. (Idle circuit terminations on incoming trunks should be removed when such trunks connect to intercepting trunks.)

4.05 To avoid false charging on distance dialed traffic, intercepting equipment should be arranged so that it will:

(a) Return neither answer supervision nor flashes

(b) Not differentiate between local and toll calls

(c) Not recall originating operator (flashing key should not be provided).

(B) Information Service

4.06 The incoming trunks to dial switching equipment at each toll center (Class 4C or higher rank office) should have access to the Information board serving that location. Here up-to-date listings should be maintained for each Class 5 or 4P dial office homed on that location. The trunks to Information (Code 131) should be arranged so that off-hook supervision is returned upon operator answer as is standard on all the other inward operator calls. Customers will not dial directly to distant information operators; instead, they will be connected by the operator at the originating office.

(C) Verification Facilities

4.07 Verification facilities should be provided where feasible, especially in offices in or near metropolitan areas. Arrangements should be made to deny customer access to the verification facilities. (This may be accomplished by such means as "building out" the verification train to require that more digits be dialed by the customer than the capacity of his switching system or by giving the trunks that can reach the verification train only a switchboard appearance. A less desirable method that only limits access is to make the trunks that can reach the verification train "last choice" on the switching equipment at the preceeding office.) In addition, incoming calls dialed by distant operators shall not override the busy condition. If verification arrangements are not provided, it may be desirable to employ Busy Line Cut-In equipment on those few important lines that should have means for accepting an emergency call while busy with an existing call.

(D) Service Observing Facilities

4.08 It is desirable that suitable service observing facilities be installed with equipment for customer dialing. In this way an up-to-date record of the performance of both operating personnel and automatic switching equipment can be obtained. Also, the resulting record of customer dialing irregularities is useful. Service observing information in addition to facilitating the administration of operating force and telephone plant will serve as a measurement of the effectiveness of training programs for operators and of instructional material furnished the customer.

4.09 Service observing facilities, if they are to be effective, should produce an adequate sample in a predetermined period of time and should be capable of determining (where applicable):

(1) Speed of operation: Recorded as the time required for significant events to occur during establishment of a telephone connection, such as:

(a) speed of answer to trunk signals

(b) speed of attention to cord signals

(c) speed of advancement

(d) speed of service

(2) Quality of service: Measured in terms of errors, irregularities, and other significant qualities of performance of equipment, operators, and customers, excepting speed.

(3) Call disposal: Recorded as calls completed and uncompleted, or in terms of other final disposition of the calls, irrespective of speed and other qualities of the service.

(E) Operator Training Equipment

4.10 Facilities for training operators are desirable and should be provided wherever feasible. Two types of training units, in-board and energized, are generally used. In-board training units are those installed in the regular commercial switchboard. Those which do not use regular positions are referred to as energized training units. If regular switchboard positions will be available for the scheduling of an efficient training program, in-board units may be used. If, however, shortages of regular positions would cause unsatisfactory arrangements for training or interfere with commercial traffic handling, energized units would be desirable. Either type of equipment should provide adequate facilities for giving operators controlled practice on each call taught in the initial and subsequent training courses.

(F) Traffic Separation Facilities

4.11 Traffic separation registers are used to give an indication of the number of intrastate and interstate connections through No. 4-type and crossbar tandem toll switching offices. These numbers of connections are used as bases to which corresponding usage is related for the purpose of apportioning book costs of plant and related expenses between interstate and intrastate services.

4.12 The diversified sources of traffic having access to certain toll crossbar locations and the variation in characteristics among these sources make it desirable to incorporate in the traffic separation register equipment additional features to provide a more detailed classification of connections than merely "interstate" or "intrastate." Thus, the No. 4-type and crossbar tandem systems are provided with incoming and outgoing class marks and when these class marks are scored in different combinations in the traffic separation registers, indications of the volume of separate classes of traffic are provided. The 4A and 4M systems are provided with four incoming and seven outgoing class marks for a total of 28 separate classes; the No. 4 and A4A systems have two incoming and three outgoing marks for a total of six classes; and the crossbar tandem systems have four incoming and four outgoing marks, but have a maximum capability of scoring only ten separate classes. The class marks and illustrative traffic separation assignments for these systems are shown in the three tables of Chart 8 attached.

(G) Single-Channel Operation Facilities

4.13 It is a Bell System long range objective that central office equipment and trunking facilities be arranged so that customers, by dialing "Operator" (Zero), will gain access to operators for assistance calls, operator handled long distance calls, and distant point information calls. This is termed "single-channel" operation. Such arrangements will afford simplicity from the customer's standpoint, eliminate calls misdirected to the wrong office, and result in uniform procedures for the traveling public in placing calls in any location.

Separate, individual codes may be utilized for customers to gain access to the local information operator, repair service, and the business office.

5. AUTOMATIC RECORDING OF MESSAGE BILLING DATA FOR DIRECT DIALED CALLS

5.01 Direct dialing of station-to-station sent-paid messages by customers requires that certain data be obtained automatically in order that chargeable calls may be billed. Two widely used billing plans are "detail billing" and "bulk billing." Detail billing furnishes the customer with detailed information for each extra charge call completed during the billing month. Bulk billing, which may be used for single or multiunit short haul calls, charges the customer on the basis of the total message units used during the billing month. Although more items of message billing data are required for detail billing than for bulk billing, detail billing can be used for all extra charge calls.

5.02 Automatic equipment for recording message billing data may be arranged to care for both bulk billed and detail billed calls. The data listed on Chart 6 are probably the minimum needed to render a detail bill under direct distance dialing; the information shown on Chart 7 is usually all that is needed for bulk billing.

5.03 The industry has developed a number of systems for automatically recording the required message billing data. These may be broadly divided into "local" and "centralized" systems.

5.04 Local automatic message billing data recording systems have the recording equipment located at the Class 5 office where the extra charge calls are originated.

5.05 Centralized automatic message billing data recording systems are those in which the recording equipment is installed at a centralized location so that extra charge calls from a number of Class 5 offices may be concentrated and recorded there. Centralized recording may prove more economical than local recording equipment in individual Class 5 offices depending on specific local considerations.

5.06 Present plans contemplate the use of centralized recording equipment at Class 4 or higher ranking toll offices. Extra charge traffic from Class 5 offices not equipped with local recording facilities, and extra charge traffic that can not be served by local recording equipment, when provided, may be trunked to the centralized location where the required billing data can be recorded.

5.07 In addition to the central office equipment mentioned above, suitable accounting equipment should be provided as required, to process the message billing data into the form needed for billing the customer.

5.08 The extent to which automatic equipment may be employed economically for the recording of message billing data is a function of the reduction it will make in operating expense, the availability of operating personnel, the volume of direct dialed traffic, the type of automatic recording equipment to be employed, the type of switching equipment, the routing of traffic, and the type of equipment at other offices through which the traffic will be routed.

5.09 Several types of equipment for the automatic recording of billing information are currently being manufactured by the Bell System and by Independent suppliers. They are generally classed in two main categories according to association with (1) common control or (2) direct control switching equipment. When the automatic equipment provided to record billing data includes a director or sender, common control features are available even though switching may be on a step-by-step basis.

5.10 Some equipments that automatically record billing information may require a substantial interval for calling number identification. This interval should not result in a delay between the sending of a connect signal forward on an outgoing trunk to a common control system and the subsequent out pulsing of digits over the trunk nor should it result in an extended interdigital time interval. Such delays could result in timeouts in the common control office and failure to complete calls.

5.11 When identification of the calling number is made after the calling subscriber dials the called number, arrangements should be made so that selection of the called line does not occur prior to identification of the calling number.

Attached:

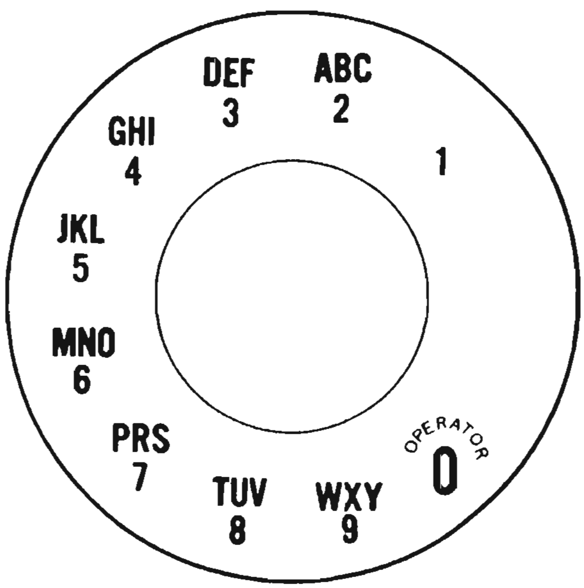
Charts 1 through 8

Appendix A - Typical Trunking Diagrams for S x S Toll Switching Trains (With Charts A-1 and A-2)

Figure A

A Typical Station Number Card
for
2L-5N Numbering

Figure B



A Typical Dial Number Plate
for
2L-5N Numbering

MINIMUM NUMBER OF DIGITS CENTRAL OFFICE EQUIPMENT SHOULD BE ARRANGED TO RECEIVE FROM THE NATIONWIDE DISTANCE DIALING NETWORK

Class of Office	Minimum Digits Incoming	Example*
5	4	(MA4) 1234
4P	5 (See Note 1)	(MA) 41234
4C	7	MA4 1234 (See Note 2)
3 (or higher)	7 or more	See Note 3

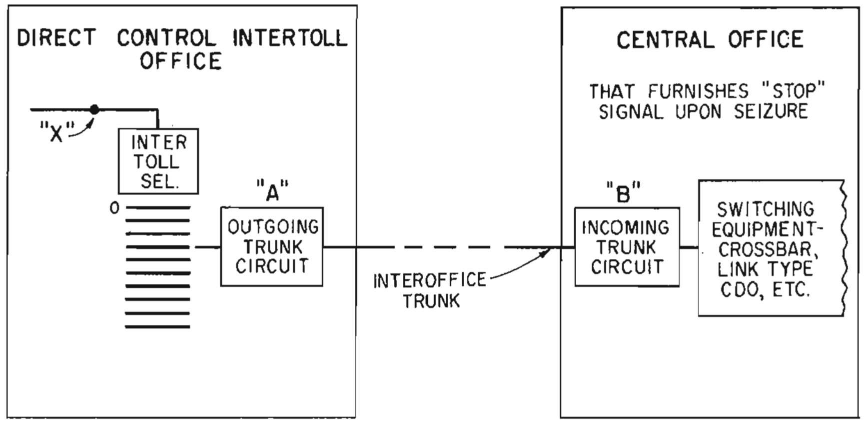
*Letters and numbers in parentheses ordinarily need not be received.

Note 1: Class 4P offices homed on switching centers equipped with common control equipment generally need the number of digits indicated. Class 4P offices homed on Class 3 offices equipped with direct control switching equipment will frequently require 7 digits.

Note 2: An exception to this requirement may be made where the cost of arranging the equipment at the toll center for full 2-5 dialing appears excessive in comparison to the advantages offered by uniform operating procedures. Such exception should be limited to the deletion of the AB or ABX digits on groups (intra-company or inter-company Intrastate) which will not be reached from the nationwide network. This is a matter for local decision.

Note 3: If the Class 3 office is of the common control type, 7 digits may be sufficient; if of the direct control type, one or more digits will be required to switch through the Class 3 office so that the full 7-digit number may be delivered to the Class 4C office. Not more than 7 digits are needed at the home switching point on calls to Class 5 offices that home directly at the switching office.

STOP DIAL SIGNALS
A TYPICAL APPLICATION



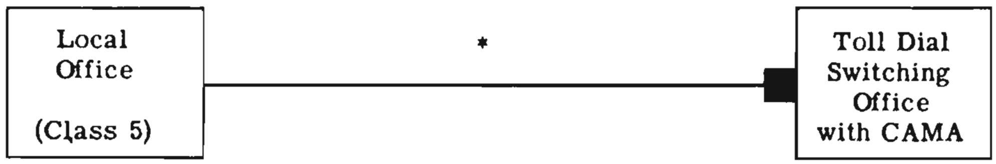
General

1. Pulsing proceeds normally when the condition on the circuit at Point "X" is "on-hook".
2. Pulsing should stop when condition on the circuit at Point "X" changes to "off-hook".
3. Pulsing should resume when condition on the circuit at Point "X" returns to "on-hook".

Analysis of Conditions and Requirements

Steps in the Progress of the Call	Conditions At Point "X"	Remarks
1. Intertoll selector being pulsed up to desired level.	"on-hook"	-
2. Intertoll selector reaches level that trunks to distant office.	"off-hook"	"off-hook" condition returned from the intertoll selector (or equivalent) as soon as the marked level is selected and before rotary hunting has begun.
3. Rotary hunting results in selection and seizure of outgoing trunk circuit "A".	"off-hook"	"off-hook" condition is maintained by the intertoll selector (or equivalent).
4. Trunk circuit "A" seized, sends seizure signal forward to incoming trunk circuit "B".	"off-hook"	"off-hook" condition is maintained by the intertoll selector.
5. Incoming trunk circuit "B" immediately upon seizure (A) Originates a request for a sender, incoming register, link, etc. (B) Returns a "stop dial" signal (off-hook condition) toward trunk circuit "A".	"off-hook"	"off-hook" condition is maintained by intertoll selector.
6. "off-hook" condition received at trunk circuit "A" causes trunk circuit "A" to present "off-hook" condition on trunk toward intertoll.	"off-hook"	"off-hook" condition still maintained by intertoll selector.
7. "off-hook" condition within intertoll selector is removed as a result of release of slow release relay.	"off-hook"	But condition at Point "X" remains unchanged because of "off-hook" condition existing on trunk due to operation of trunk "B"
8. Distant central office equipment ready to receive digits.	"on-hook"	Incoming trunk circuit "B" returns "on-hook" signal toward originating end as an indication that pulsing may proceed.

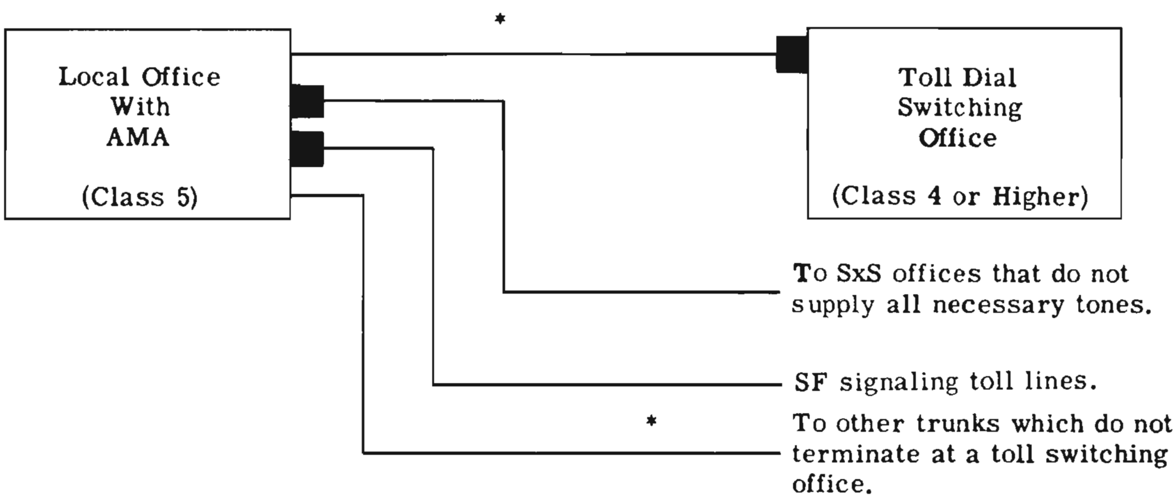
TONE APPLIERS



* Interoffice trunk not employing Bell System type single frequency signaling.

Figure 1

Location When Centralized Message Billing Data Recording Equipment is Used.



* Interoffice trunk not employing Bell System type single frequency signaling.

Figure 2

Location When Local Message Billing Data Recording Equipment is Used.

LEGEND

■ Tone applier (either individual equipment or part of trunk circuit)

SIGNALING FUNCTIONS

REQUIREMENTS OR LIMITATIONS IMPOSED BY DISTANCE DIALING

Item		Remarks
1. Dial Tone	-	Should not be applied to any incoming toll connecting or intertoll trunk. If for circuit reasons dial tone can not be removed from incoming toll connecting trunks terminated on links or line circuits at the Class 5 office, provision should be made for blocking the tone at the toll office nearest the Class 5 office.
2. Second Dial Tone	-	Equipment arrangements that do not require the use of second dial tone on outgoing direct distance dialed calls are to be preferred.
3. Control of the Connection	- (A)	On direct dialed calls, the connection should be under immediate control of the calling party and under delayed control (timed disconnect) of the called party. The timed disconnect ranges from 13 to 32 seconds in the later Bell System designs.
	(B)	On operator dialed calls, the connection between the operator and the calling customer should be under joint control; the equipment from the outward operator to the called station should be under the control of the outward operator.
4. Timed Cutoff Feature	-	If provided in Class 5 offices to limit conversation time on local calls, provision should be made to disable operation on both inward and outward toll calls.

MINIMUM DATA REQUIRED FOR RECORDING
DETAIL BILLED MESSAGES

1. Called Customer's Telephone Number

   This may be either a 10-digit or a 7-digit number, i.e., $\begin{matrix}\mathrm{X0X}\\ \mathrm{X1X}\end{matrix}$ + 2L + 5N, if the call is to a place in a foreign area, or 2L + 5N, if the call is to a place in the home area.

   In the recording process, a single digit is often substituted for the $\begin{matrix}\mathrm{X0X}\\ \mathrm{X1X}\end{matrix}$ code of each of ten of the most frequently called areas.

2. Calling Customer's Telephone Number, 2L + 5N, or Equivalent.

3. Date.

4. Time of Day.

5. Duration of Conversation.

MINIMUM DATA REQUIRED FOR RECORDING
BULK BILLED MESSAGES

1. Calling Customer's Telephone Number, 2L + 5N, or Equivalent.

2. Message Units Chargeable to Calling Telephone.

   This quantity is determined from the following data that needs to be available to the recording equipment:

   2a. Office code of called telephone
   2b. Duration of conversation

   (An indication of the initial period rate or a code designating the appropriate charging plan may be substituted for information called for in Item 2a. It may also be desirable to record the date and time of day.)

TRAFFIC SEPARATIONS AVAILABLE WITH NO. 4 TYPE AND CROSSBAR TANDEM SYSTEMS

4A and 4M Systems

Incoming Trunk Class Marks	Outgoing Trunk Class Marks						
	0	1	2	3	4	5	6
	Possible Combinations						
A	A-0	A-1	A-2	A-3	A-4	A-5	A-6
B	B-0	B-1	B-2	B-3	B-4	B-5	B-6
C	C-0	C-1	C-2	C-3	C-4	C-5	C-6
D	D-0	D-1	D-2	D-3	D-4	D-5	D-6

No. 4 and A4A Systems

Incoming Trunk Class Marks	Outgoing Trunk Class Marks		
	1	2	3
	Possible Combinations		
A	A-1	A-2	A-3
B	B-1	B-2	B-3

Crossbar Tandem Systems

Incoming Trunk Class Marks	Outgoing Trunk Class Marks			
	A	B	C	D
	Possible Combinations			
A	A-A	A-B	A-C	A-D
B	*B-A	B-B	B-C	B-D
C	C-A	C-B	C-C	C-D
D	D-A	D-B	D-C	D-D

* The combinations B-A, C-A, C-B, D-A, D-B, and D-C are scored respectively as A-B, A-C, B-C, A-D, B-D, and C-D.

TYPICAL TRUNKING DIAGRAMS
FOR
STEP-BY-STEP TOLL SWITCHING TRAINS

1. GENERAL

1.01 Every office has individual requirements that must be met when establishing trunking arrangements for intertoll dialing. The sketches shown on Charts A-1 and A-2 and the following discussion are intended to illustrate some of the fundamental principles of automatic intertoll switching. Specific trunking, signaling, and pulsing arrangements should be worked out jointly by the Companies whose offices are involved.

1.02 Chart A-1 covers numbering and trunking considerations in Class 3 and 4 offices and shows how digit-absorbing selectors may be used to hold the required ranks of selectors to a minimum. The relationship between office code assignments and operating characteristics of digit-absorbing selectors is also pointed up. Chart A-2 shows how toll and local trains may be integrated in the end office.

2. NUMBERING PLAN - TRUNKING PLAN CONSIDERATIONS

2.01 Substantial savings in switching equipment and uniform operating procedures at distant toll offices can frequently be had by the use of digit-absorbing facilities in direct control local and toll offices. The capabilities and limitations of available digit-absorbing equipment need to be kept in mind, however, when developing trunking and numbering plans. The attached Charts A-1 and A-2 show some applications of the digit-absorbing principle. The left-hand portion of Chart A-1 shows, in simplified form, a step-by-step intertoll office that serves as a primary center, (Class 3 office) and, in addition, has Class 5 offices homed on it. The primary center is homed on a sectional center (Class 2 office) which is a CSP provided with common control type switching equipment. A method is shown for switching through traffic to the Class 4C offices by means of arbitrary digits prefixed by the CSP. In this example, the arbitrary code "00" is used to switch through the Class 3 office to reach the Class 4C toll center shown on the right-hand side of the figure. In addition to its through switching functions, the primary center also serves as the toll office for the following local offices:

(a) "625," "626," "627," and "628" Class 5 offices located in the same building.

(b) "232," "233,". . . "239" Class 5 offices in the same exchange but in a different building.

(c) "445" and "437" end offices, each of which required only four effective digits for switching purposes.

(d) "33" building which houses several end offices "332," "333," etc., and, therefore, requires five effective switching digits.

(e) Lastly, since inward and delayed operation is cared for at Class 3 offices the auxiliary train is also provided.

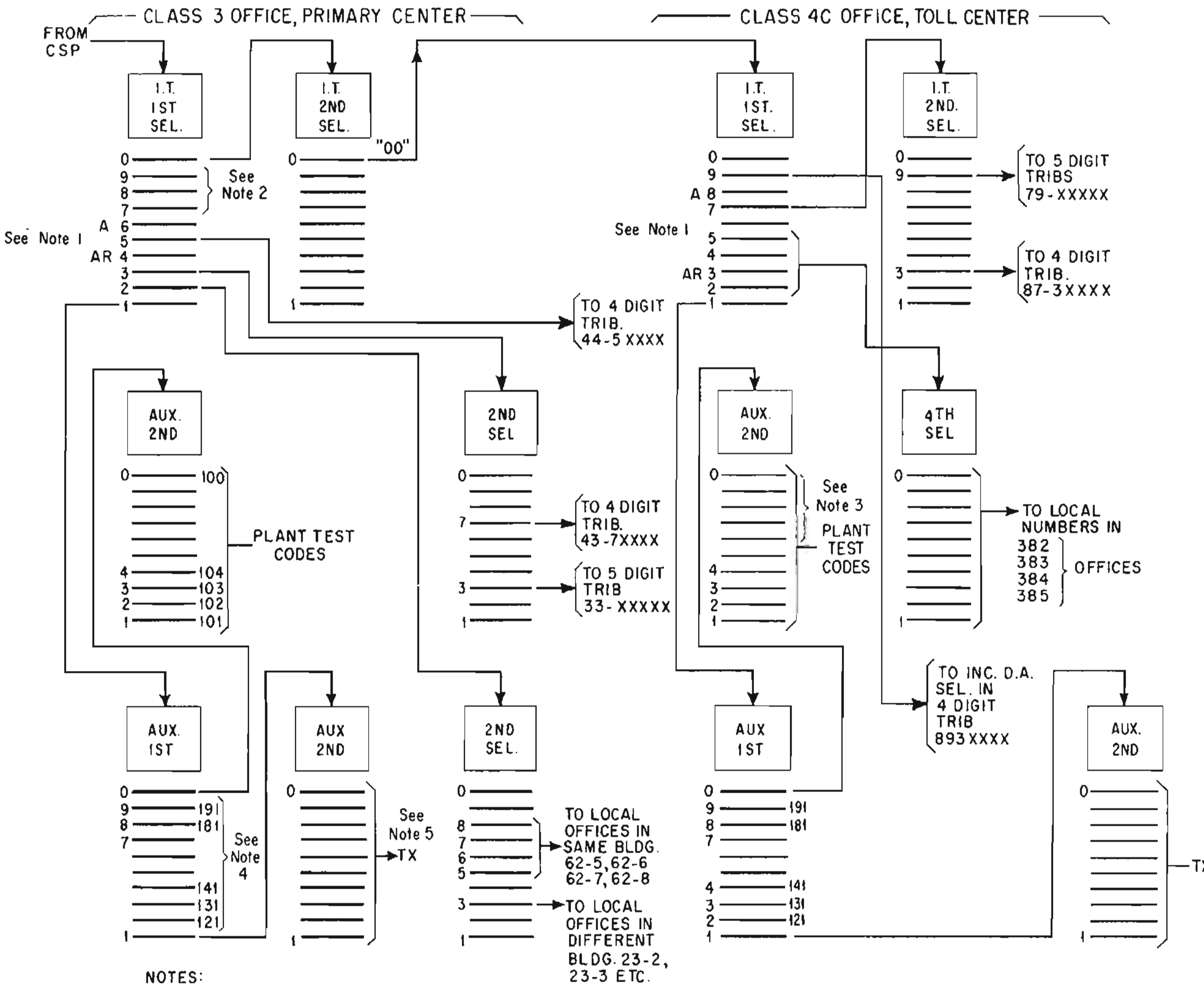
2.02 By arranging the intertoll first selectors to absorb "four" repeatedly (AR4) and to absorb "six" once and unlock all levels (A6) the desired operational features are obtained.

2.03 To reach the Class 5 offices homed on the Class 4C toll center, the Class 2 Sectional Center pulses "00" to switch through the primary center and follows this with the seven digits of the called number. Digit-absorbing intertoll first selectors or the equivalent in the Class 4C office provide the necessary trunking in an economical manner.

2.04 Chart A-2, Figure A shows a local office (about 3000 numbers) with office code "437." The local customers may make local calls by dialing either the listed 2-5 number or the abbreviated 5 or 4-digit number, if desired. It will be noted, also, that the incoming toll connecting trunks have been terminated on four-wire local switches arranged to return flashing busies rather than on a toll train. The incoming fourth selectors need to be separated from the local selectors by being placed on different shelves. The fifth selectors may be combined (instead of separated as shown) if all the fifth selectors are of the four-wire type.

2.05 Figure B, Chart A-2, shows a somewhat larger installation, the four units of the "79X" offices. For this installation a regular toll train using AB toll transmission selectors is provided for inward toll traffic.

SIMPLIFIED HYPOTHETICAL TRUNKING PLAN



NOTES:

1. DIGIT ABSORBING BY SELECTORS HAVING LEVELS DESIGNATED A AND AR:
   A = ABSORB DIGIT ONCE ONLY, ON NEXT DIGIT TRUNK ON ALL LEVELS.
   AR = ABSORB DIGIT REPEATEDLY UNLESS A DIGIT HAS BEEN ABSORBED ONCE ONLY ON A LEVEL DESIGNATED A.
2. BY PROVISION OF ADDITIONAL GROUPS OF 2ND. SELECTORS FROM OTHER LEVELS OF THE 1ST. SELECTORS ACCESS MAY BE OBTAINED TO ANY REQUIRED NUMBER OF LOCAL OFFICES, TRIBS. AND INTERTOLL GROUPS. THE LOCAL OFFICE AND TRIB. OFFICE CODES DETERMINE THE ASSIGNMENT OF LEVELS AND DIGIT ABSORBING ARRANGEMENTS. INTERTOLL GROUPS MAY BE ASSIGNED TO ANY GROUPS OF 2ND SELECTORS NOT REQUIRED FOR OTHER PURPOSES.
3. UNUSED LEVELS SHOULD BE INTERCEPTED.
4. FINAL "1" SHOULD BE ABSORBED IN THE TRUNK CIRCUIT BEFORE OPERATOR IS SIGNALED.
5. THIS METHOD INVOLVES USE OF 11XX TX CODES. THE "11" IS USED TO REACH THIS AUXILIARY SECOND SELECTOR WHICH ABSORBS THE FIRST "X" AND SWITCHES ON THE SECOND "X"

DIAGRAM SHOWING RELATION BETWEEN LOCAL AND TOLL TRAINS

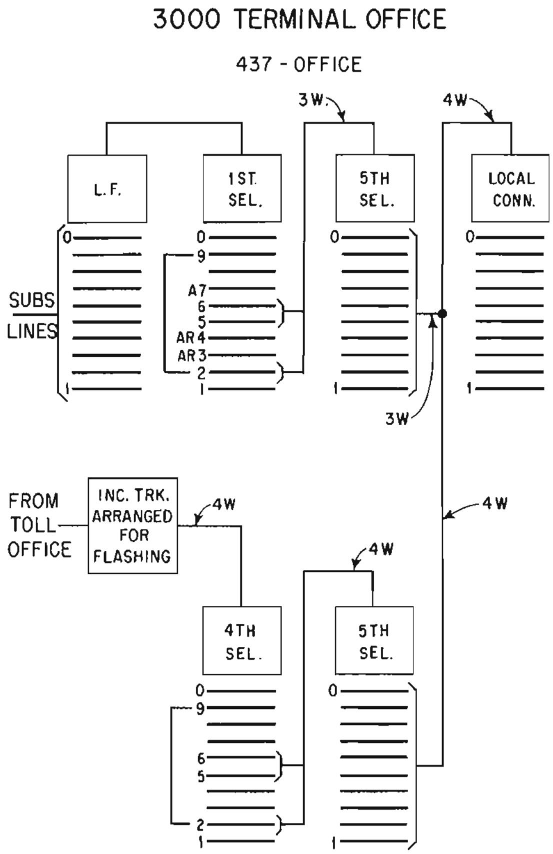


FIG. A
FOUR EFFECTIVE DIGIT OFFICE WITHOUT TOLL TRAIN

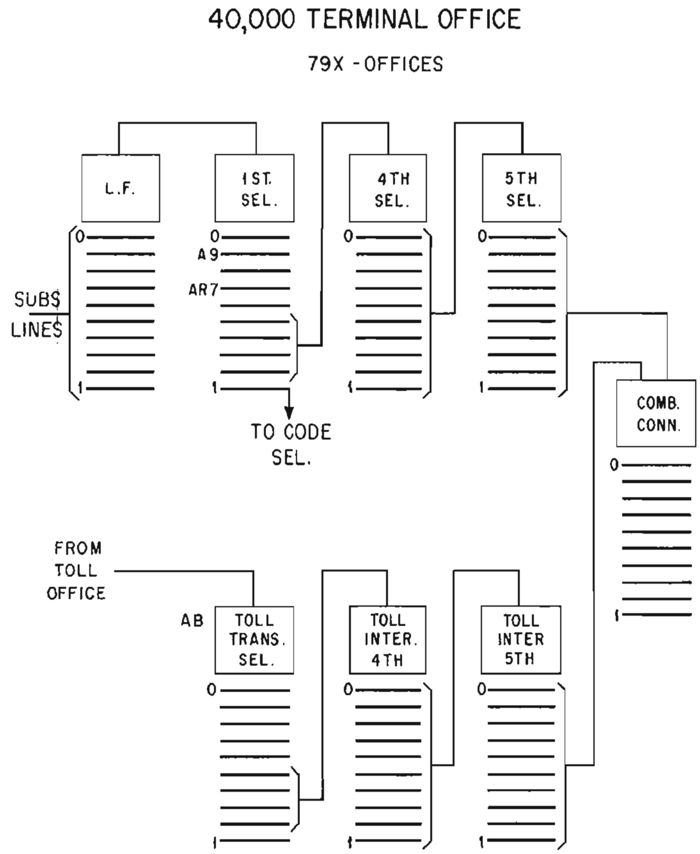


FIG. B
FIVE EFFECTIVE DIGIT OFFICE WITH TOLL TRAIN

TRANSMISSION CONSIDERATIONS

CONTENTS PAGE

1. INTRODUCTION

1.01 In the new distance dialing switching plan using switching machines, the layout of toll circuits and the routing of traffic will be quite different from those used in earlier manual switching plans. From the transmission standpoint the principal impact of the new plan results in changing from a plan in which as much traffic as practicable was handled over direct circuits, with a minimum of switching, to one in which two or more, up to a maximum of seven intertoll circuits (eight on U.S.-Canada intercountry traffic) will be used in tandem on many calls. In addition there will always be two terminating links (toll connecting trunks) or equivalent, one at each end, in each intertoll connection. Furthermore, as a result of alternate routings contemplated by the new plan, different numbers and makeups of circuits may be encountered on successive calls between the same two telephones.

1.02 What this means to the transmission engineer is that the transmission loss of each circuit which may be used in a connection must be low in order to provide adequate transmission on all calls and to avoid large differences in transmission on successive calls between the same two places.

1.03 The ideal would be to operate all circuits at zero loss since this would make the transmission loss independent of the number of circuits used in a connection. However, the distances involved in the United States and Canada are so great that even the best types of transmission facilities must be operated at some loss in order to provide suitable transmission characteristics as covered in later parts of this section. Also, the plan must provide for the most effective utilization of all kinds of facilities (carrier, radio, loaded voice frequency cable, and open wire voice circuits) each with its own particular transmission capabilities.

1.04 The practical transmission solution, therefore, is to:

(1) Operate every circuit at the lowest loss practicable considering its length and the type of facilities used.

(2) Assign circuits with different transmission capabilities in accordance with their particular role in the operation of the over-all network.

The various factors affecting the transmission design of the plan are discussed in Parts 2 through 6 of this Section.

1.05 It is clear that no matter how carefully the design of the plant is carried out, the success of the whole switching plan will depend on how closely circuit losses can be maintained to their assigned values. This is important from two aspects:

(1) Expected circuit loss variations have an important bearing on the extent to which circuit losses can be driven down toward zero.

(2) Unless circuit losses are maintained fairly precisely, large positive or negative losses can accumulate on multi-switched connections with substantial effects on satisfactoriness of conversation either from the standpoint of low volume (high loss) on the one hand, or excessive echo or hollowness on the other.

1.06 The importance of this closer maintenance stems from two peculiarities of toll switching on a dialing basis:

(1) On many connections and particularly with direct dialing there will be no operator to observe the quality of transmission.

(2) With direct dialed calls encountering trouble, it will be next to impossible to identify and locate the trouble since the customer must release the connection to report.

1.07 With the continuously increasing use of repeaters and carrier systems in modern toll plant an entirely new concept of maintenance arises. No longer is it enough to insure that the physical components of transmission systems are trouble free; the loss at which a circuit operates depends on the care and understanding with which the various adjustments at terminals and intermediate points have been made. A further important feature of these electronic transmission systems is that the adjustments made at any one point in a circuit will have an important reaction on adjustments made at other points.

1.08 A successful approach to the transmission maintenance job will involve:

(1) The closest cooperation between the engineers who design the circuits and the plant forces who establish, operate and maintain them.

(2) Training of all people involved in operating toll circuits in the "why" as well as the "how" of maintenance procedures.

(3) Providing the maintenance people with good tools to do their job — adequate test equipment which is well understood and simple to operate.

(4) Clearing transmission maintenance difficulties by correcting the basic cause of variations, rather than making terminal adjustments to eliminate the symptoms.

Some suggestions on handling the transmission maintenance job are discussed more fully in Parts 7 and 8 of this Section.

2. INTERTOLL TRUNK CIRCUIT DESIGN

2.01 An Intertoll Trunk is that link in an over-all telephone talking connection which extends between two toll switching systems (Class 4 and higher ranking). In addition to trunks between toll offices in different cities, all trunks between toll offices at separate locations in the same city and between toll switching systems in the same building are also classed as intertoll trunks (intermediate links).

2.02 Before any system of transmission design can be formulated, it is necessary to have a definite plan for interconnecting intertoll trunks on a nationwide basis. Such a plan has been in effect for years on the basis of making such connections manually. However, with proposed ultimate interconnection of intertoll trunks by switching machines (i.e., automatically), it has become necessary to review the old plan to obtain the best economic balance between intertoll trunk costs and switching costs. As a result, a revised switching plan (see Section III for detailed discussion) has been adopted that contemplates automatic alternate routing with as many as eight intertoll links in tandem. (The maximum number of intertoll links for calls within Canada and within the United States will be seven as shown on Chart 3; however, for calls between Canada and the United States there will be some RC-RC-RC switching, resulting in a maximum of eight intertoll links for a small portion of such intercountry calls.) While connections involving eight intertoll links will rarely be encountered, and though the large majority of calls will involve no more than three or four intertoll links, still the transmission design will have to provide for the maximum condition. To the intertoll links there will always be added the two terminal links (toll connecting trunks), one at each end, to connect the intertoll trunks to the local offices (Class 5 or End Offices).

2.03 Any switching plan (and the associated transmission design requirements) must necessarily depend on the current state of development of the art and, therefore, requires continuous review as new and improved instrumentalities become available. In order to provide satisfactory transmission regardless of the routing selected to complete a connection, it will be necessary to operate each trunk which might be involved at as low a loss as its inherent capabilities will permit. The widespread use of carrier systems, with their high velocity and inherent stability, is of outstanding importance in meeting the transmission objectives of the new switching plan.

2.04 The best transmission performance is obtained at switching centers where the toll terminal equipment, dial switching system, and associated toll switchboards are in the same building. Multi-building switching center layouts necessarily introduce tie cables between buildings which result in special transmission problems. At best, transmission through such centers will be inferior to single building layouts. Recognition of this fact in the early stages of planning by the groups concerned with traffic, buildings, equipment, transmission, outside plant, and maintenance will assure that all cost elements are properly evaluated and weighed against the possibly lower costs of a building at a new location. It is important that cost advantages of a separate building location be substantial — not merely marginal — in deciding on layouts of less desirable service performance.

(A) Design Factors

2.05 The following considerations are the most important in determining the lowest practicable losses at which intertoll trunks may be operated.

(a) Echo

(b) Singing

(c) Noise and Crosstalk

Echo

2.06 Chart 1 has been prepared to show how an echo arises on a telephone connection. This chart shows the relatively simple case of a 4-wire intertoll trunk connected by means of the usual hybrid (4-wire terminating set) arrangements to a 2-wire local termination at each end. These local terminations may be anything from a telephone set adjacent to the toll offices, to sets on a wide variety of lengths of customer loops both non-loaded and loaded or even on carrier systems. There will always be intervening toll connecting trunks (terminating links) which likewise may be on cable (either non-loaded or loaded) or on carrier systems. The range of impedances presented by these terminations to the toll facility, therefore, varies widely, being different for each connection. The best that can be done under such circumstances in selecting a balancing network for the 4-wire terminating set is to choose one which is the best compromise for the range of conditions. This is customarily known as a compromise network. It consists of a resistance and capacitor in series whose values are determined by the general level of impedance of the particular office. Naturally, the balance in any given connection is likely to be far from perfect.

2.07 Now, getting back to the echo, when the customer at Point A talks, his speech energy (the heavy solid line) travels along the circuit to Point B and on to the distant customer. However, because of the impedance mismatch between the local plant and the compromise network at Point B, some of this energy leaks across the 4-wire terminating set (the dash-dot line) and is transmitted back to the talker's receiver. Thus, he hears his own voice, and if the time for his speech to travel down to Point B and back is long enough, the returned energy will appear as a distant echo — hence the term "talker echo." In addition to causing possible hollowness, talker echo is disturbing because it creates the impression that the listener is trying to interrupt.

2.08 At Point A, the same kind of impedance mismatch is present as at Point B. Consequently, some of the talker echo arriving at Point A leaks across the 4-wire terminating set at that point and is conducted back (the dotted line) to the subscriber at Point B. This is known as "listener echo." However, the extra loss across the 4-wire terminating set at Point A and the added loss encountered in the additional trip down the circuit so attenuates the listener echo that it is usually not controlling in this type of connection.

2.09 The magnitude of the reflected currents at Points A and B depends on the degree of impedance mismatch between the compromise network and the local plant. This is conveniently expressed by the term "terminal return loss," and is equal to $20 \log_{10} \frac{Z_N + Z_L}{Z_N - Z_L}$, where Z_N is the impedance of the compromise network and Z_L is the impedance of the local plant. Since the impedance of the local plant varies over the frequency band, the return loss likewise varies. As will be discussed shortly, a single weighted figure of the return losses in the frequency band important from the echo standpoint (500 to 2500 cycles) is used for purposes of assigning circuit net losses.

2.10 In the case of 2-wire circuits with repeaters, echo currents arise at the terminals just as in the 4-wire case, but in addition there are echo paths at each intermediate repeater. These are compensated for in the design factors for 2-wire circuits discussed later in this Section.

Tolerance to Echo

2.11 Extensive tests under controlled conditions have shown that people's tolerance to echo depends on the loudness of the echo and the time it is delayed in arriving at the talker's ear. There is also a very wide difference between individuals as to the relative loudness and delays which they will tolerate. Table 1 gives the average tolerance to talker echo in terms of the minimum loss in the echo path to be just satisfactory for different round trip delays in milliseconds.

Table 1

Round Trip Delay (Milliseconds)	Average Tolerance to Echo Loss in Echo Path - db
0	1.4
20	11.1
40	17.7
60	22.7
80	27.2
100	30.9

Note: Recent tests made to confirm these values indicate that present-day customers may be somewhat less tolerant to talker echo, particularly at the longer delays, than the above figures indicate. However, when combined with the somewhat more favorable echo return loss data recently obtained, (Paragraph 2.24), the net effect indicates that present design factors described herein should be retained.

2.12 The range of tolerance to echo for individual observers is such that on the more critical side some 34 per cent require losses ranging from the averages shown in Table 1 to about 2.5 db greater than the average; and the most critical, about 7.5 db greater. On the more tolerant side 34 per cent were satisfied with losses ranging from these averages to values 2.5 db less; and the most tolerant, 7.5 db less. In statistical terms, therefore, the variation among people in tolerance to echo can be expressed as a standard deviation of 2.5 db.

Note: Standard deviation is the root-mean-square of the individual deviations from the average. In mathematical form, the standard deviation, $\sigma = \sqrt{\frac{a^2 + b^2 + ----}{n}}$ where a, b, etc., are individual variations from the average and n is the total number of variations involved.

2.13 Referring again to Chart 1, the loss in the talker echo path for a talker at A is equal to the circuit loss from A to B, plus the return loss between the compromise network in the 4-wire terminating set of the intertoll trunk and the local plant at B, plus the circuit loss from B to A. The round trip delay (usually expressed in milliseconds) is the time it takes the energy from the speaker's voice waves to travel down to the distant end of the circuit and back again.

2.14 It will be clear from the discussion of echo, that this characteristic of a connection will impose a lower limit on the loss at which the toll circuit can be operated. The return loss is a fact of life — there it stands, its value being set by the large bulk of existing plant. It can and should be improved by use of the new techniques now available and in the offing as discussed in Part 4. It is recognized that the work needed to improve return loss is likely to extend over a long period of time. Thus it is the circuit loss itself to which we must look to control echo. There is one reservation — high speed carrier circuits will permit a lower circuit net loss for a given length of circuit than, say, voice frequency loaded cable circuits, because the round trip delay is so much shorter.

Echo suppressors are devices which effectively block the return current, thus stopping echo. However, they can not be considered for general use in controlling echo on each link of a multilink connection as discussed in Paragraph 2.34.

Singing

2.15 Referring to Chart 1 again, it can be seen that if the current returned to Point B by the "listener echo" path is greater than the original current arriving at that point, a condition is set up to sustain a circulating current around the loop consisting of the two sides of the circuits and the hybrids at the ends. This condition can arise at any frequency from low return losses at Points A and B and higher gains in the line repeaters. In other words a singing condition has been set up. Stated in another way, singing will occur when, at any one frequency, the sum of all the gains in the transmission paths exceeds the sum of all the losses. The surest way to prevent singing, then, is to limit repeater and carrier system gains, or to improve the terminal return losses, or both. Experience indicates that singing in built-up intertoll connections will occur most often in the frequency ranges 250 to 500 cycles and 2500 to about 3200 cycles. Hence the singing frequency range extends beyond the edges of the echo range.

2.16 One of the interesting aspects of singing phenomena is that impairment of transmission occurs well before actual singing takes place. The effect has been called "hollow" and is likened to shouting into an empty rain barrel. Experience with this sort of thing indicates that to avoid this effect in long built-up connections there should be a minimum margin of 5 to 6 db against singing at any frequency under the poorest circuit conditions. This means that the average singing margin should be considerably higher.

Note: Singing margin can be thought of as the gain which can be added to a given connection to just start singing.

2.17 It will be clear that the way to stay out of trouble from singing is either to operate circuits at sufficiently high losses or to make sure that return losses in the singing frequency ranges are maintained at high values. Since high circuit losses are obviously contrary to transmission objectives of distance dialing, attention should be directed at getting good return losses.

2.18 As will be developed in Part B which follows, circuit design is based on factors derived from the echo requirements. So long as the return losses in the singing frequency ranges are maintained as good as in the echo range, the circuit design will be adequate from the singing standpoint as well as from the echo standpoint. But the singing frequency return losses require constant attention to make sure that proper layouts and apparatus units are specified. This will be treated further under "Office Balance" in Part 3.

2.19 In the case of 2-wire voice frequency circuits, it is important to pay close attention to layout and design to obtain optimum singing performance and still achieve low circuit losses. In particular, care should be taken to avoid repeater sections of excessive length, and to use uniform facilities with a minimum of impedance irregularities so as to permit precision balancing of the network against the line facilities.

Noise and Crosstalk

2.20 Noise and crosstalk are best controlled by the design of the individual transmission systems and in the layout and construction of the associated outside plant rather than by running up circuit losses. In other words, the preferable approach is to get at the basic causes of noise and crosstalk and not to cure only the symptoms.

2.21 In carrier, repeatered voice, and radio systems, noise and crosstalk control means care in locating repeaters and terminals, the provision of suppression devices to nullify disturbances, and coordination with the communication systems of not only other telephone systems, but those of power companies and radio services as well.

2.22 In voice frequency cable systems, it is necessary (1) to use cables well balanced in order to minimize crosstalk, and (2) to employ sound splicing practices. In open wire systems, both voice frequency and carrier, it is necessary to employ transposition layouts adequate for the frequencies employed, and to provide for coordination with power lines.

(B) Determination of Circuit Net Loss

2.23 Where adequate control of singing has been incorporated into the design of intertoll trunks and associated switching systems, echo is usually the factor which determines the lowest loss at which a given connection can be operated. The basic information comes from Table 1 which for a given round trip can be expressed as the formula:

One-way net loss = 1/2 (Average echo tolerance minus Average terminal return loss)

The average echo tolerance comes from Table 1. However, it will be recalled from Paragraph 2.12 that echo tolerance is not a single figure but is a distribution covering a wide range which is measured by saying that it has a standard deviation of 2.5 db.

2.24 It will be clear from Paragraph 2.09 that return loss in the echo range also is not a single value but is a wide spread of values. The figures for terminal return loss which have been used in deriving current circuit net loss design factors were based on field tests of a large number of calls. The average return loss is 11 db and its standard deviation is 3 db. Hence, practically all of the return losses could be expected to fall in the range from 2 to 20 db. (That is, three standard deviations on either side of the average.)

> Note: Recent field data indicate that for plant free of equipment and wiring errors, and free of loading irregularities an average return loss of around 14 db with a standard deviation of a little more than 1 db is obtainable. However, when used in connection with the recently determined more severe echo tolerance (Paragraph 2.11) the net effect is to retain the circuit design factors at their current values.

2.25 Another factor which has to be taken into consideration is the variation of circuit net losses from their assigned values, since any such changes affect directly the loss in the echo path. In the present state of the art, it is expected that by the use of improved maintenance procedures (discussed in Part 7 of this Section) it should be practicable to maintain circuit stability to a standard deviation of 1 db* one-way which for practical purposes is equivalent to a standard deviation of 2 db in the round trip echo path. This variation would apply to each link in a connection.

*Other writings have used a figure of 1.15 db which was derived empirically from an assumed standard deviation of round trip loss of 2 db. It is here rounded down to 1 db to be consistent with the practical maintenance objective of 1 db (see Paragraph 7.16). This results in no significant effect on the Via Net Loss Factors.

2.26 To take these distributions into account it is necessary to make one more assumption — namely, that seldom, if ever, will a customer get a call with objectionable echo. It is believed this will be realized if the determination of net loss is based on assuring satisfactory echo performance in 99 per cent of all connections encountering the maximum delay likely to be experienced. The 99 per cent point on a distribution curve is equivalent to 2.33 standard deviations. However, by the judicious use of echo suppressors and by the margins included in the simplified design methods discussed below, satisfactory echo performance is actually achieved in much more than 99 per cent of all connections.

2.27 We are now ready to rewrite our formula for one-way loss by adding to the average losses in the echo path a quantity equal to 2.33 times the combined standard deviations of all the variables as follows:

$$\text{One-Way Loss} = \frac{\text{Avg. Echo Tol.} - \text{Avg. Ret. Loss} + 2.33\sqrt{Do^2 + Dt^2 + NDv^2}}{2},$$

where

Avg. Echo Tol. = Average Echo Tolerance in db (Table 1)

Avg. Ret. Loss = Average Return Loss, or 11 db (Paragraph 2.24)

Do = Standard Deviation of distribution of tolerance to echo among observers, or 2.5 db (Paragraph 2.12)

Dt = Standard deviation of terminal return loss distribution, or 3.0 db (Paragraph 2.24)

Dv = Standard deviation of distribution of round-trip circuit loss variation, or 2.0 db (Paragraph 2.25)

N = Number of intertoll links

2.28 As an illustration, taking the condition for one intertoll link with 20 milliseconds round-trip delay, the one-way loss becomes:

$$\frac{11.1 - 11 + 2.33 \sqrt{2.5^2 + 3^2 + 2^2}}{2} = 5.0 \text{ db}$$

2.29 By using the required losses for the various values of round-trip delay of Table 1 the circuit losses shown in Table 2 are obtained for various numbers of links.

Table 2

Round-Trip Delay (Milliseconds)	Approximate Working Net Loss (db) Which Gives Satisfactory Echo in 99% of Cases			
	1 Link	2 Links	4 Links	6 Links
0	0.3	0.8	1.7	2.5
20	5.0	5.6	6.5	7.4
40	8.5	9.0	9.8	10.6
60	10.9	11.4	12.3	13.1
80	13.2	13.7	14.6	15.4
100	15.1	15.6	16.5	17.2

(C) Via Net Loss and Via Net Loss Factors

2.30 It is apparent that the formula of Paragraph 2.27 would be quite cumbersome for detailed circuit design since each possible connection would have to be computed individually to take into account the round-trip delay and number of links. However, with some approximation it is possible to provide a much simpler method for detailed design application. This consists of a set of factors called Via Net Loss Factors (VNLF) which when multiplied by the circuit length gives the Via Net Loss at which each circuit can be operated regardless of the number of links in a connection. (Via Net Loss or VNL is defined as the loss of intertoll trunk when it is an intermediate link in a switched connection.) The deriviation of Via Net Loss Factors is given in the following paragraphs.

2.31 Experience has shown that intertoll circuits can be worked at lower losses (via net losses) when they form an intermediate link in a switched connection than when they terminate in a telephone set directly or through local plant at either one or both ends (terminal net losses). This is primarily due to the fact that when circuits are switched, either at 4-wire switching offices or at 2-wire switching offices where care has been taken in arranging their terminations (as discussed in Part 3 of this Section) sufficiently high return losses are obtained effectively to eliminate an echo return path at the switching office. The added loss required to control echo currents, singing, noise and crosstalk in terminal connections with their widely varying impedance terminations has been furnished by means of switchable pads ("S" pads) which are in the connection for the terminal condition, but which are out on through intertoll connections. In the newer 2-wire toll switching systems, switching pads have been omitted and the intertoll trunks operated at via net loss in the terminal as well as the switched condition. This requires certain modifications in the local connecting plant to provide the equivalent of the "S" pad as will be discussed in Part 4.

2.32 Consideration of noise and crosstalk, singing and echo has indicated that in the present state of the telephone art an S pad of 2 db is the best value of switchable loss.

2.33 To derive the Via Net Loss Factors, the data for a one-link connection from Table 2 are plotted as Curve X on Chart 2. Now, with a circuit of 0 round trip delay, the minimum loss is that of the S pads at the two ends of the circuit. Assuming values of 2 db each, this gives a minimum loss of 4 db. Referring again to Table 2, it will be observed that there is roughly a difference of about 0.4 db per link in the minimum permissable losses in the important delay ranges as additional links are operated in tandem. This 0.4 db will be recognized as an allowance per link to reflect expected variations in net losses from their assigned values. It is added to the 4 db for the S pads to make the 0 delay loss 4.4 db.

2.34 Echo suppressors are voice operated devices, and experience indicates that generally satisfactory operation will not be obtained on switched toll connections with more than two operated in tandem, because clipping and lockout result in a high percentage of such cases. On this basis an upper limit of round-trip delay not requiring an echo suppressor must be selected. The choice of 45 milliseconds, corresponding to about 2400 miles of carrier, seems reasonable under present views of the toll switching plan. On Chart 2, then, starting at the 4.4 db point on the 0 delay axis, a line (designated Line Y) can be drawn through the 45 millisecond delay point of Curve X. It will be seen that the slope of Line Y is one way net loss in db per millisecond round trip delay; and that the one way net loss corresponding to any point on Line Y is equal to 4.4 db (or 2S + 0.4 db) plus 0.1 db multiplied by the number of milliseconds round trip delay.

2.35 With the velocity of propagation known for the various types of facilities employed, the slope of Line Y can be evaluated in terms of db per mile — a much more workable form.

This is done by dividing 2 times the slope of Line Y by the velocity of propagation. (The factor 2 enters into the transformation since the db in the slope is one way while the delay is round trip.) The resultant db per mile figure is called the Via Net Loss Factor (VNLF).

Example: Intertoll trunks on K carrier have a velocity of propagation of 105,000 miles per second or 105 miles per millisecond.

$$\text{The VNLF is then } \frac{2 \times 0.1 \text{ db/ms}}{105 \text{ miles/ms}} = 0.0019 \text{ db per mile.}$$

To determine the lowest loss at which an intertoll trunk in a built-up connection can be operated satisfactorily from an echo standpoint, it is only necessary to multiply the VNLF of the facility by its length and add the factor 0.4 db as discussed in Paragraph 2.33. Table 3 gives the via net loss factors of the more commonly used facilities in the telephone plant. As an example, the via net loss (VNL) of a 1,000 mile intertoll trunk composed of K carrier facilities will be (.0019 x 1,000) + 0.4 = 2.3 db. The terminal net loss of this trunk will be VNL + 2S or 2.3 + 4.0 = 6.3 db.

Table 3

Via Net Loss Factors for Typical Telephone Facilities

Facility	VNLF (db per mile) 2-Wire Facility	VNLF (db per mile) 4-Wire Facility
19H 88-50 side	.03	.014
19H 88-50 phantom	.03	.014
19B 88-50 side	.04	-
19B 88-50 phantom	.04	-
19H 44-25 side	-	.010
19H 44-25 phantom	-	.010
Open wire, voice frequency	.01	-
Open wire carrier (all types)	-	.0017
Type K or N carrier	-	.0019
Type L carrier	-	.0015
Carrier circuits on radio	-	.0014
H88 on paired exchange type cables, any gauge	.04	

2.36 The Via Net Loss Factors for 4-wire circuits are derived from the lowest losses permitted from a talker echo standpoint which, under conditions previously discussed, also meet the current objectives for singing, crosstalk and noise. The factors for 2-wire circuits have been increased over the echo requirements on a judgment basis to allow for the effect on singing as well as on talker echo of additional return loss paths at intermediate repeater points. In 2-wire voice frequency facilities it will be necessary to support the required repeater gains by adequate impedance balancing to permit working at the losses determined by the Via Net Loss Factors. At switching points it is desirable to employ terminal repeaters of the hybrid coil type where practicable because the impedance of a properly designed repeater of this type has characteristics which are helpful in obtaining a satisfactory balance against a compromise network. It can be expected that with increasing use of carrier systems in the future the employment of 2-wire voice frequency facilities will be largely confined to short terminating links, except possibly open wire circuits and circuits between switching centers in large metropolitan areas.

2.37 General guides in the assignment of gain to a 2-wire voice frequency intertoll trunk to obtain optimum transmission are given below. There may be exceptions to these guides dictated by economic factors but deviations will result in somewhat poorer performance. See Paragraph 4.45 for discussion of repeater location in toll connecting trunks.

(1) Place first terminal repeater (of the type discussed in Paragraph 2.36) at the switching office, Class 1 to 3, having the lowest class number.

(2) The second repeater should be placed on the other end of the circuit.

(3) If the intertoll trunk is long enough to require intermediate repeaters, they should be located at normal intervals in the circuit.

2.38 Chart 3 shows some of the possible paths of interconnection of circuits on a countrywide basis and lists the range of via net losses of trunks that are expected to be obtained. These losses are made possible only by the large expected use of carrier systems, particularly on the final routes. (See Section III for general discussion of the Switching Plan for Distance dialing.) It is planned that loss on high usage groups will be as follows:

High Usage Group	Loss
CSP-CSP; CSP-TC; TC-TC	VNL
CSP-EO; TC-EO	VNL + 2
EO-EO	VNL + 2 to VNL + 4

However, in the transition period before carrier facilities are in use on all routes, TC-CSP circuits (both high usage and final) and TC-TC high usage circuits may be operated at VNL + 2 db. For such operation, each TC (Toll Center; Class 4 Office) should be studied from the standpoint of costs and obtainable transmission improvements.

2.39 It will be noted from Chart 3 that echo suppressors are installed on each RC-RC intertoll trunk. On this basis, every connection involving an RC-RC circuit will contain one echo suppressor. A connection involving a final route RC-RC-RC will contain two echo suppressors. It is hoped that by the use of only carrier facilities on the chain of final groups of circuits, echo suppressors can be avoided on the final route circuits other than RC-RC. On the proposed basis, then, the circuits in the final routes must be designed so that a call from any toll center to another toll center in the same region but routed through their regional center must be operated in a satisfactory manner from an echo standpoint without the aid of an echo suppressor. It is believed that this can be achieved if the intertoll trunks are designed in accordance with the above-described plan and the necessary maintenance attention applied to ensure that the deviations from assigned 1000-cycle losses of the individual trunks are kept within established objectives. Echo suppressors will be used on high usage circuits between offices on different final route chains where required by the length of circuit and type of facility; they will not be used on high usage circuits to offices on the same final route chain. In order to reduce "hangover" time, it is planned to employ an echo suppressor at each end of some of the longer RC-RC circuits. Each such echo suppressor will be disabled in one direction of transmission. Such an arrangement will be particularly helpful in RC-RC-RC connections and in connections involving the Trans-Atlantic or Hawaiian Cables.

3. 2-WIRE VS. 4-WIRE SWITCHING – OFFICE BALANCE

3.01 It is planned that the Regional Centers and the large majority of the Sectional Centers situated within the United States will employ 4-wire switching systems. Some of the larger primary centers will also be equipped with 4-wire switching systems. The remainder of the switching centers will employ 2-wire switching arrangements. The use of 2-wire switching systems at primary and sectional centers has been made possible by the extended application of high speed carrier systems which eliminate the intermediate singing and echo paths that would be present in 2-wire voice facilities. The echo paths at the 2-wire switching points can be effectively minimized by providing a high office balance at the switching offices as discussed in the following paragraphs. It is important, however, that the 4-wire terminating sets employed at 2-wire switching offices be designed to have input impedance (viewed from the 2-wire side) that, over the transmitted frequency band, closely resembles the impedance of the compromise network (with allowance for average office cable resistance) to provide adequate singing as well as echo conditions.

3.02 The via net loss factors shown in Table 3 assume that all interconnection of intertoll trunks at intermediate toll offices will encounter no appreciable echo paths at the switching centers. In 4-wire switching offices, such an echo path is automatically eliminated by retaining 4-wire operation through the switches. By careful engineering and maintenance 2-wire switching systems, particularly at the smaller switching offices, can be made to give satisfactory transmission performance. The best transmission results are obtained if the switching system, the toll terminal equipment (carrier terminals or voice-frequency terminal repeaters). and the associated toll switchboards are in the same building. Where these conditions do not exist, a complete review of the overall switching layout is desirable to determine the steps to be taken to insure satisfactory transmission performance. (See Paragraph 2.04).

3.03 On connections through an intermediate 2-wire switching point return currents (echo and singing) can arise due to unbalance between the office equipment and wiring and the balancing network in the terminal repeater or 4-wire terminating sets. By using capacitors for balancing office cabling as outlined in the following paragraphs, these return currents can be held to such small values as to cause little or no impairment on the switched connections.

3.04 Chart 4 shows typical connections of two intertoll trunks at a 2-wire switching office. Fig. A shows the condition where switching pads are employed in the intertoll trunks at the switching office. Fig. B shows the arrangement at a newly established switching office where switching pads are omitted in the intertoll trunks. In the latter case fixed 2 db pads are placed in the short (less than 2 db) terminating links (toll connecting trunks, not shown in Figures) and the sending end impedance of the longer loaded trunks is modified by the use of impedance compensators as discussed in Part 4.

3.05 In order to interconnect 2-wire circuits at random at switching points, a single type compromise network must balance any of the circuits in the office. It follows that the impedance of all the circuits terminating in the office must be equal to that of the network within reasonable limits of precision. A nominal toll office impedance of 600 ohms was selected some time ago after due consideration of the relative series and shunt losses of office cable, and is currently used in the trunk circuits terminating at step-by-step, No. 5 crossbar, and No. 4 type toll crossbar offices. More recently, toll switching has been introduced at crossbar tandem offices which are designed to have office impedance to match the impedance of outgoing switching trunks. Since the present standard outgoing trunks are usually H-88 loaded cable, crossbar tandem office impedance for toll switching is considered to be 900 ohms. The circuit terminal impedances are designed to match the nominal impedance of the office. However, since supervisory signals are often transmitted over the talking path conductors, capacitors are required in certain locations to isolate parts of the signaling circuit. Consequently, the office impedance is assumed to be 600 or 900 ohms (depending on type of office) in series with a 2 mf capacitor and circuit terminal impedances are so designed.

3.06 The office cable required to extend the circuit terminal to the switching point (switches or switchboard) modifies the input impedance of the circuit. Also, there are different amounts of cable in different circuits and this difference may be great enough to impair the office return loss. Where the impairment is too great, the capacitance of each switching path is adjusted to a uniform value by means of the capacitors shown as C_2 on Chart 4. (This is known as drop building out.) Having resorted uniformity to the terminal impedance, the capacitor shown as C_1 on Chart 4 (known as network building out) is adjusted to a value such that the compromise network will balance the circuit terminal impedance as modified by the office cable and building out capacitance on the two circuits that are interconnected. Since the office cable has distributed shunt capacitance and series resistance, it is practically impossible to balance its effects perfectly. The shunt impedance resulting from the distributed capacitance of the office cabling can be satisfactorily balanced by an adjustable capacitor. Experience indicates, however, that it is necessary to limit the series resistance of office cabling in 2-wire switching offices in order to obtain satisfactory balances on through connections by means of simple balancing networks. The desired return losses can be obtained by limiting the value of series resistance introduced by the wiring on the 2-wire side of 4-wire terminating sets to a maximum of 65 ohms in 900 ohm impedance offices and 45 ohms in 600 ohm impedance offices. Such limitations involve consideration of office layouts, use of 22 gauge (instead of 24 gauge) wiring in transmission leads wherever possible, and provision of direct cabling (rather than cross-connections) between 4-wire terminating sets and intertoll trunk relay equipments. It is desirable to have the minimum length of office cabling both series and bridged, because, quite aside from balance considerations, the relatively high capacitance of office cables tends to cause transmission distortion on through switched connections.

3.07 The procedure for determining the values of C_1 and C_2 to obtain a good office balance in a 2-wire switching office is as follows:

(1) If the difference in the capacitance of the shortest and the longest cabling path through the switches (referring to Chart 4 this cabling is that of the two circuits between the switches and terminal equipment) is less than 0.015 mf, the adjustable capacitors C_1 across the compromise networks can be set to a value equal to the average of the shortest and the path through the switches and no capacitors C_2 are required. These capacitances should be measured by means of a suitable capacitance measuring bridge since there is appreciable variation in the capacitance of office cables even of the same type. Experience indicates that best results are obtained if a 2000-cycle tone is used for these measurements to minimize the effect of bridged inductances and series capacitances in the trunk circuits.

(2) If the difference in capacitance as measured in (1) above exceeds 0.015 mf it will be necessary to employ an adjustable C_2 capacitor on each intertoll trunk as shown in Chart 4. (In dial switching systems having several different paths through the switches this may require more than one capacitor per intertoll trunk.) When these capacitors are employed, the capacitance of each intertoll trunk is built out by means of the adjustable C_2 capacitor to be equal to the capacitance of the longest trunk in the office. The value of the capacitor C_1 is now made about equal to the sum of the value of the capacitance of two intertoll trunks. Its actual value is determined by connecting two trunks together and adjusting C_1 to give the maximum return loss at 2000 cycles. This value of capacitance will then be employed as the value of the C_1 capacitor in each terminating set in the office. The actual values of the C_2 capacitor adjustments are then obtained by connecting each intertoll trunk to a properly built out test drop and adjusting for best return loss at 2000 cycles.

3.08 After adjustment at 2000 cycles, measurements can be made at 1000 cycles or by using a noise generator properly weighted from an echo standpoint. If the average of this measured return loss for all the intertoll trunks connected to the test drop as above is equal to 27 db or better with a standard deviation for the distribution of 3 db or less, the 2-wire switching office may be considered to be equivalent to 4-wire switching from the transmission standpoint. If this degree of balance is not achieved, a "B" factor is assigned to the switching office. "B" factor is the additional loss assigned to each intertoll trunk terminating at a 2-wire switching office to provide the same echo performance as with 4-wire switching. In other words, there is a transmission penalty whenever switching is done on a 2-wire basis unless the office can be balanced properly and maintained in balance. The B factors are as follows:

Average Office Balance	B Factor (db)	Average Office Balance	B Factor (db)
27	0	19	.5
25	.1	17	.8
23	.2	15	1.2
21	.3	13	1.7

3.09 It is desirable to avoid the need of assigning a B factor since this adds loss in each switched connection and, if occurring at a number of offices on a connection, will increase the number of calls that would be unsatisfactory due to the over-all transmission loss being too high. Since the added loss represented by the B factor is assigned to each intertoll trunk, the switching penalty through an office requiring such assignment is equal to twice the value of the B factor.

3.10 This discussion has concerned itself primarily with balancing the office paths through the switches. There will be other paths for assistance traffic through associated switchboards which will also need to be taken into account in the office balance job. Techniques will depend on types of equipment, office layout, etc., but the same broad principles apply as for the paths through the switches.

4. DESIGN OF TERMINATING LINKS (TOLL CONNECTING TRUNKS)

4.01 Terminating links for the purposes of the following discussion are considered that group of trunks connecting the subscriber's local switching unit (Class 5 or End Office regardless of size, type, classification or relative geographical location) and the next higher ranking switching point. On Chart 3 they are represented as the group of trunks connected to the End Offices and always serve as the final link at each end of any intertoll connection. In the past this class of trunks has been called "Toll Connecting Trunks."

4.02 Under the distance dialing switching plan, as indicated on Chart 3, as many as nine or ten trunk links, including the terminating links at the ends, may be encountered on a call between two end offices. It is evident from this that if the multi-link connections are to provide good transmission service, all links must be designed and operated at as low a loss as is consistent with the transmission capabilities of the facilities involved. This is true even though few calls would encounter the maximum of ten links.

4.03 To achieve this, the present technique for designing the intermediate links (known as "via net loss" or VNL design) must also be applied to the terminating links. The basis for designing the intermediate (intertoll) links is discussed above in Part 2. The application of VNL design to the terminating links is discussed below.

(A) Design Objective (VNL + 2 DB) and Method

4.04 Where the intermediate (intertoll) links will terminate and switch at VNL, the design objective of the terminating links is the value of VNL + 2 db. For normal applications of carrier or voice-frequency loaded cable facilities, this loss will lie in the range of 2 to 4 db. Variations from this objective are discussed in Paragraph 4.12.

4.05 Via net loss (VNL) is the lowest loss in db, at which it is desirable to operate a trunk facility as an intermediate link (intertoll link), considering limitations of echo, crosstalk, noise, and singing. The via net loss is not a fixed figure but is determined by the type of facility and its length. Each type of facility has a loss factor proportional to its speed of propagation and its VNL is this factor times the length of the facility. Typical VNL factors are: for carrier facilities — about 0.002 db per mile; for loaded cable — about 0.04 db per mile; and for open wire — about 0.01 db per mile. Specific factors for various types of facilities are included in Table 3, Part 2. The stated objective assumes that the structural return loss of each trunk will be adequate and that sufficient repeaters are provided to give the specified performance. To the loss for each trunk determined by the product of the factor times length is added an average figure of 0.4 db to allow for the effect of operating several links in tandem. This is discussed in Paragraph 2.33.

4.06 As discussed above in the material relating to the development of the VNL factors (Paragraph 2.33), a minimum loss of 2 db is required at each terminal between the subscriber and the VNL point of the trunk. Previously, this 2 db has been supplied by the switching pad loss or an equivalent increase in the loss of the end link (see Chart 6). In the new design the switching pad will be omitted from its previous position in the intertoll trunks, and fixed pads (if required) will be associated with the toll connecting trunks as terminating links.

4.07 Where at least 2 db line loss exists in the terminating links, this will serve as the basic 2 db loss required by the VNL design providing that measures are adopted for improving return losses, as discussed later in Part 4. Where the actual facility loss of the terminating link is less than 2 db, a fixed 2 db pad will be added. This is discussed in Paragraph 4.13 and following.

4.08 The VNL + 2 db value will be determined for each toll connecting trunk based on the facilities to be used. The trunk will then be designed to operate at this value. Some examples of VNL + 2 db design are given in Chart 5.

4.09 Experience has indicated that with loading spacing accuracy of 2 to 3 per cent, repeatered voice-frequency terminal links should be stable (not sing) in the idle condition for VNL + 2 design. For H-88 loaded facilities the losses designed on this basis will range from about 2.5 to 3.5 db. Since a large number of these trunks will be associated with loop signaling facilities where no special incoming or outgoing trunk circuit is involved, it is expected that they can be operated satisfactorily without the provision of an idle circuit termination. With other types of signaling where a trunk circuit is provided, it is the custom to incorporate idle circuit termination in the trunk circuit design and this feature should be used where available. Operation of trunks at losses of lower than VNL + 2 will almost always require the use of idle circuit terminations which should be provided with the initial design.

4.10 Occasionally a terminating link proposed for operation without an idle circuit termination, may be found unstable at the VNL + 2 value because of some line irregularity or deficiency. Pending correction of the faulty condition, the trunk loss should be increased to the point of stability instead of operating the trunk with the known irregularities by the use of idle circuit terminations.

4.11 Toll connecting trunks also used as intermediate links, such as in present tandem CDO operation, are not considered terminating links (VNL + 2 db links), but should be designed as intermediate (intertoll) links at VNL only, usually requiring idle circuit terminations at one or both ends to keep the trunk from singing during its idle intervals. Where the tandem CDO is to be retained for an indefinite period it should be considered, from the transmission standpoint, a Class 4 office; and the office at which it homes should be considered a Class 3 office.

4.12 Under certain conditions it may be desirable or necessary at Class 4 offices to terminate the intermediate links at terminal net loss (TNL). Situations contributing to this condition would be: particular plant conditions which will not support adequate return loss performance; call distributions which would result in only a very limited benefit from a large expenditure; and, in some cases, single-channel operation where the transmission design is controlled by the routing and facilities associated with "assistance" calls rather than "long distance" calls. Where the intermediate links are switched at terminal net loss the terminating links may be operated, if conditions permit, at lower than VNL + 2 db. The only controlling factor in terminating links under these circumstances would be the singing limitations when the trunk is used to connect to subscribers at its own terminals.

(B) Omission of Switching Pads

Benefit of Pad Omission

4.13 Terminating links designed at VNL + 2 db, and coordinated with the VNL termination of the intermediate links result in a 4 db reduction in the trunk loss on over-all connections when the terminating links each have a facility loss of at least 2 db. This is illustrated in Chart 6.

4.14 Fig. A, Chart 6 shows an intertoll trunk arranged with conventional switching pads and designed for terminal net loss at the switches. As indicated in Chart 4 and discussed above in Part 3, when one intertoll trunk is connected to another, the pads are switched out of the connection. The 2 db or S pads, therefore, provide only a terminating function.

4.15 An inspection of losses associated with Fig. A, Chart 6 reveals an interesting condition, i.e., that 14 db of a maximum over-all loss shown of 15 db, is chargeable to the two terminations, only 1 db is contributed by the via net loss of the intertoll circuit. If further important improvement in over-all trunk losses is to be obtained, it must be realized by reducing the losses associated with terminating the call.

4.16 Fig. B, Chart 6 shows the arrangement for the terminating links when the intermediate links are arranged for VNL switching, that is, terminating directly on the switches without the 2 db switching pad or its equivalent. For purposes of design the terminating links at each end are classified in two groups; the first, those of less than 2 db loss in the line facility, and the second group, those having at least 2 db of facility loss.

4.17 The first group, those of less than 2 db facility loss, represent the trunks to offices in the same building or in the vicinity of the switching office. In such trunks a fixed 2 db pad will be used to offset the 2 db pad removed from the intertoll circuit. For this minimum or most favorable loss condition there has been no change in the transmission performance by transferring the 2 db pad from one side of the switches to the other.

4.18 On the second group of trunks, those having at least 2 db facility loss, it is proposed that the 2 db pad be omitted since the facility loss serves the purpose of the pad. Consequently, there is a net improvement of 2 db at each end and a total over-all reduction of 4 db in such connections.

4.19 In the second classification of trunks in Fig. B, Chart 6, while the omission of the 2 db has given a direct improvement in transmission, it has also resulted in a degradation of terminal return losses affecting both echo and singing margins by 4 db at each end. It is both desirable and necessary, therefore, that all practical measures which may restore any part of this 4 db degradation be adopted. The use of impedance compensators as indicated in Fig. B is one of the measures provided for this purpose. The theory and application of impedance compensators are discussed in Paragraphs 4.37 to 4.45. Terminal return loss of the local plant has been referred to in Part 2 above and the adverse effects of the pad omission are discussed in the following paragraphs.

Effect of Pad Omission on Terminal Return Losses

4.20 Terminal return losses affect both echo and singing conditions. Their magnitudes express the measure of similarity between the impedances of the trunk plant and that of a compromise impedance at the switches at the various frequencies. In the past these return losses have been applied at the terminal net loss point of the intertoll trunk, and in the over-all echo computations were augmented by a loss equal to twice that of the switching pad. If the over-all echo and singing conditions are to remain substantially unimpaired with the omission of the switching pad, means must be adopted for improving the low spots of the present distribution of return losses by at least 4 db.

4.21 While considerable emphasis has been given to echo return losses, it is important that those losses affecting the singing margins — both below and above the echo frequency range — not be overlooked. Frequency, both may be quite low and about equal in magnitude. A sizeable improvement engineered for one may have little or no effect on the other and, therefore, result in only a small improvement in over-all singing stability of the circuit. It may merely shift the singing to the other end of the frequency range.

4.22 When terminating links appear at the switching point with properly selected 4-wire terminating sets or hybrid coils not requiring additional repeating coils to derive signaling leads, the input impedance of this equipment is the same as that of the compromise network on the intertoll trunk. The return loss at both echo and singing frequencies resulting from such a combination should be relatively good and no need for improvement would be expected.

Echo Frequencies

4.23 The echo range is considered to extend between 500 and 2500 cycles and the return loss of a local plant combination would be the composite of the return losses over this range. In the determination of via net loss factors for design of intertoll circuits in Part 2 above, the echo return losses presented by the wide variety of terminating plant conditions to a compromise network were described as a distribution having an average of 11 db with a standard deviation of 3 db. The lower portion of this distribution presents the hazard to service from an echo standpoint. To offset the omission of the switching pad, it is important that steps be taken where possible to improve basic conditions directly reacting on the poorer cases.

4.24 In the broader picture it would, of course, be desirable to improve the over-all condition, either by reducing the standard deviation of the distribution, or by improving its average with the same standard deviation. Any corrective action which is both technically and economically practical, and which would effect such broad improvements should be considered for application.

4.25 Since the bulk of the terminating links involve loaded cable plant, which has low return losses against a compromise network at the upper frequencies, some of the desired 4 db can be restored over the upper section of the frequency range by the use of impedance compensators as described below under that heading.

Singing Frequencies – Below and Above the Echo Range

4.26 The lowest return losses, those that tend to cause singing, as a rule fall outside of the echo range. On the low frequency side they may be below 500 cycles, and on the high frequency side usually will be above 2500 cycles.

4.27 The poor return loss at the low frequencies, which may be as low as 2 to 3 db, usually results from the poor impedance characteristic of the repeating coil circuits at those frequencies. Past practice generally specified 4 mf capacitors in both the line and drop sides of repeating coils associated with the terminating links at the switching point. It was found that an improvement of as much as 6 db in return loss at 300 cycles could be obtained by the substitution of a 1 mf instead of the 4 mf capacitor on the drop side of certain of the commonly used repeating coils without appreciable effect on transmission. This modification has been adopted in the Bell System for all future applications of these repeating coils on toll connecting trunks.

4.28 The above arrangements apply specifically to types of apparatus normally used in the Bell System. It is an important consideration which needs to be checked for each type of trunk circuit likely to be encountered to determine what improvement in low frequency return losses can be obtained by a procedure similar to that of Paragraph 4.27.

4.29 At the high end of the frequency range very low return losses result from the extreme variation of the line impedance from the midband values as the facility approaches cutoff. The impedance compensator used for improvement in the echo range also gives some benefit to the singing margin at frequencies just below cutoff.

Switchboard Operator's Telephone Set

4.30 At the time VNL switching is adopted in a particular office, the switchboard operators will have access to the outgoing intermediate trunks at the VNL point and, consequently, also will be affected by the pad omission.

4.31 Normally the low frequency end of the operator's telephone set circuit produces a very poor return loss, and without benefit of the pad is approaching instability from a singing standpoint around 200 to 300 cycles. It is possible to improve this low frequency return loss, by about 6 db, by the addition of a 2 mf capacitor in series with the receiver in those operators' telephone set circuits installed without this capacitor.

4.32 On the average, operator talking volume is more than 2 db lower at the switchboard than that of the average subscriber on a zero connecting trunk. This fact coupled with the improvement in return loss derived from the 2 mf capacitor makes it possible to waive the requirement for a 2 db pad in the operator telephone circuit and thereby improves operator transmit and receive volumes about 2 db.

4.33 The above arrangements apply specifically to operators' telephone set circuits normally used in the Bell System. It is an important consideration which needs to be checked for each type of operator's telephone set circuit likely to be encountered to determine what improvement in low frequency return losses can be obtained by a procedure similar to that of Paragraph 4.31.

(C) Fixed 2 DB Pads

4.34 Generally, the 2 db fixed pads proposed for use in the local office trunks will be simple resistances arranged as a balanced H type, with a small capacitor also connected in the shunt branch. This capacitor is required to avoid a d-c path between the two wires of the line circuit and its capacitance is small to prevent excess distortion of d-c pulse signals transmitted over the trunk.

4.35 The pad should be located in or adjacent to the trunk circuit and should be of either 600 or 900 ohms impedance depending on the circuit into which it is connected and on its position with respect to the repeating coil if the repeating coil is not a 1:1 type. For some special types of trunk circuits it is impractical to use the conventional cross-connected pad because of the effect of the series resistance components on the signaling system. For such cases, a special arrangement of pad associated with the repeating coil and relay wiring is provided. This and other pad arrangements are shown in Chart 7.

4.36 In order to obtain maximum return loss benefit from the 2 db pad, it is desirable that, when the pad is required in the local trunks, it be installed preferably on the drop side of the repeating coil, corresponding to its present sequence in the transmission path. Frequently, signaling and circuit conditions control the application of this pad and the following is the order of preference from a transmission standpoint at which pads should be applied in the circuit. Referring to Chart 7, Figures A and B:

Transmission Order of Preference	Type of Pad-Figure	Side of Repeating Coil
1	A	Drop
2	A	Line
3	B	Drop
4	B	Line

(D) Impedance Compensation

4.37 Compensated loading, or impedance compensation, is an artifice to make the sending end impedance of a loaded cable pair remain substantially uniform and predominately resistive in the frequency range from about 1000 cycles up to about 0.85 of its cutoff frequency.

4.38 It is common practice to use half section termination for loaded pairs at the switching point. The impedance characteristic of a loaded pair at half end section has a resistance component (which increases with frequency) but a very small negative reactance component. The compromise network in the terminating intertoll circuit has a fixed resistance which retains the same magnitude at all frequencies. In the past, a suitable ratio repeating coil has been selected based on the nominal 1000-cycle impedance of the local plant and the nominal value of the compromise network. As a result, at 1000 cycles, the return loss of the compromise network against the toll connecting trunks is good, frequently in the order of 20 db.

4.39 However, since the resistance component of the trunk impedance increases with frequency, the return loss against the same fixed value of the compromise network deteriorates with increasing frequency, the extent depending on the cutoff frequency of the loading system. With H-88 loading, the 3000-cycle return loss is in the order of 9 db. To substantially improve this return loss it is, therefore, necessary to do something to the cable pair which will keep its impedance from changing importantly over the frequency range from the 1000-cycle magnitude for which the basic impedance ratios were selected. The impedance compensator does this.

4.40 The compensator proposed for this work is a simple circuit arrangement consisting of a bridged multi-unit capacitor and a series 44 mh inductance coil connected as shown in Chart 8. The capacitor is used to build out the loading end section of the cable to approximately 0.8 section, for which the resistance component of the impedance is substantially uniform over the frequency range up to a high fraction of the cutoff frequency and the reactive component becomes increasingly negative with frequency. Since an inductance has a positive reactance proportional to frequency, the addition of a coil of suitable magnitude at this point in the loading end section tends to cancel the negative reactance over the frequency range in question resulting in an impedance substantially resistive and of fairly uniform value between 1000 cycles and a frequency corresponding to about 0.85 cutoff.

4.41 The multi-unit capacitor should be located adjacent to the cable pair so that it will directly augment the cable pair capacitance. The compensator normally will be cross-connected between the MDF and the incoming or outgoing trunk circuit, or the switches if no trunk circuit is provided.

4.42 The compensators should be provided on all loading systems having cutoffs equivalent to or less than that of H-88 loading on exchange type cable (approximately 3500 cycles). This includes H88, H135, H175, and B135 of the loading systems now generally in plant. It excludes (1) B88, D88, and H44 loading systems; (2) H88-50 on quadded cables; and (3) open wire entrance loading, since the higher the cutoff of a loading system the less the 3000-cycle impedance departs from the nominal 1000-cycle value.

4.43 On loading systems with cutoffs below 3000 cycles, such as H135 and H175, it will be necessary to augment the compensator with a high frequency adjunct which will hold the impedance of the circuit down to a reasonable value as it passes through the cutoff frequency. This is done by using 2000 ohms in series with the multi-unit capacitor of the impedance compensator.

4.44 A compensator is not required on any toll connecting trunk terminating at the switching office with a hybrid coil or a terminating set such as on a carrier system or V-type repeater terminating a voice-frequency circuit for the same reason given in Paragraph 4.22.

4.45 The use of a terminal ET repeater (Western Electric designation for a negative impedance type repeater using both series and shunt units) at the switching office end of a terminating link will not change the need for an impedance compensator if it is required by the type of trunk facility. The ET repeater will have the effect of adding capacitance in the loading end-section which will reduce the build-out value of the capacitor in the impedance compensator. (This effect is approximately equal to 0.05 loading section per db of gain in an H-88 circuit.) Better return loss results are obtained in most instances by locating the ET repeaters away from the switching office, preferably at the distant Class 5 office or at an intermediate point, if available. Where design conditions permit and the cost differential is not great, the preferable location should be adopted. Where V-type repeaters are used, the assignment guides discussed in Paragraph 2.37 should be followed.

(E) Drop Building Out

4.46 Occasions may arise where some important advantage may be obtained by adding a drop building out capacitor to the terminating links. This would occur in offices where office drop balancing has been applied to the intertoll trunks and a large value of capacitance has been added to the compromise networks due to long central office cable runs, as discussed in Part 3 and shown in Chart 4.

4.47 In Chart 4 the magnitude of C_1 usually is equal to about the sum of the capacitance of the cable pair plus C_2 of both drops since, as shown, there are two C_2 quantities modifying the input impedance of the other hybrid coil for the condition of intertoll switching. However, when either intertoll trunk is switched to a toll connecting trunk which may have considerably less office wiring and multiple, and no drop building out, the magnitude of C_1 may be too great for the condition encountered and a low return loss may result at the higher frequencies. This can be corrected by the use of a drop building out capacitor on the toll connecting trunks adjusted to make up the deficiency of capacitance for which C_1 was adjusted.

(F) Office Impedances

4.48 An office impedance, when designated, permits the selection of suitable ratio repeating coils so that at the point of switching a common impedance is presented by all facilities to the switches. This matching of impedances is necessary at toll offices to obtain the desired return loss conditions. At local offices when coils are required for signaling purposes, the use of the optimum ratio will substantially eliminate any reflection loss which would result from dissimilar impedances.

4.49 Traditionally, the toll office impedance has been 600 ohms and the local office impedance (that is, the average of the impedances looking into the distribution of subscriber loops) has been 900 ohms. At toll offices all intertoll circuits and all toll connecting trunks have been brought to a common impedance of 600 ohms. At local offices all incoming and outgoing trunk circuits having repeating coils have been arranged to terminate on the subscriber side at a 900-ohm impedance.

4.50 With the advent of crossbar tandem, which has no repeating coil on the outgoing trunk circuits, the impedance at the switches of the crossbar tandem was selected as that representative of the type of facility used in the outgoing trunk. In the majority of metropolitan areas the facility used in outgoing trunks is expected to be H-88 and the nominal value of 900 ohms has been selected as the switching impedance of crossbar tandem.

4.51 With the exception of a few isolated cases, the following summarizes the nominal switching impedances currently used in the Bell System:

Local offices	900 ohms	No. 5 crossbar - toll	600 ohms*
Manual toll offices	600 ohms	No. 4 type toll crossbar	600 ohms
Step-by-step intertoll	600 ohms	Crossbar tandem	900 ohms
No. 5 Crossbar - local	900 ohms		

*A 900-ohm arrangement somewhat similar to the crossbar tandem system discussed above is being considered for possible ultimate use for CAMA applications to this system. The initial CAMA trunks will have 600 ohms impedance.

5. SUBSCRIBER LOOP PLANT DESIGN

5.01 The loop between the subscriber's telephone set and the local central office is always the first (and the last) link in any telephone connection. Satisfactory transmission design of this loop is as important to the distance dialing plan as is the design of intermediate links (intertoll trunks) and terminal links (toll connecting trunks).

5.02 With the best telephone sets formerly available, it was the practice in design to assign to each operating center a transmission value known as a loop limit, or toll terminal loss in a single office area, which defined the maximum permissible loss for any loop in the office.

5.03 The improved telephone set (Western Electric 500-type or equivalent) has permitted extension of the subscriber loop range and simplification of loop plant design methods. With the improved transmission performance of the new set, the controlling limitation on subscriber loops is no longer the loss on the loop but is now the conductor resistance ranges set by supervision and pulsing limitations. The revised (and simplified) subscriber loop plant design method has consequently been termed "resistance design."

5.04 Resistance design is applied by use of the following simple guides:

(1) Select the most economical gauge or combination of gauges permitted by the conductor resistance range of the central office.

(2) Use 500-type sets or equivalent where needed. (Generally justified economically on cable loops over 10,000 feet.)

(3) Apply proper loading to cable portion of all loops which extend beyond a selected distance, usually about 18,000 feet.

(4) Limit the length of bridged cable in total to about 6000 feet. For addition discussion see Reference No. 48 in Bibliography, Section VIII of these Notes.

5.05 The choice of gauge depends only on the total cable resistance. Detailed knowledge of the transmission art is not required, yet if the procedures are followed the transmission results will be good. Hence, loop design can, in general, be performed by field engineers.

5.06 The gauge of cable placed in the subscriber loop plant will automatically be the cheapest for the permissible conductor resistance gauge. The resulting transmission using 500-type sets or equivalent and loop loading as specified will be better on the average than under the previous complex procedure employing the sets that were available before the advent of the new sets.

5.07 Application of the resistance design principles offers the following advantages:

(1) Better transmission,

(2) Simplified engineering and time saving, and

(3) Important economies.

Resistance design has been adopted as standard for subscriber loop plant design by the Bell System. It also appears that this method could be applied industry-wide with the same advantages. Loop plant for offices currently magneto should be designed in anticipation of conversion to dial operation.

6. METHOD OF RATING TRANSMISSION PERFORMANCE

6.01 The present system for rating loops and over-all transmission losses, known as "the effective transmission basis," is geared to a particular working reference condition. Since its establishment many years ago, the numerical quantities now associated with loop plant have changed due to transmission improvements until many are now expressed as negative numbers. The negative numbers associated with an effective transmission rating in no sense imply an objective gain.

6.02 A laboratory version of a new transmission measuring system, currently identified as the "Electro-Acoustic Transmission Measuring System," is now being used to obtain objective ratings of loops and over-all connections. This system provides a true insertion loss measurement by determining the relationship between the speech pressure at the transmitter and that produced by the distant receiver in a coupler equivalent to the ear. Equal pressures represent 0 db transmission loss of the over-all system; greater received pressures are true gains; and lower pressures are true losses.

6.03 With the new measuring system it will be possible to establish a reasonably accurate objective rating for the transmitting and receiving performances of loops and sets. These, when available, can be added directly to the trunk losses for the determination of a single value for the over-all objective transmission rating.

6.04 It seems desirable, therefore, that until the new objective ratings can be established for loops, the over-all transmission rating of any call be expressed only in terms of the sum of the thousand cycle losses of the trunks between the end (Class 5) offices. In the meantime, where the subscriber loop plant is based on the resistance design basis (see Part 5) a satisfactory distribution of loop losses and an adequate inherent performance should result.

6.05 Simple light-weight equipment is contemplated for obtaining transmission performance measurements on loops and instruments, and for other maintenance work. Development work will be undertaken along these lines as soon as practicable.

7. MAINTENANCE CONSIDERATIONS — INTERTOLL TRUNKS

7.01 In dealing with transmission maintenance, it is necessary to:

(1) Know what the problem is,

(2) Know that when an adjustment is called for, the right adjustment is made to eliminate the cause rather than to correct only a symptom of the trouble, and

(3) Be able to evaluate the results.

What the Problem Is

7.02 A deviation of one db of excess loss or gain from the design value is as serious in the operation of the trunk plant as an error of the same magnitude would be in the design value itself.

7.03 Maintenance requirements for intertoll trunks are becoming more complex because of the following:

(a) Operator and direct distance dialing on intertoll calls.

(b) Increased use of multi-link switching, and

(c) Automatic alternate routing.

7.04 In fact, the maintenance problem becomes more and more serious with the realization of each successive step of the following phases of the distance dialing program:

(1) Operator distance dialing on intertoll trunks: For most calls the operator does not have to talk on or listen on the connection — instead she watches her lamp supervision. The operator, therefore, has lost the necessity to talk over the connection and with it the opportunity to exercise judgment as to whether transmission is unsatisfactory. Hence the operator

is not conscious of customer difficulties until the customer makes a complaint. The machine picks the first idle trunk in the routing pattern whether or not that trunk is suitable transmissionwise. Formerly, in many cases the operator could avoid specific trunks or connections which experience taught her were unsatisfactory and often she could identify the trunk for testboard action. With operator distance dialing, if it is necessary to re-establish the call, the facilities used in the original connection which experienced trouble must be released and no direct investigation of the original connection by the testboard is practicable.

(2) Automatic alternate routing of switched connections: This type of operation is spreading through the country rapidly. Multi-switched connections are more frequent and the number of switches permissible is greater than was permitted under manual operation. Unless the loss variations in individual trunk links are kept small they combine too often in multi-switched connections producing unsatisfactory conditions. Testboard identification of troubles is difficult between the calling end and the first switch and is impracticable beyond that point with currently available techniques.

(3) Direct distance dialing over the intertoll network: No operator is involved in the connection — hence, to get an unsatisfactory condition corrected, the customer must release the intertoll facility in order to report the poor transmission or request assistance. Testboard identification of the trouble then becomes nearly impossible.

When an Adjustment is Called For

7.05 With manual intertoll trunk operation and with the relatively small amount of multi-switched connections used under this type of operation, tolerances for net loss variations were somewhat generous.

Even when these were exceeded somewhat service did not fall apart. In addition to the fact that most connections were direct or single-switched connections, this can be at tributed in part of the ability of the operator to eliminate serious cases while establishing the connection.

Maintenance requirements were on a go-no-go basis of limits. These limits were based partly on design tolerances and partly on the results of actual experience with maintaining the facilities. Thus it was assumed that not over about 8 per cent of the measurements could be expected to exceed the limits without indicating the presence of troubles.

7.06 Under dial operation such maintenance criteria become inadequate.

The very idea of a limit is that a trunk which is at or just under that limit is as good as one which is right at the specified value. This produces a tendency for trunk losses to hover around the limits, rather than to be pulled back to operate around their assigned values.

7.07 By the laws of probability, the effect on net loss variations of adding more links to any given connection varies directly as the square root of the number of links involved, assuming other variables to be present in the same degree.

A connection with four links may be expected to have variations twice as bad as a direct connection. This is true if the tendency to vary from the specified (design) value is the same on all links. This is not compensated for by design arrangements, switching pads or otherwise, which are used merely to equalize the design losses under the various types of connection and are not effective in correcting for variations.

7.08 The judgment as to whether trunk maintenance is adequate or not under dial operation, therefore, must be based on criteria which are easily obtained from mass statistical analyses of the trunk net loss deviations from their specified values, i.e., criteria which give a picture of the trunk stability.

This assumes, of course, that design considerations and plant adjustments are adequate to secure stability with time in the individual trunks. A discussion of the mass statistical analysis of data is covered in subsequent paragraphs.

Why Curing Causes and Not Just Symptoms is Important

7.09 An illustration may be given of how easily maladjustments may cure symptoms and not clear causes.

Assume that one of the components of a trunk is a carrier system and that the trunk develops a trouble which increases the over-all loss by 2 db. A quick corrective is to call the receiving terminal of the carrier system and request 2 db more gain obtained by means of a demodulator potentiometer adjustment. However, this may make the receiving transmission level wrong. The trouble may be at some intermediate point in the transmission path, or in the pilot levels or in some other terminal component needing correction. A check should first have been made of all of these items to determine the real trouble. If this is not done, when the real trouble cleared of itself or was discovered and cleared later, the maladjustment of the demodulator potentiometer would create a new trouble which would then show up as too much gain.

How Results Can Be Evaluated

7.10 Factors that cause intertoll trunk variations are of two types, i.e., (a) purely random variations and (b) maladjustments or other troubles. The objective of good maintenance practices is to eliminate all variations due to assignable causes and leave only those which are random departures from design values.

7.11 This fact makes it possible to appraise how good a job of maintenance is being accomplished by an examination of:

(1) How nearly the results approach a true random condition, and

(2) How narrow the pattern spread is and how will it center on the specified (design) value.

The advantage of this approach is that it can be expressed in numbers which give a rating to the grade of that maintenance.

7.12 The first thing to be known about the results of trunk tests is the average departure of the measurements of that group from their specified values.

The average departure may be plus or minus, i.e., long or short. This average may be considered as a "bias" that applies to the group of trunks at the particular time of the measurements. This bias then is one number that gives a rating to the grade of maintenance on the given group of trunks and is expressed in db.

7.13 Another thing that should be known about a given group of trunks is how the measurements spread out from the average or bias value applying to that group.

If all of the variations are random, they would be grouped about as shown in Chart 9 when plotted on a uniform scale of number of measurements vs. departures. Under these conditions approximately 65 to 70 per cent of the transmission measurements would lie within an area of departures from their specified values 2 "d" wide and centered about the average of the whole group. Also about 93 to 97 per cent of those measurements would lie within an area 4 "d" wide and centered about the average of the group. The number of db represented by "d", then, gives a rating to the spread of the measured values and is called the "distribution grade" of that particular group of measurements.

Note: The term distribution grade used in this instance is synonymous with the term "standard deviation" discussed in Paragraph 2.12.

7.14 Both bias and distribution grade may be computed quite simply. The methods are given in Chart 10.

The Requirements for Bias and Distribution Grade

7.15 Under manual operation it is doubtful whether a distribution grade much better than 2 db and often not as good as that was being obtained under the former "limit" type of maintenance.

On the basis of a 2 db distribution grade and with a 4-link connection, some 2 or 3 per cent of the connections would be expected to be 8 db or more longer than they should be and some 2 or 3 per cent of the connections would be expected to be 8 db or more shorter than they should be. Furthermore, some 16 per cent of the connections would be expected to be 4 db or more longer than they should be and another 16 per cent would be expected to be about 4 db shorter than they should be. With a 7-link connection these db departures would be about 35 per cent greater. In addition, the individual bias values of multi-link connections add directly on an algebraic basis. Under the former "limit" type of maintenance, biases tended to be plus (long) and many of them exceeded 1 db. Accordingly, with this former type of maintenance there would be still further tendency for multi-link connections to have too large net losses. Practicable methods of keeping bias small are some of the most troublesome problems we have to face in maintaining trunks near their specified (design) values.

7.16 For nationwide intertoll dial operation such variations would not give good service and such distribution grades, therefore, need to be cut at least in half and biases have to be reduced.

Based on this, via and common grade intertoll trunks with electronic equipment have the maintenance objective of about 1.0 db distribution grade. Purely terminal grade repeatered or carrier equipped trunks, however, probably can be permitted a distribution grade of about 1.8. Based also on this, via and common grade trunks should have a bias objective of not over ± 1/4 db. On purely terminal grade repeatered or carrier equipped trunks a bias of about ± 1/2 db probably can be permitted.

8. MAINTENANCE CONSIDERATIONS — TERMINATING LINKS

8.01 In the nationwide switching plan with the design of intermediate links at via net loss, it appears that the terminating links (toll connecting trunks) may be designed at VNL + 2 db, and still provide adequate echo, singing and crosstalk margins for the built-up connections.

8.02 In order to be able to operate these links at VNL + 2 db, it is important that both line-up and routine maintenance tests be made to insure that the following are at or near their expected values.

(a) Over-all net loss

(b) Echo return loss (at the toll end)

(c) Singing point (at the toll end)

8.03 In view of the large numbers of terminating links, transmission tests are made using dial test lines whenever possible, with only one testman whenever possible. In order to do this, the following equipment is necessary.

(a) Dial one milliwatt test lines at both local and toll offices.

(b) Balance test lines (900 ohms termination) at both local and toll offices.

(c) Oscillators and transmission measuring sets at the toll offices.

(d) Singing point test sets and test hybrids at the toll offices.

8.04 The over-all net loss of a terminating link is usually measured at 1000 cycles. The tester at the originating end of the trunk dials the milliwatt test line at the distant office and measures the loss with a transmission measuring set. The net loss is usually measured when the circuit is first installed, and at periodic intervals, depending upon the type of transmission system on the trunk. Typical intervals are as follows:

Carrier - 3 months

V.F. Repeatered - 6 months

Non-Repeatered - optional

8.05 Equivalent 4-wire circuits (carrier or hybrid type voice repeater) must be measured in both directions of transmission. Original line-up is usually done with a tester at each end of the trunk. Routine one-man two-way net loss measurements may be made in either of two ways.

(a) Using a "loop-around" procedure measuing out on one circuit and back on a second.

(b) Making manually-dialed use of far end transmission test equipment (such as that used for Code 104 in intertoll testing) where available at the toll office, and where suitable seizing, dialing, and measuring arrangements are available at the originating office.

8.06 Return loss and singing point measurements are made on terminating links at the toll office with the trunk terminated in 900 ohms at the local office and with any repeaters at their normal gains. A test hybrid with a 900-ohm network is used. Three types of measurements are commonly made when a trunk group is put into service.

(a) The impedance compensators are adjusted by means of a single frequency (2000 cycles) return loss.

(b) An echo return loss measurement, using a thermal noise generator as a source, is made on each circuit.

(c) A singing point measurement is made on each circuit.

8.07 Individual circuit singing points and echo return losses will have quite a broad range, due to the wide variety of impedances which are being balanced against 900 ohms. In general, in order to support VNL switching to the terminating links, average echo return loss and singing point values at least as high as shown below should be measured at the toll office. These values are for measurements made with the trunk terminated at the local office with 900 ohms.

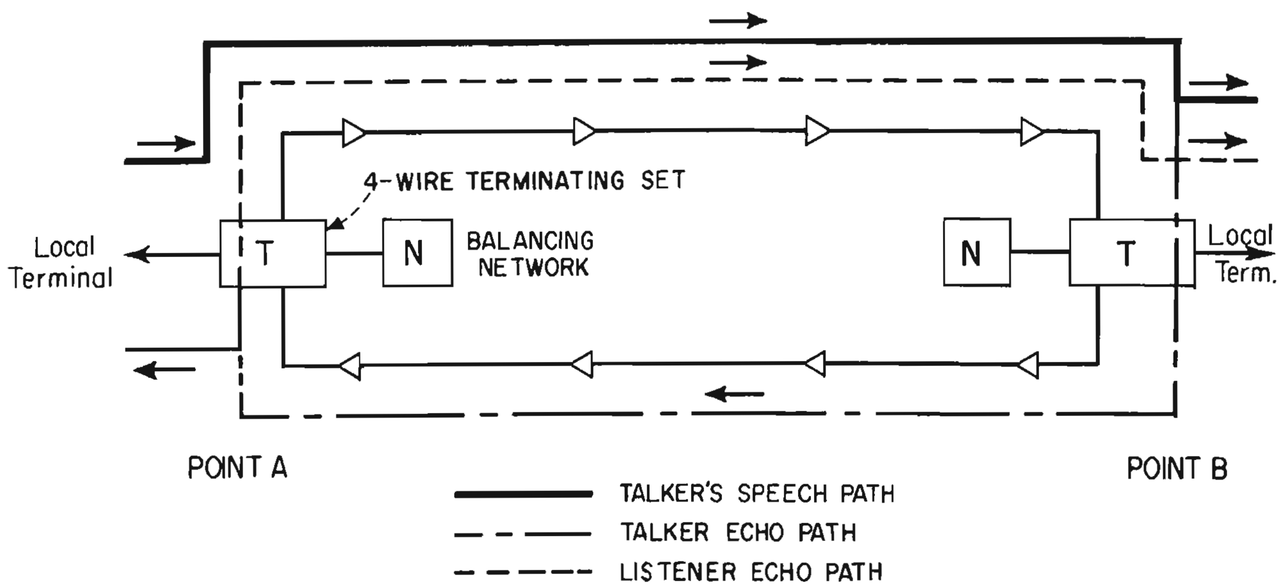
	Average	Standard Deviation
Echo Return Loss	18 db	2.5 db
Singing Point	10 db	2.0 db

8.08 If the above average echo return loss of 18 db is obtained under test, it is expected that the design echo return loss of 15 db (standard deviation of 3 db) will be met under service conditions with actual subscriber loop terminations.

Attached:

Charts 1 through 10

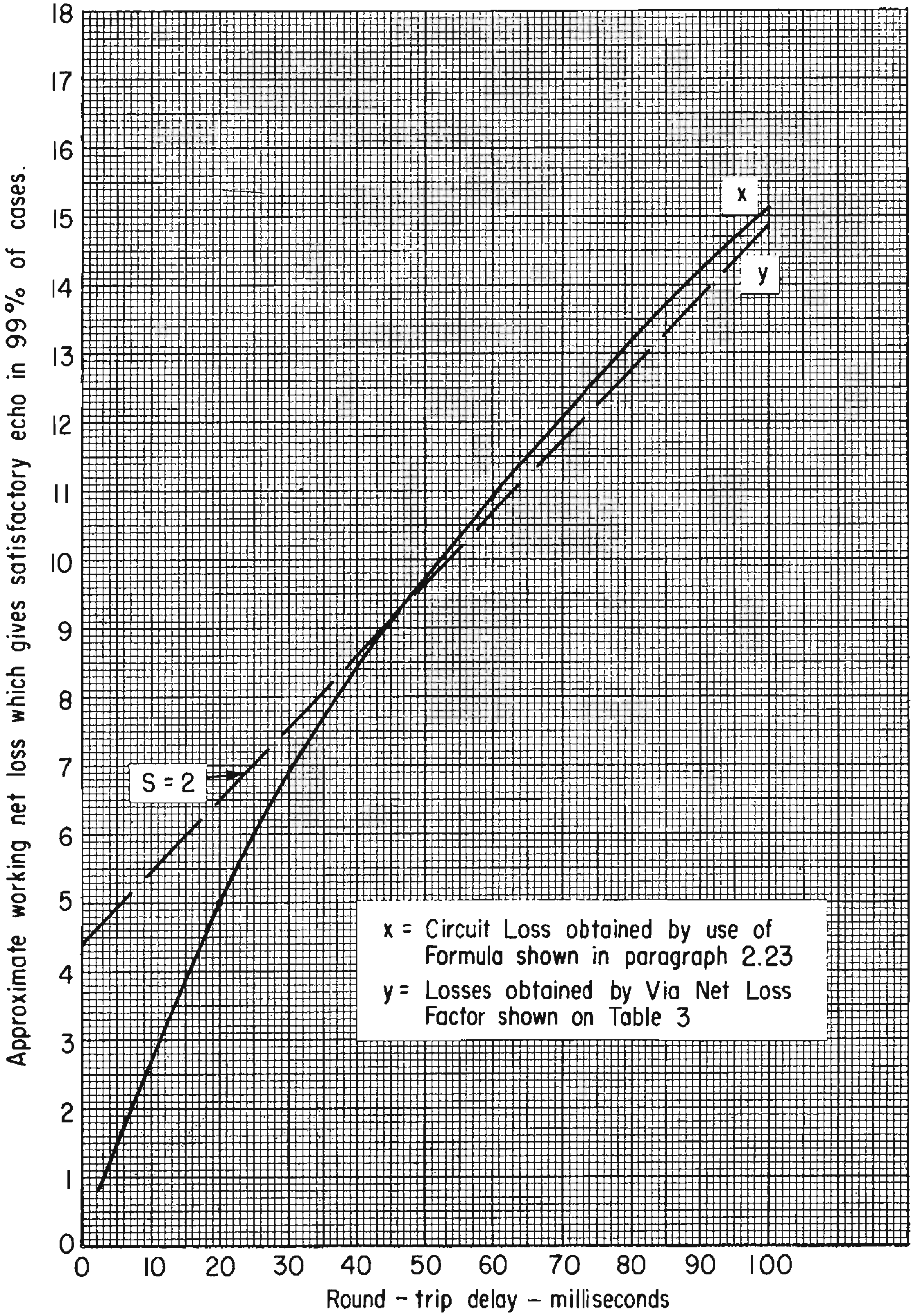
ECHO PATHS



Notes.

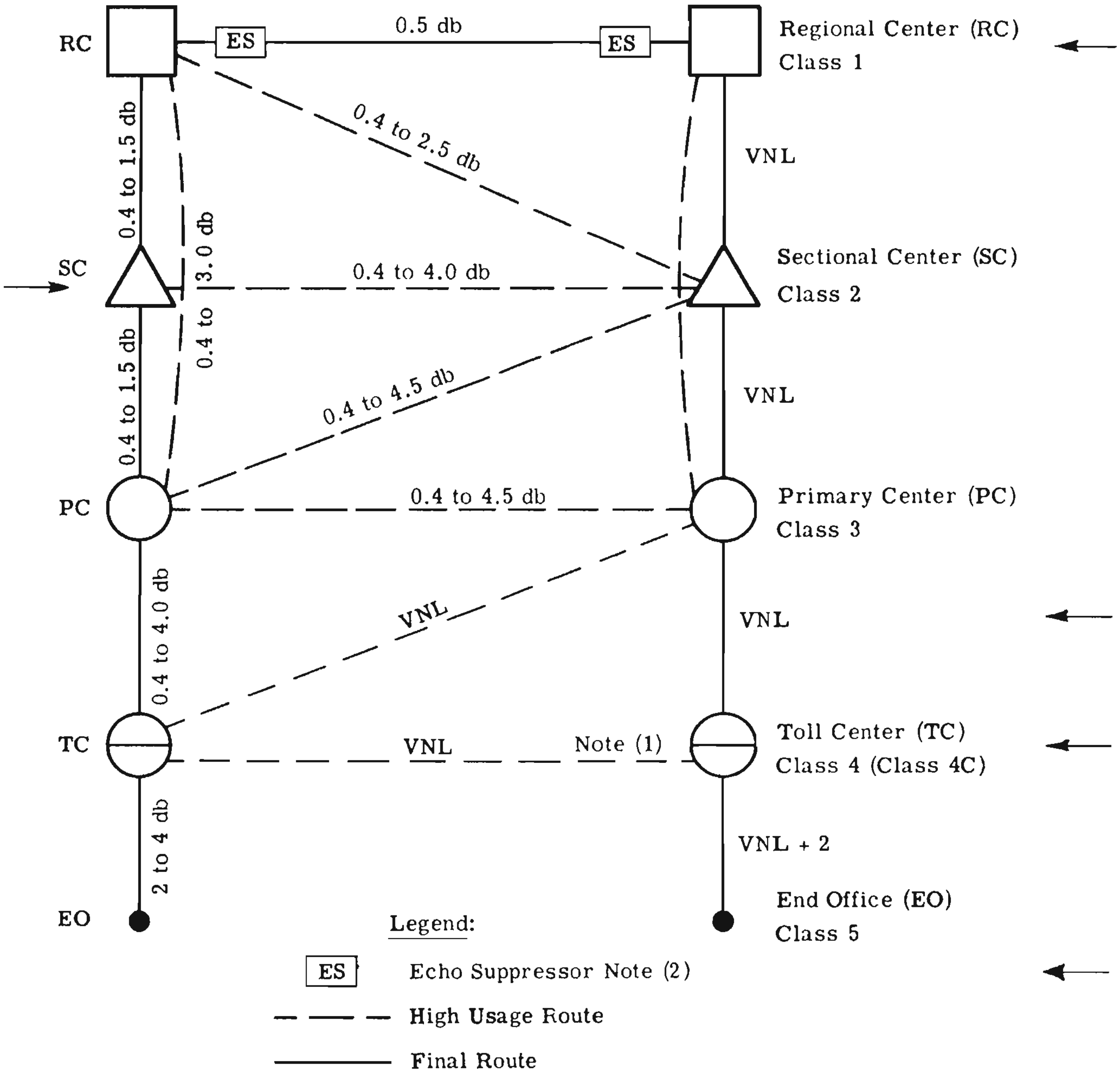
1. ▷ = Repeater
2. Hybrid Arrangements are a part of the 4-wire terminating set

APPROXIMATE RELATIONSHIP BETWEEN ROUND-TRIP DELAY AND PERMISSIBLE WORKING ONE-WAY LOSS FOR AN INTERTOLL TRUNK FROM ECHO STANDPOINT FOR 4-WIRE CIRCUITS AND 4-WIRE SWITCHING.



S is the loss inserted in the terminating connection

DISTANCE DIALING
RANGE OF VIA NET LOSS (VNL)



Note (1) Also  Toll Point (TP)
Class 4 (Class 4P)

Note (2) Disabled in one direction of transmission

TYPICAL CONNECTIONS OF TWO INTERTOLL TRUNKS AT A 2-WIRE SWITCHING OFFICE

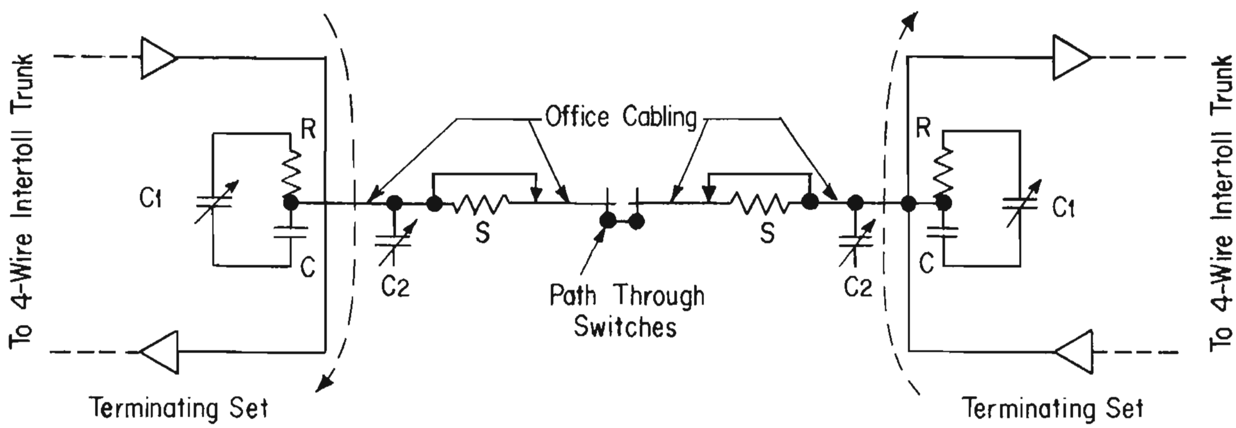


Fig. A– Switching Pads Employed

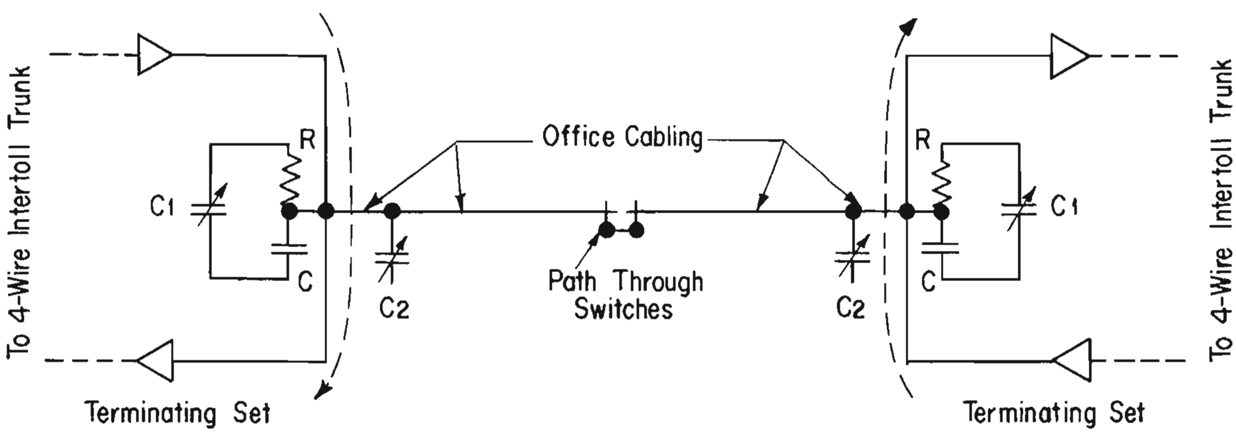


Fig. B– No Switching Pads Employed

Legend:

R = Resistor } Parts of balancing
C = Capacitor } (compromise) network
C1 = Capacitor } of terminating set
C2 = Capacitor in trunk circuit
S = Switching Pad
▷ = Repeater

EXAMPLES OF VNL + 2 DB DESIGN FOR TOLL CONNECTING TRUNKS

Example 1: 10-mile H88 Cable Circuit

Actual Loss:	
(10 miles x 0.42 db/mile) + (2 x 0.5 db/coil) =	5.2 db
VNL + 2 db Loss:	
(10 miles x 0.04 db/mile) + 0.4 db maint. + 2.0 db =	2.8 db
Required Repeater Gain =	2.4 db

Example 2: 25-Mile Carrier Circuit

Actual Loss (Adjustable - No specific value)	
VNL + 2 db Loss:	
(30 miles x 0.0019 db/mile + 0.4 db maint. + 2.0 db =	2.5 db
The carrier channel would be lined up to	2.5 db

Example 3: 50 Miles of Open Wire including 1 mile of incidental entrance cables

Actual Loss:		
49 miles x 0.076 db/mile	= 3.8 db	
1 mile x 1.2 db/mile	= 1.2	
2 coils x 0.5 db	= 1.0	
	Total	6.0 db
VNL + 2 db Loss		
(50 miles x 0.01 db/mile) + 0.4 db + 2.0 db =		2.9 db
Required Repeater Gain =		3.1 db

Example 4: 13 Miles of 19H44 and a 14-mile M1A Carrier on 104 Wire

Actual Loss:		
13 miles x 0.5 db/mile	= 6.5 db	
1 coil x 0.5 db	= 0.5	
14 miles M1A System	= 1.0 (min. loss)	
	Total (Actual)	8.0 db
VNL + 2 db Loss:		
13 miles x 0.03	= 0.4 db	
14 miles x 0.002	= 0.1	
Maint. variation	= 0.4	
Term. loss	= 2.0	
	Total (VNL + 2)	2.9 db
Required Repeater Gain		5.1 db

BENEFIT OF TRANSFERRING PADS FROM INTERTOLL TO CONNECTING TRUNKS

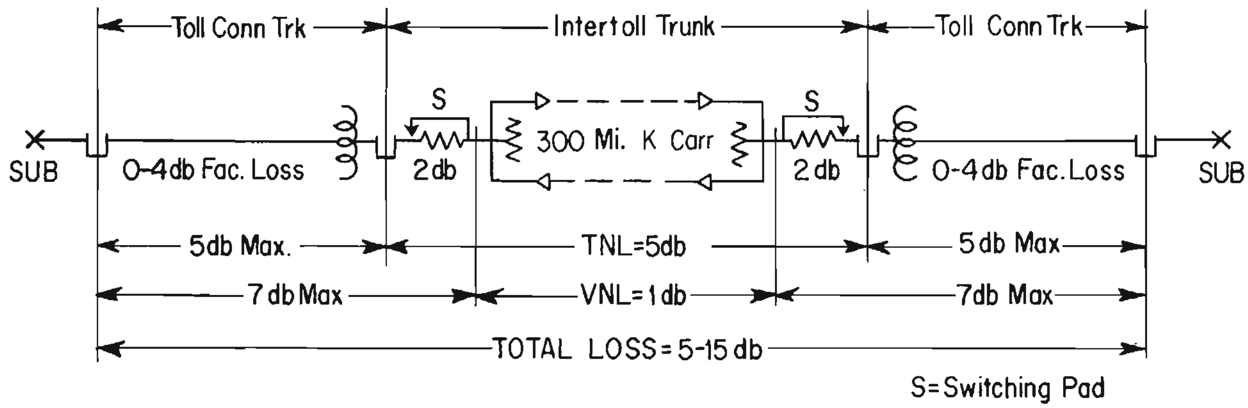


Fig. A – Intertoll Trunks Terminated at Terminal Net Loss

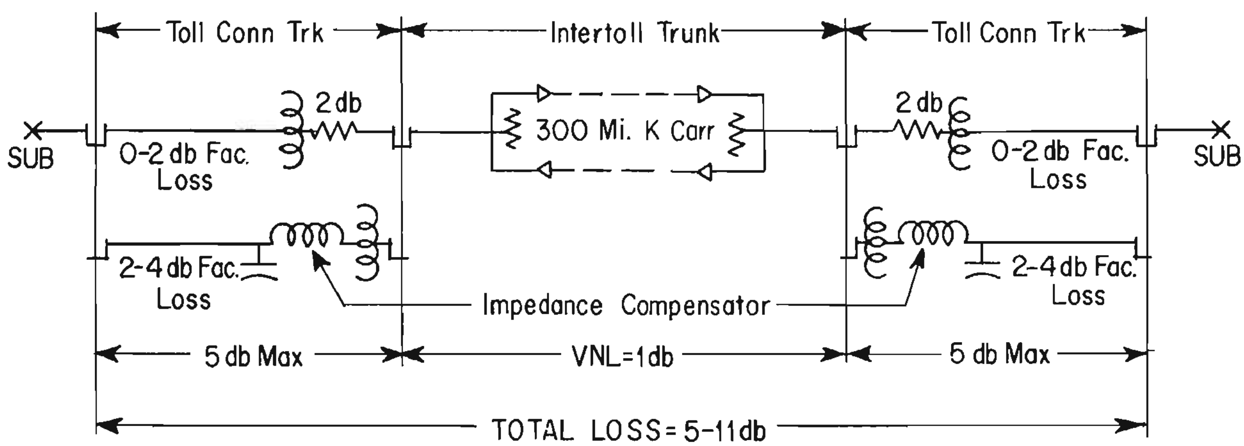


Fig. B – Intertoll Trunks Terminated at Via Net Loss

FIXED 2 DB PAD ARRANGEMENTS

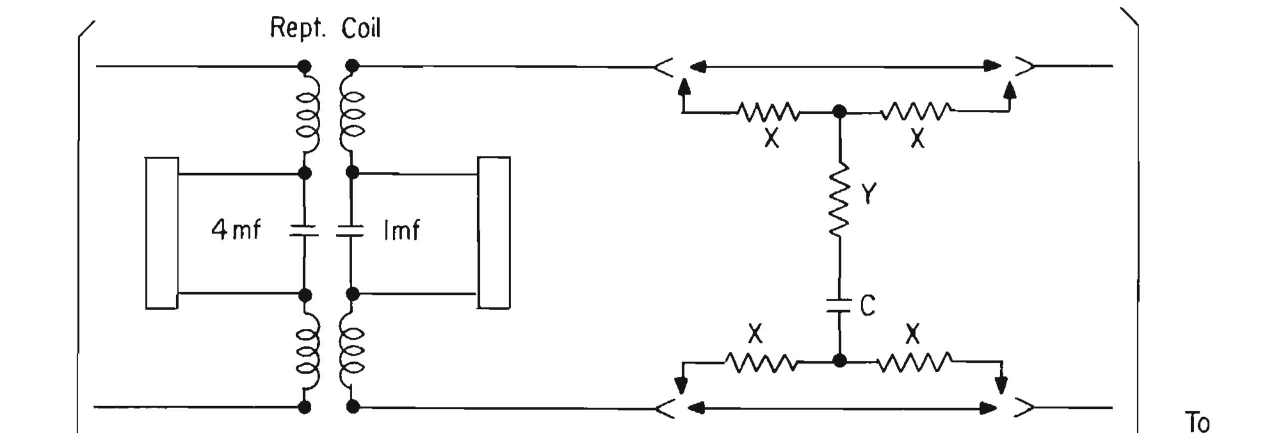


Fig. A 2 db Pad on Drop Side - Cross Connected Arrangement

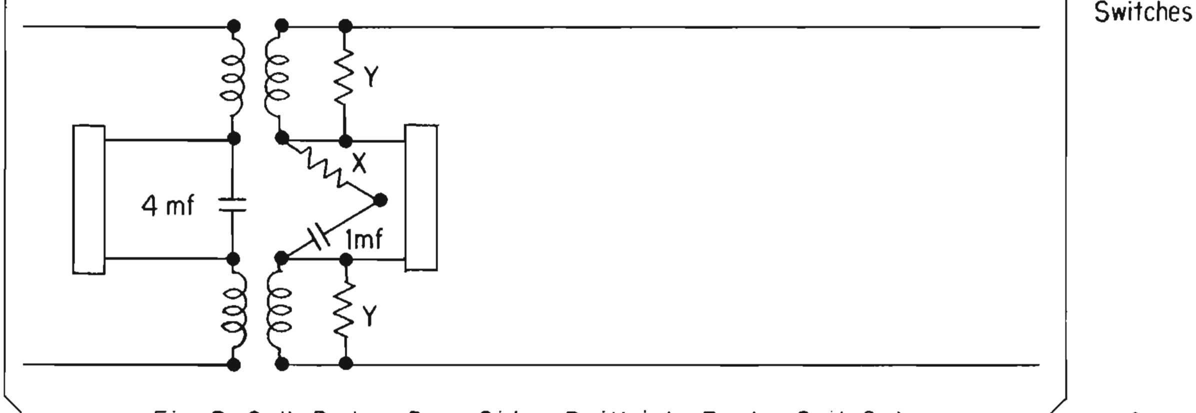
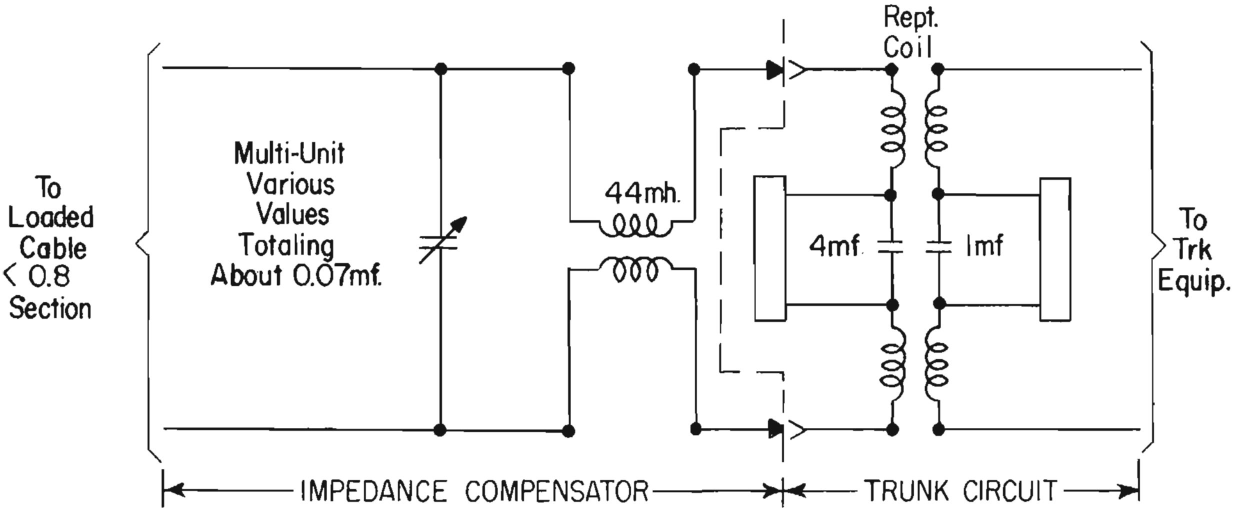


Fig. B 2 db Pad on Drop Side - Built into Reptg. Coil Cct.

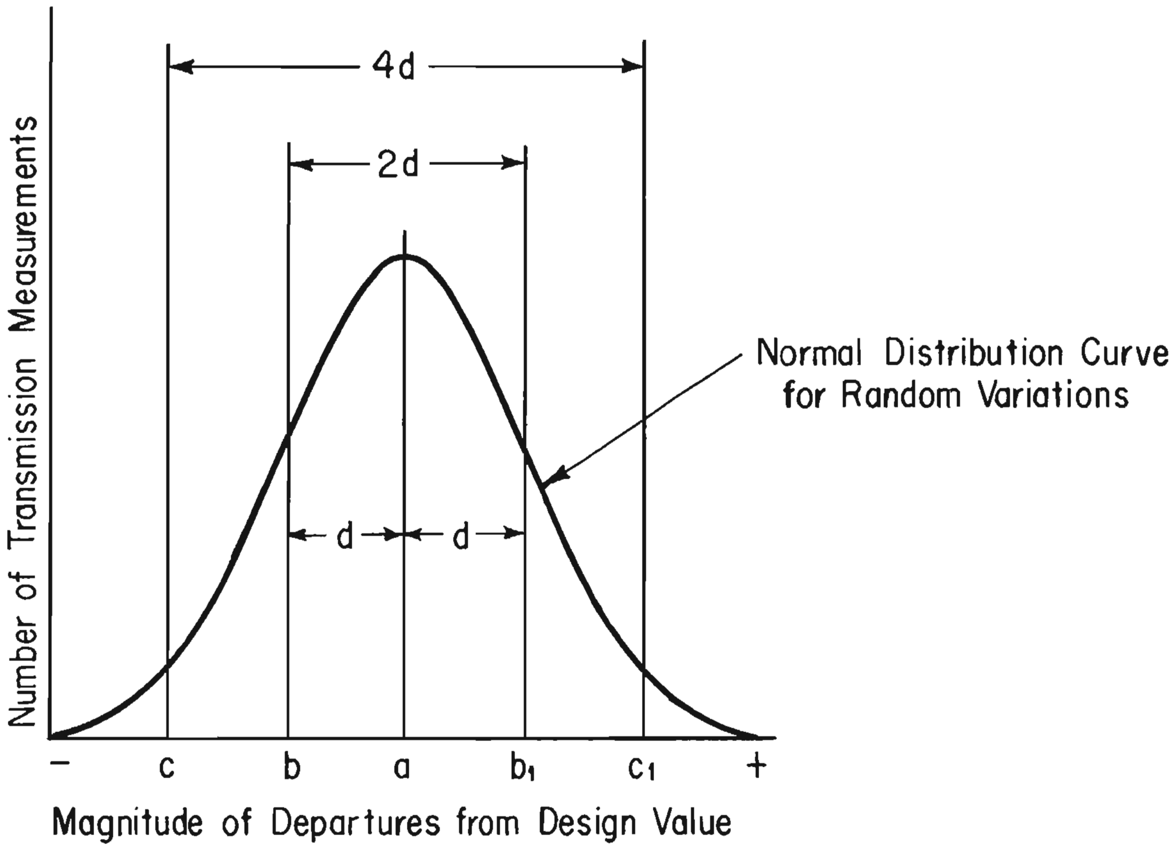
DESIGN VALUES FOR PADS

Fig.	Imped.	Resist. Ohms (± 2%) X	Resist. Ohms (± 2%) Y	C - mf (± 10%)
A	600ω	34	2560	0.25
	900	51	3855	0.25
B	600	123	1160	1.0 Assoc. with Rept. Coil
	900	185	1740	1.0 Assoc. with Rept. Coil

ARRANGEMENTS SHOWING APPLICATION OF IMPEDANCE COMPENSATOR



DISTRIBUTION GRADE FOR RANDOM VARIATION OF INTERTOLL TRUNK TRANSMISSION



a = Specified or design value of transmission measurement (assumes average is identical with design value)

$b-b_1$ = 65 to 70 per cent of measurements occur in this region

$c-c_1$ = 93 to 97 per cent of measurements occur in this region

d = Distribution grade

METHOD OF COMPUTING BIAS AND DISTRIBUTION GRADE ON INTERTOLL TRUNKS

Bias

1. Subtract from each measurement the specified (design) value for that particular trunk giving it a + sign if the measurement is larger than the specified value or a - sign if the measurement is smaller than the specified value.

2. Add up all the + values and then add up all the - values.

3. Subtract the sum of the - values from the sum of the + values giving the answer a + sign if the sum of the + values is greater than the sum of the - values, or a - sign if the sum of the + values is less than the sum of the - values.

4. Divide the answer obtained in Step 3 by the total number of measurements involved, retaining the sign. This is the bias and it is + or - as determined by the computation.

Distribution Grade

5. Square each one of the differences (deviations) obtained in Step 1.

6. Add these squared values. All are +, of course.

7. Divide this sum by the total number of measurements involved.

8. Square the bias obtained in Step 4. The sign is +, of course.

9. Subtract the square of the bias, Step 8, from the value obtained in Step 7.

10. Take the square root of the difference obtained in Step 9. This is the distribution grade of that group of measurements and it is expressed without signs. Often this is referred to as obtaining the distribution grade by an RMS computation.

SWITCHING MAINTENANCE REQUIREMENTS AND CONSIDERATIONS

CONTENTS PAGE

1. GENERAL

1.01 The nationwide distance dialing arrangements are predicated on rapid and dependable switching supplemented by a maintenance plan that assures a high level of performance, promoting the optimum use of the plant and resulting in customer satisfaction.

1.02 For both operator and direct distance dialing, the personnel, test equipment, methods and organization of the maintenance job should be of a high quality in order to maintain the precision and stability required of the nationwide network of interconnecting switching systems. Trouble detection is more difficult with nationwide direct distance dialing because operators can no longer supervise the connections that are established. Employment of alternate routing adds to the difficulty of identifying circuits in trouble. Accordingly, maintenance methods and facilities based on requirements for dial operation have to be provided rather than attempting to use older techniques based on manual operation, since many of the trouble indicators under ringdown operation will no longer be applicable.

1.03 Under automatic switching, poor maintenance at one office can result not only in excessive trouble in that office but also in adverse reaction elsewhere in the switching network. Therefore, it is essential that good maintenance be provided at all locations. To assist in this effort, inter-Company as well as interdepartmental cooperation and coordination of the maintenance job is essential. Service measurement plans are likewise important. Clear lines of responsibility among forces, departments and Telephone Companies are necessary, along with an organized procedure for reporting and analyzing trouble to insure prompt action.

1.04 There will be an evolutionary development of maintenance procedures as experience is gained in direct (customer) dialing and as new switching techniques and methods are adopted. It is expected that the continuing trend will be toward:

(a) Reduction of maintenance effort through the use of optimum circuit and equipment design, selection of trouble-free components and the provision of automatic test devices and self-alarming arrangements which will automatically indicate troubles in the switching network; and

(b) Rapid and efficient trouble reporting and analysis procedures. Maximum use of operator verbal toll trouble reporting and holding procedures will do much to expedite prompt location and correction of trouble conditions. Recently developed maintenance techniques permit quick answers to operators' reports together with means for rapid circuit identification. These methods have been very successful in the detection of near or distant trouble conditions, thus insuring that customers experience fewer direct distance dialing difficulties.

At the same time, continuing improvement is expected in dial switching service standards. For the present, a reasonable service objective would seem to be about one failure per 100 calls. In the future it may be practicable to improve this objective.

1.05 The remaining parts of this section discuss test and maintenance facilities and contain applications for their use in various types of offices. Since, with few exceptions, the sectional centers and regional centers will be Bell operated, discussion in this section is confined to the other classes of offices, namely:

(a) Class 3 (or Primary Center).

(b) Class 4 (or Toll Center or Toll Point).

(c) Class 5 (or End Office).

Classification, rank, and homing arrangements for the various offices are discussed in Section III of these notes.

2. MAINTENANCE FACILITIES

2.01 Terminal room facilities for the termination and testing of intertoll trunks and associated equipment is contingent upon the type of equipment and facility (such as carrier of the various types, composite (CX) signaling, single frequency (SF) signaling, repeaters, connecting trunks, and switching equipment and its associated testing equipment). The major facilities which should be considered for maintenance and testing are listed as Items 1 to 14 below. Chart 1 indicates probable requirements for these items by class of office. In this chart certain assumptions have been made such as a Class 3 office being sufficiently large to justify full complements of patching facilities and that senders would not usually be employed in Class 5 offices. Actual conditions in any location will, of course, be the final criteria for selecting terminating and testing facilities.

(1) Primary Toll Testboard Positions: Usually of the 4-jack per circuit type for terminating, testing, and patching physical lines. Testing equipment consisting of test and talking cords, test battery, voltmeter and Wheatstone Bridge can be provided either in an associated unit or on a portable basis.

(2) Secondary Toll Testboard Positions: Usually consist of test multiple, patching jack bay facilities and test positions equipped for monitoring, talking, transmission measuring, signaling and making miscellaneous tests. The test multiple is usually a single appearance of two-jacks per circuit. One of its jacks is a multiple of the switchboard appearance (and may also be a multiple of the switches) which permits making over-all tests, including monitoring, and tests toward the line or carrier facilities. The other jack is provided to make the circuit test busy and remove it from service.

(3) Patching Jack Bays: May have a 4, 5, 6 or 7 jack circuit. Two of the jacks provide a testing and patching appearance of the transmission path between the trunk relay equipment and the toll terminal equipment (repeat coils, repeaters, carriers, etc.). By means of these jacks, transmission path troubles can be sectionalized, the switchboard drop circuit can be patched to the transmission path of any dial intertoll trunk, and the line can be patched through to any other line using proper pads.

Two other jacks provide a testing and patching appearance of the signaling and dialing path (E and M leads) between the signaling equipment and the trunk relay equipment. By means of these jacks signaling troubles can be sectionalized.

In those switching systems requiring two additional leads for conducting the d-c supervisory signal from the trunk relay equipment to the signaling equipment (usually designated as A and B leads) it is necessary to provide two additional jacks for patching these leads if a trunk relay or signaling equipment is patched.

For those switching systems in which the test multiple is cut off on an inward or through call, a single monitoring jack, which is a multiple of the drop patching jack, is desirable because it is always available for monitoring tests. This jack should be installed in the same general location as the multiple test jacks.

(4) 4-Wire VF Patch Bays: Provide a patching junction point between carrier terminals and voice-frequency circuits. (If the carrier system includes "E" and "M" lead signaling it may be advantageous to provide additional jacks for these signaling leads.)

(5) Testing Jacks: Associated with CX or SF signaling paths.

(a) Composite Line Jacks: Used to obtain testing access between the signaling and dialing equipment and the CX set. This permits a test of circuit continuity and "line" current in the signaling path.

(b) Test Jacks or Test Points: For testing SF or CX equipment units - associated with individual equipments.

(6) Toll Pulse Repeating Test Set: For pulsing over CX signaling paths and measuring pulsing speed and per cent break.

(7) Pulse Generating and Measuring Test Set: For pulsing over SF signaling paths and N, O, and similar type carrier signaling paths. For measuring pulsing speed and per cent break characteristics.

(8) Switchboard Cord and Position Maintenance Test Facilities and related test lines from the toll terminal and switching rooms as required.

(9) Make-Busy Facilities: For intertoll and toll connecting trunks in the operating rooms for use by the Traffic personnel where desired.

(10) Centralized Test and Make-Busy Jacks: For toll connecting trunk maintenance as required.

(11) Switching Equipment Maintenance Test Sets: In accordance with the type of switching system employed.

Note: Bell System common control type offices utilize various means for ensuring a satisfactory level of performance of the switching system. These include self-checking features in common control units, and trouble recorders, trouble indicators, registers, alarms, flow lamps, and testing equipment (automatic and manual) for applying operational and marginal tests to the various components of the switching system. The switching system also provides testing access to outgoing trunks for automatic trunk test frames.

Direct control type offices are not currently equipped with self-checking features and extensive automatic testing equipments. It is, therefore, essential that more emphasis be placed on operator reporting of troubles. Furthermore, it is recognized that with the increase in customer dialing and diminished operator contact, greater reliance must be placed on automatic checking or testing features and more efficient direction of maintenance efforts.

(12) Sender Test Facilities: Used where senders are involved.

(13) Carrier Testing Facilities: To test the various types of carrier units that may be involved.

(14) Test Lines: Details of test lines are discussed in Appendix A to this section. Test lines for intertoll trunks are known as National Code Test Lines (or test terminations) and are a part of the basic maintenance pattern in the intertoll dialing plan. They complement manual and automatic test facilities and procedures. The National Code Test Lines provide assistance in connection with maintenance tests at testboards and automatic testing equipment. Test lines (or terminations) for toll switching trunks are located in End Offices (local central offices) and complement the test facilities at the outgoing end of the switching trunk.

(a) National Code Test Lines

(1) Code 100 – Provides a termination for balance and noise testing on intertoll trunks for transmission maintenance.

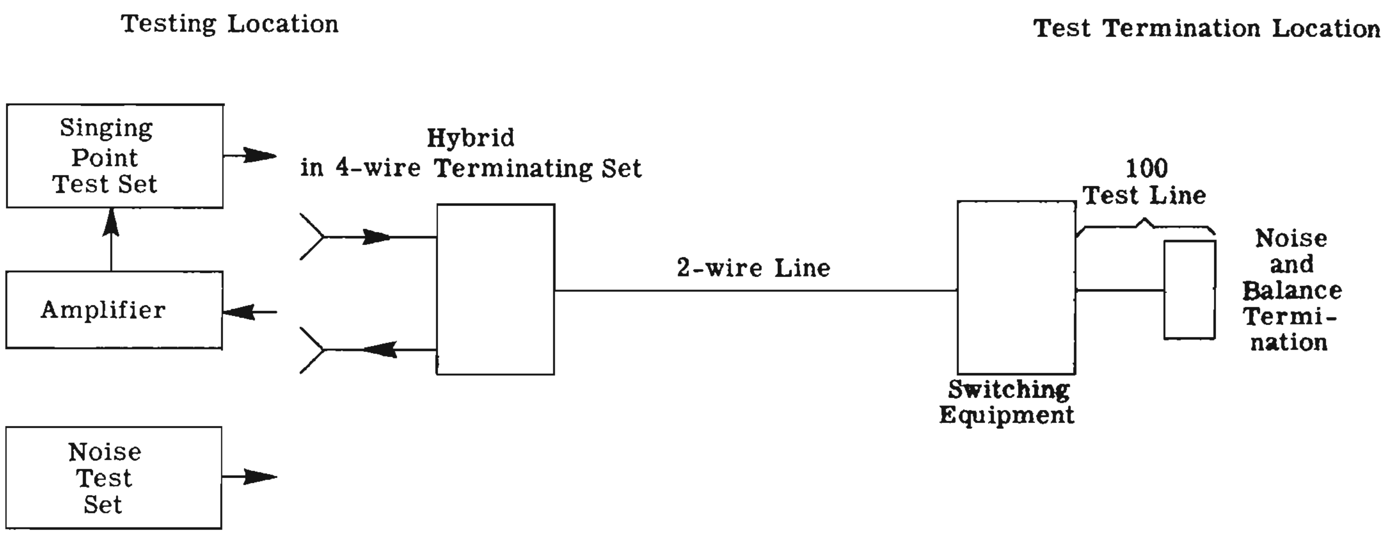


Fig. 1. Arrangement For Code 100 Test Line

(2) Code 101 – Provides a dial communication line into a toll testboard or test position which can be reached by any dial trunk in the switching system served by that test position. It is used for reporting trouble, making transmission tests, etc.

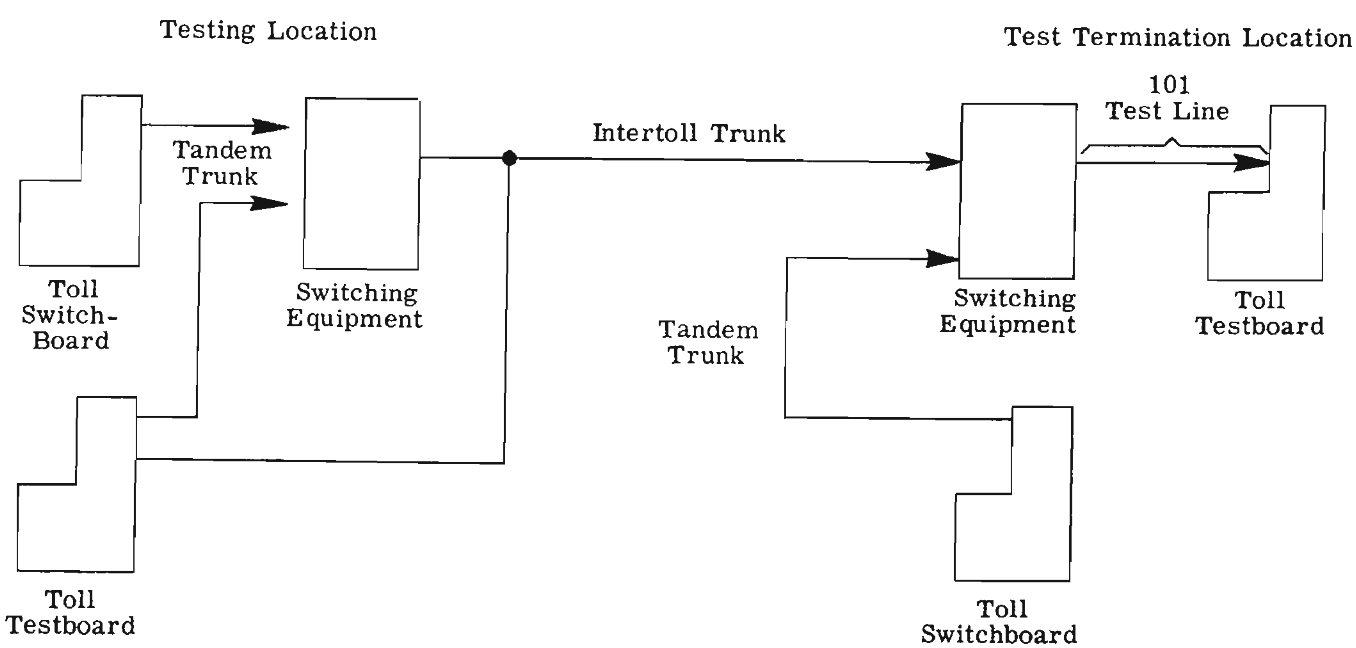


Fig. 2. Arrangement For Code 101 Test Line

(3) Code 102 — Provides a connection to a 1000-cycle one-milliwatt testing power source for one-way transmission measuring and includes automatic, timed disconnect features.

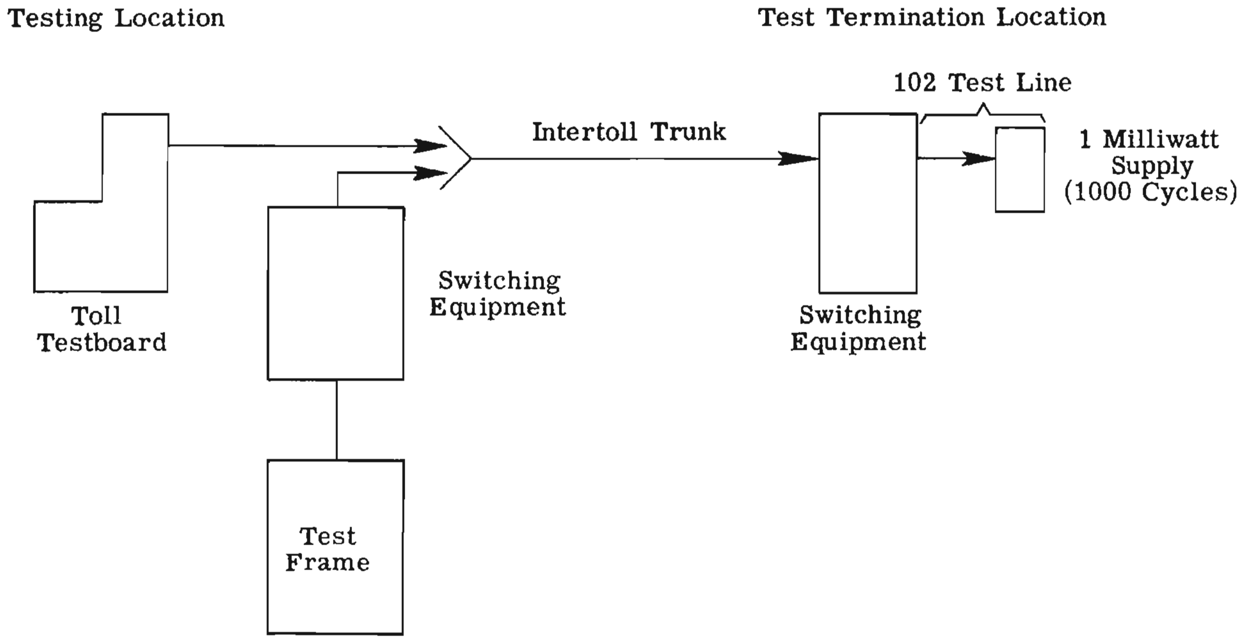


Fig. 3. Arrangement For Code 102 Test Line

(4) Code 103 — Provides a connection to a supervisory and signaling test circuit for overall testing of these features on intertoll trunks which can be reached by the automatic outgoing intertoll trunk test frame or by dialing manually.

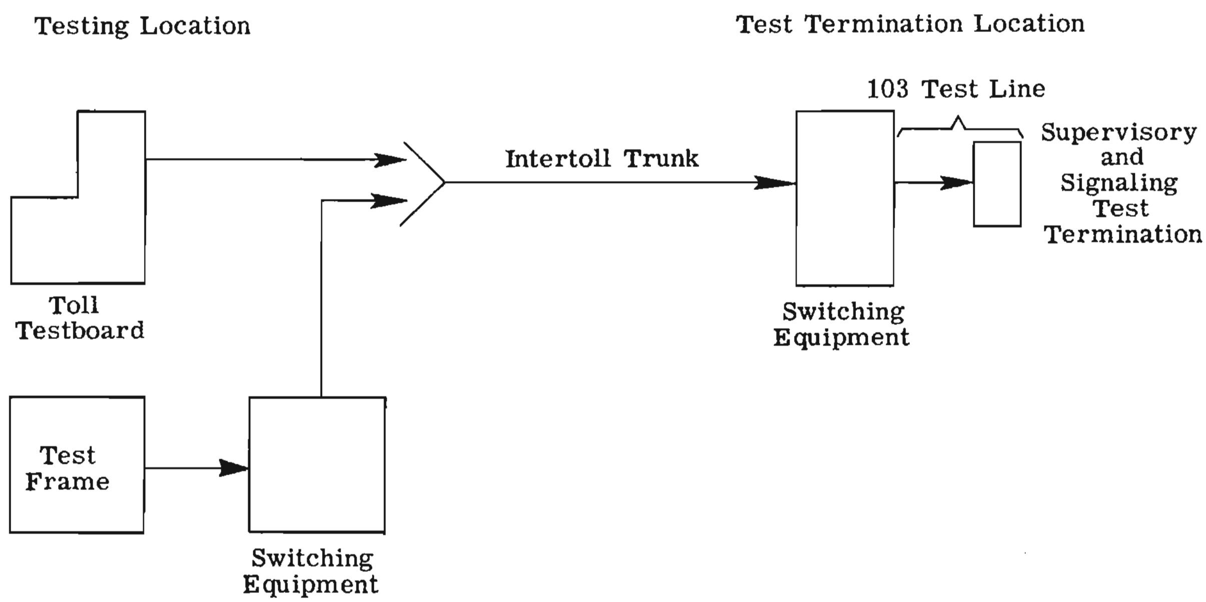


Fig. 4. Arrangement For Code 103 Test Line

(5) Code 104 — Provides a connection to test lines (usually 2 to 4) at the far end of intertoll trunks, the test lines connecting to a single far end measuring circuit. The measuring circuit is designed to transmit to the near end of the dial trunk (the end originating the test) test power, received transmission measurement information and a rough check of noise at the far end of the trunk. Such 2-way measurements are made automatically by the near end automatic transmission test and control equipment (ATTC) associated with the automatic outgoing intertoll trunk test frames (AOIT) such as those provided in No. 4-type crossbar offices. They may also be made on a manually-dialed basis by a man at a testboard or test location which is capable of seizing, dialing, holding and measuring on the trunk. As indicated in Appendix A, Paragraph 2.01 (e), the manually-dialed usage should not be excessive to avoid interference with use by the ATTC.

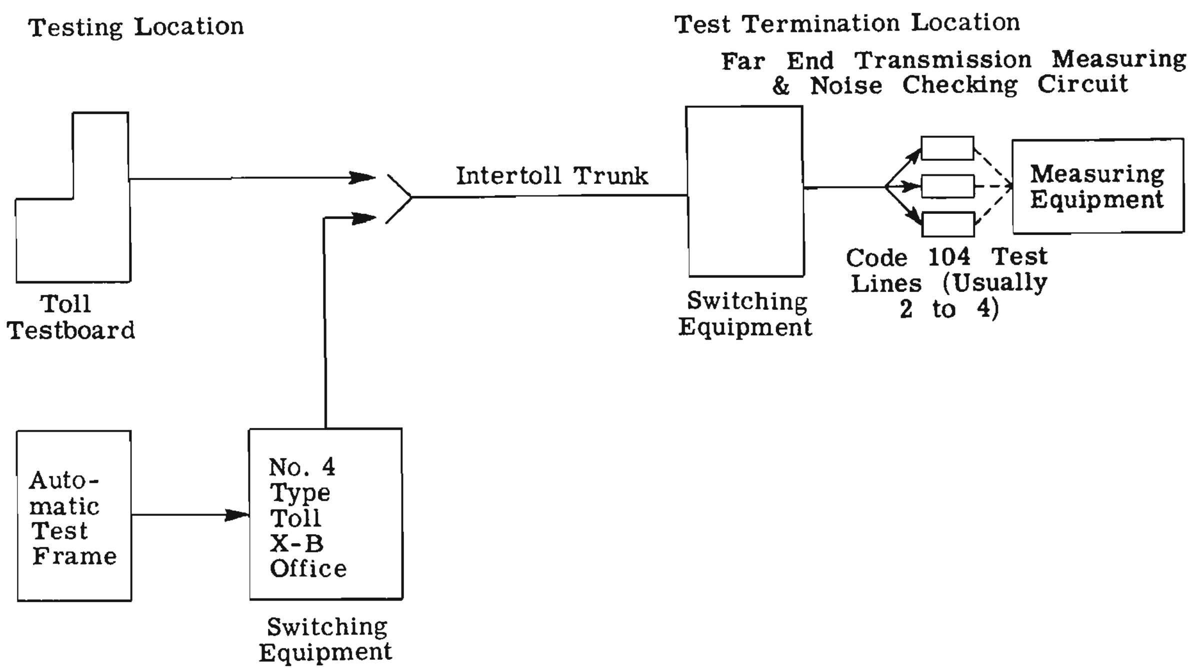


Fig. 5. Arrangement For Code 104 Test Line

(b) Test Lines for Terminating Links

(1) A termination connected to a one-milliwatt 1000-cycle source of testing power reached by means of a subscriber-type number (not Code 102). Currently this is a one-way device for use on toll switching trunks only. However, increased application of repeaters and carrier systems to all terminating links will require a two-way testing arrangement such as this incorporated in the dial-up circuit. This matter is now under study.

(2) A termination for noise and balance tests reached by calling a subscriber type number. The impedance (at 1000 cycles) of this termination is 900 ohms at the local office.

(3) Incoming trunk "synchronous" test line for testing ringing, tripping, and supervisory features in the incoming trunk relay equipment. (Usually in connection with Bell

System type panel and crossbar offices.) Termed synchronous since it is synchronized with automatic progression test equipment in the originating office.

(4) A "nonsynchronous" test line for operation test. (Not synchronized with automatic progression test equipment.)

(5) A test termination for office identification.

→ Note: The maintenance facilities for terminating links (other than toll switching trunks) are determined on the basis of the components and transmission requirements for the trunk in question. For example, a trunk from an end office to its home toll office may be so complex that it requires the same treatment as an intertoll trunk. Under other circumstances the trunk may be so simple that no maintenance facilities other than switchboard and frame appearances need be provided.

Attached:

Chart 1 – Test and Maintenance Facilities by Class of Office

Appendix A – Description of Test Lines

TEST AND MAINTENANCE FACILITIES BY CLASS OF OFFICE

(Subject to modification depending on type of trunk or circuit facility, type of switching system, and economic considerations.)

Item No.	Test and Maintenance Facility	Class of Office: Class 3	Class 4	Class 5
1	Primary Toll Testboard	x	x	
2	Secondary Toll Testboard	x	x	Note 1
3	Patching Jack Bays	x	x	
4	4-W Patch Bays	x		
5	CX or SF Signaling Path Test Jacks:			
(a)	CX Line Jacks	x		
(b)	With Equipment Units	x	x	x
6	Pulse Repeating Test Set for CX	x	x	
7	Pulse Generating and Measuring Test Set for SF or N, O, and Similar Carrier Systems	x	x	
8	Switchboard Cord and Position Test Facilities	x	x	x
9	Operating Room Trunk Make-Busy Facilities	x	x	
10	Centralized Test and Make-Busy Jacks for Maintenance Use on Toll Switching Trunks	x	x	
11	Switching Equipment Maintenance Test Sets	x	x	x
12	Sender Test Facilities	x	x	
13	Carrier Test Facilities	x	x	
14(a)	National Code Test Lines:			
(1)	100 Balance	x	x	
(2)	101 Testboard Communication	x	x	
(3)	102 1000-cycle - 1 MW	x	x	
(4)	103 Signal-Supervisory Feature	x	x	
(5)	104 Transmission Measuring and Noise Checking	x	x	
14(b)	Test Lines for Toll Switching Trunks:			
(1)	1000-cycle - 1 MW			x
(2)	Noise and Balance Termination			x
(3)	"Synchronous" Test Line			x Note 2
(4)	"Nonsynchronous" Test Line			x
(5)	Office Identification			x

Note 1: Toll test units may be applicable in some cases.

Note 2: Provide if incoming trunk provides ringing, tripping and supervisory features and may be tested directly.

DESCRIPTION OF TEST LINES

1. GENERAL

1.01 Test Line and Test Termination are terms sometimes used interchangeably to name a testing equipment, facility, circuit, or testing communication channel. These include simple static terminations and relatively complex testing circuits capable of applying marginal tests and recognizing and replying to specific signals received.

1.02 The selection of supervisory signals to be returned by a test termination is influenced by the type of circuit involved and the possibility of subscriber message charges where the test termination is reached by means of a subscriber type number code. National Code Test Lines (100, 101, 102, 103, and 104) will return a steady state "off-hook" signal which removes the single frequency signaling tone that would otherwise interfere with certain measurements. Conversely, in order to prevent false charging, a steady state "on-hook" signal is returned on test lines reached by means of a subscriber type number code which might be inadvertently dialed.

2. SPECIFIC PURPOSE TEST LINES

2.01 National Codes 100 to 104:

(a) Code 100 — Code 100 is recommended for industrywide use to facilitate connection to a termination for balance and noise testing in connection with intertoll trunks. The requirements for this termination are as follows:

(1) Provides off-hook supervision to calling end as long as curcuit is held by calling end.

(2) Provides a "pad-in" signal to connected toll circuits in offices employing switching pads.

(3) Provides a termination, the impedance of which simulates the impedance at 1000 cycles presented by the intertoll trunks at the point at which the termination is connected.

(b) Code 101 — This is a toll testboard trunk for receiving incoming calls to a toll testboard attendant for purposes of obtaining assistance in testing intertoll trunks.

(c) Code 102 — Code 102 has been assigned for use throughout the Bell System for connection to a one milliwatt 1000-cycle source required for one-way transmission testing of intertoll trunks. Test calls directed to this termination are usually manually originated.

(1) Returns an off-hook signal when the testing power is connected.

(2) Returns an on-hook signal and removes testing power after ten seconds.

(3) Provides an idle circuit termination in the on-hook condition.

(4) In offices employing pad control, provides a "pad-in" signal to the connected toll circuit.

(d) Code 103 — Code 103 has been assigned for use throughout the Bell System to reach a test termination required for over-all tests of the signaling and supervisory features of intertoll dial trunk circuits. Test calls directed to this test trunk may be originated manually or by automatic test equipment. The following operation in the sequence indicated is required:

(1) Return an off-hook signal on seizure of the test trunk.

(2) Return an on-hook signal on receipt of a ring forward (rering) signal.

(3) Return 120 IPM flash on receipt of second ring forward (rering) signal.

(e) Code 104 — Code 104 has been assigned to reach a test circuit for two-way transmission testing and one-way noise checking. This circuit is being used in the Bell System at offices with far end equipment in conjunction with the automatic transmission test and control circuit (ATTC) associated with the automatic outgoing intertoll trunk test frame (AOIT) at No. 4 type offices (home or near end). Use of the Code 104 termination at the far end also permits semiautomatic (i.e., "one-man") two-way transmission measurements to be made manually from a toll testboard over dial-type trunks though such use should not be excessive lest it interfere with tests by the ATTC. Presently, the Code 104 test termination at the far end can be proved in for offices having a minimum total of 40 to 50 intertoll dial trunks to distant crossbar offices with near end equipment. The features of the Code 104 test terminations are

(1) Provides for normal terminal pad arrangement under measuring condition.

(2) Receives and measures 1000-cycle one milliwatt minus circuit loss.

(3) Arranges a network to simulate the loss measured under (2).

(4) Sends 1000-cycle one milliwatt toward testing pad.

(5) After a timed interval, sends 1000-cycle one milliwatt through a loss equivalent to the loss measured in (2). If the loss in (2) exceeds 10 db, the sending level is raised 10 db and an appropriate signal is sent to the testing end to indicate this condition.

(6) Checks noise from the home or near end test location to the far end termination against a single preset value.

2.02 Test Lines for Testing Terminating Links:

(a) A termination connected to a one milliwatt 1000-cycle source is required for one-way transmission testing of toll switching trunks. It is reached by means of a subscriber type telephone number. Test calls directed to this termination are manually originated. The requirements for this termination are as follows:

(1) Trips machine ringing.

(2) Returns an on-hook condition to the calling end as long as the connection is held at the calling end.

(3) Connects testing power for nine seconds and disconnects power for one second. This cycle is repeated continuously as long as the connection is held by the calling end.

(4) Provides an idle circuit termination during the one second that testing power is disconnected (on-hook condition).

(b) A termination for noise and balance (return loss and singing) tests, reached by calling a subscriber's telephone number, is required for trunks with repeaters, trunks which are provided by means of carrier channels, and nonrepeatered trunks equipped with hybrid coils at a 4-wire switching office. The requirements for this termination are as follows:

(1) Arranges to trip machine ringing.

(2) Returns an on-hook condition to the calling end as long as the connection is held at the calling end.

(3) Provides a termination at the local office with impedance of 900 ohms at 1000-cycles. This termination is not for use with intertoll trunks since the on-hook condition will not cause single frequency signaling tone to be removed on circuits employing this type of facility.

(c) "Synchronous" type test lines are required for offices (usually in connection with Bell System panel and crossbar type offices) where ringing, tripping, and supervisory features are in the incoming trunk relay equipment and may be tested directly. Marginal tests of the supervisory and tripping functions are provided. Tests may be originated on either a manual or automatic basis. The test line is required to perform the functions as described below:

(1) Test for application of the ringing signal.

(2) Test for pretripping of machine ringing during the silent interval.

(3) Provide interrupted audible ringing tone during one 2-second ringing interval.

(4) Test for tripping machine ringing during 3-second silent interval.

(5) Provide the following supervisory tests:

(a) An off-hook signal of approximately 1.3-second duration for synchronizing with automatic progression test equipment in originating offices. During the off-hook period soak current is applied to supervisory relays.

(b) The synchronizing signal is followed by two separate off-hook signals of 0.3-second duration during which the soak current is applied to the supervisory relays.

(c) Following one synchronizing signal and each of the two successive short off-hook signals, an on-hook signal of approximately 0.2-second duration is returned during which time the release current is applied to the supervisory relays.

(d) A second series of off-hook signals consisting of a synchronizing signal and two flashes is returned. During each off-hook interval of this series, operate current is applied to the supervisory relays. During each on-hook interval, an open circuit condition is presented to the supervisory relays.

(6) Send tone signals to the originating office as follows:

(a) Audible ringing tone for 0.3-second intervals interrupted for 0.2-second as an indication that the trunk circuit tripping feature operated on the pretripping test.

(b) A "tick-tock" tone at the rate of 120 IPM without flash as an indication that the test termination has completed all tests and is awaiting disconnection.

Note: The incoming trunk circuit should return the regular audible ring to indicate tripping failure.

(d) A "nonsynchronous" test line is required for all dial type End Offices including those having the synchronous type test line. This line provides an operation test which is not as complete as the synchronous test but can be made more rapidly. The nonsynchronous type is the only one required for those offices where marginal type tests can not be applied directly to the incoming trunk circuit as is frequently the case in connection with step-by-step type systems. However, test terminations provided for application of marginal type tests to circuits such as connectors in step-by-step offices generally meet the minimum requirements for nonsynchronous type incoming trunk test lines and are frequently used for this purpose. In some instances connector test terminations can be used to apply marginal tests to such circuits as toll transmission selectors. The minimum requirements for a nonsynchronous test line where the synchronous test line is not provided are as follows:

(1) Starts to function under control of ringing signal.

(2) Permits audible ringing signal to be returned for a minimum 0.5-second to originating office.

(3) Causes ringing to trip.

(4) After ringing is tripped, returns the 60 IPM line busy signal which consists of alternate 0.5-second off- and on-hook signals with low tone applied during each off-hook period until disconnection. Where the synchronous test line is provided only the 60 IPM line busy signal is required.

The nonsynchronous test line used in many Bell System step-by-step offices for the application of marginal tests to connector circuits provides the following:

(1) Starts to function under control of the ringing signal.

(2) Permits audible ringing to be returned for 1.0 to 1.5 seconds.

(3) Returns an initial off-hook signal of 1.0- to 1.5-seconds duration during which time ringing is tripped.

(4) Provides the following supervisory signals sequentially after the initial off-hook tests are applied:

(a) 0.5-second on-hook.

(b) 1.0 to 1.5-seconds off-hook.

(c) 0.2-second on-hook.

(d) 0.3-second off-hook.

(e) 0.2-second on-hook.

(f) 0.3-second off-hook.

(g) 0.2-second on-hook.

(h) 0.3-second off-hook.

(i) 2.0-seconds on-hook period to permit disconnection from the test line.

(j) Alternate 5-seconds off-hook and 2.0-seconds on-hook intervals are repeated until disconnection takes place. The first two 5-seconds intervals are provided to facilitate testing of the ring forward (rering) and control features provided on some operator selected toll switching trunks and are desirable where these features are provided.

(e) A test termination is required for identification of the terminating office on test calls from other offices. To insure identification a different telephone number is required for each series of telephone numbers comprising a terminating local office unit in an area. The test line provides for:

(1) Tripping of machine ringing.

(2) Automatically removing the tripping circuit on completion of tripping to prevent the return of off-hook supervision to the calling end of the connection.

(3) Returning high tone to the calling end of the connection as a means of identification.

2.03 Assignment of Test Numbers at End Offices (Class 5 Offices): To permit use of automatic testing facilities for testing toll switching trunks to Class 5 offices each such office should have telephone number assignments for synchronous and nonsynchronous operation and for transmission test terminations in accordance with the following:

(a) The last four digits of the test numbers should be the same for each local office unit served by separate trunk groups to which automatic test calls are directed. A number common to all offices having switching trunks from the same toll office is desirable for each of the following test terminations:

(1) One milliwatt 1000-cycle power source for transmission tests.

(2) Noise and balance test terminations (900 ohms impedance at local office).

(3) Synchronous test lines.

(4) Nonsynchronous test lines.

(b) The directing digits preceding the directory 4-digit number used to select a particular office should be kept to a minimum.

2.04 <u>Test Lines for One-Way Intertoll Trunk Transmission Test at a Manual Toll Switchboard Position:</u> A test line designated as "1 MW TEST" may be given a toll switchboard jack appearance to which incoming intertoll trunks may be connected manually by the operator. This procedure is similar, therefore, to reaching the test power by dialing the Code 102 test line where it is available. The requirements for this termination are as follows:

(a) Furnishes "off-hook" supervision during the test interval.

(b) Starts the 1000-cycle power supply.

(c) Sends 1 milliwatt of test power at 1000 cycles on the trunk to which it is connected for a test interval of about 10 seconds.

(d) Furnishes "on-hook" supervision, releases the demand for test power, and automatically disconnects at the end of this test interval.

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CONTENTS PAGE

1. INTRODUCTION

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1.02 In addition, many other valuable papers have been written by people outside the Bell System relating to distance dialing generally, as well as to particular problems that distance dialing poses to Independent manufacturers. No attempt has been made to include these, nor has any attempt been made to include text books on the subject. The list, though not complete, may nevertheless be helpful.

1.03 In general, reference has been made only to articles published subsequent to 1944, since it has been during this period that the most intensive activity has occurred in distance dialing. This period has been one of evolution and some of the earlier articles have, in certain respects, been superseded by later material. Care should be taken, therefore, to select the latest writings on a particular subject.

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