Notes on DISTANCE DIALING

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NOTES ON DISTANCE DIALING

AMERICAN TELEPHONE AND TELEGRAPH COMPANY
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NOTES ON DISTANCE DIALING

FOREWORD

This issue of Notes on Distance Dialing has been updated to reflect changes in technology and to amplify and clarify material published in previous issues. The primary purpose of these Notes is to outline the technical requirements and fundamental principles of operator and direct distance dialing.

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

In many instances, it has been necessary to specify certain 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 Marketing fields as well as Engineering and Network Services that relate to distance dialing but are not covered by these Notes. Nevertheless, the Notes do furnish much of the information needed by the telecommunications industry for the successful coordination of efforts between manufacturing and Operating Companies in furthering distance dialing.

It should be emphasized that an orderly program should exist to coordinate new technological advances into the distance dialing network. While the Notes describe requirements as visualized today, details will necessarily change as experience is gained and new instrumentalities are developed. Decisions in the technical area should be based on the results of well thought-out fundamental plans with the ultimate plan selected on the basis that it is least costly to the entire telephone-using public.

In situations where operator and direct distance dialed traffic items do not reach the distance dialing network and where exception to the provisions of the Notes will result in significant industry economy, the requirements contained in the Notes need not be rigidly applied. A book of such general nature as these Notes cannot cover all the details of every technical requirement for distance dialing. To care for 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.

As customer needs and serving arrangements become more complex, the planning efforts for distance dialing will involve the entire telecommunication industry. In this connection, information relative to this issue of Notes on Distance Dialing reflects the combined efforts of the United States Independent Telephone Association (USITA) Subcommittee on Network Planning and American Telephone and Telegraph Company. The importance of continuous joint planning by Independent and Bell Companies cannot be overemphasized since the plans of one are bound to affect the plans of others and influence the determination of the most economical industry solution.

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SECTION 1

GENERAL INFORMATION

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1. INTRODUCTION

1.01 The term distance dialing as used in these Notes and as commonly understood within the telephone industry means the completion of long distance calls by either customers or operators dialing from the originating location without any assistance from intermediate operators. CAMA, TSP, or TSPS operators who may enter on the line for momentary assistance are not considered intermediate operators. The phrase "Direct Distance Dialing" is used to describe calls dialed by customers to points outside their local or extended service area. When these calls are dialed by operators, the phrase "Operator Distance Dialing" is sometimes employed. Since the distance dialing method provides for fast, accurate, and dependable telephone service, and at the same time results in overall operating economies, it has been accepted as an industry-wide objective.

1.02 The Notes are intended to serve as a general reference and guide for the telecommunications industry on the principles of distance dialing. They describe minimum requirements and are not intended to provide detailed engineering information. Since the basic plan is designed for both operator and customer dialing, no distinction is made between the two except in instances where requirements differ. Detailed description of circuit operation has been avoided and the requirements for switching systems are covered only to the extent that they affect distance dialing considerations.

1.03 Generally, the Notes describe the requirements that apply when distance dialing has been fully realized and do not cover interim arrangements which may be both expedient and appropriate during transitional periods. Many things dictated by local conditions must be considered before the methods and equipment arrangements for a given office can be properly determined.

1.04 Some references are made to equipment of Bell System manufacture; however, appropriate equipment for other manufacturers with the necessary operating features can be employed.

2. DESCRIPTION OF SECTIONS

NUMBERING PLAN AND DIALING PROCEDURES (SECTION 2)

2.01 A primary concern of the distance dialing plan, first conceived in the early 1940s, was the creation of a numbering system that would uniquely identify each station. It was essential that the numbering plan reflect uniformity, be convenient to use, and be compatible with existing local and extended area dialing arrangements.

2.02 The numbering system that resulted is referred to as "destination code" numbering which utilizes the disciplines of destination code routing. Telephone numbers for distance dialing consist of two basic parts.

(1) A 3-digit Numbering Plan Area (NPA) code identifying a geographical area

(2) A 7-digit telephone number consisting of a 3-digit Central Office (CO) code and a 4-digit station number.

2.03 As the demand for telephone service increases, care must be taken in assigning Area and Central Office codes. Parts 4 and 5 discuss relief plans for these codes. Economical utilization of these codes can be accomplished by careful planning.

2.04 Numbering plan arrangements and dialing procedures for the North American Network are discussed in Section 2. International numbering arrangements are discussed in Section 10.

SWITCHING PLAN FOR DISTANCE DIALING (SECTION 3)

2.05 Another requirement for distance dialing is a switching plan that routes traffic automatically, economically, and rapidly to its destination. This need is met by switching and trunking arrangements that adhere to the rules of a hierarchical network.

2.06 The distance dialing plan takes full advantage of the overall economies offered by alternate routing within the limits of an orderly discipline. Trunk plant is used more efficiently under the alternate routing plan than under manual operation. Section 3 describes the switching plan in considerable detail.

EQUIPMENT REQUIREMENTS (SECTION 4)

2.07 There are several miscellaneous equipment requirements for distance dialing in addition to the signaling requirements detailed in Section 5. Section 4 summarizes these requirements and includes brief discussions of the demands of distance dialing on station equipment, switching systems, long distance switchboards, automatic equipment for recording message billing data, and miscellaneous central office and network administrative facilities.

2.08 Section 4 is confined to those specific central office equipment arrangements which need to be provided to interconnect an office with the distance dialing network. No attempt has been made to cover the many other requirements for local and long distance services. The type of equipment employed is not important from the standpoint of distance dialing as long as the minimum requirements outlined in this section, in Section 5 on signaling, and in Section 7 on transmission are met. For this reason, Section 4 covers a number of fundamental considerations regarding miscellaneous and somewhat unrelated items.

SIGNALING (SECTION 5)

2.09 One of the most important needs for industry-wide information about distance dialing is a statement of the signaling requirements. With automatic switching, a complex system of signals is needed to pass information over the dialing network. These signals include address information and supervisory states. They must be designed to actuate and be recognized by switching systems of different types and manufacture and must be capable of being carried accurately and rapidly over many types of transmission facilities.

2.10 Section 5 discusses the signals required for distance dialing and related matters. Considerable technical information is included to illustrate 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 switching and transmission systems are shown for informational background. A number of charts and schematic diagrams illustrating signaling fundamentals are also included. Since basic signaling requirements are essentially the same for both operator- and customer-dialed traffic, no distinction has been made between the two except where necessary.

COMMON CHANNEL INTEROFFICE SIGNALING (SECTION 6)

2.11 Common Channel Interoffice Signaling (CCIS) is a method of signaling between processor-equipped switching systems. Essentially, CCIS provides 2-way signaling between switching systems independent of the transmission path of the message circuits.

2.12 Section 6 gives details on the advantages, potential, operation, administration, and maintenance of the CCIS system.

TRANSMISSION CONSIDERATIONS (SECTION 7)

2.13 The switching plan for distance dialing contemplates that most calls are to be completed on direct circuits or over two or three intertoll trunks switched together in tandem. A very small portion of the total number of calls may encounter as many as seven intertoll trunks within the United States or Canada. This requires careful transmission design as well as concentrated effort in maintaining transmission values close to design objectives.

2.14 The transmission requirements for distance dialing raise no design problems that differ from the design problems of the telephone industry since its beginning. Design parameters and objectives for trunk plant are covered in some detail in Section 7. The section is organized by transmission parameters. Within each section, a brief description is made of the parameter, its effect on service, and its control in terms of performance and maintenance objectives.

MAINTENANCE REQUIREMENTS (SECTION 8)

2.15 A high level of equipment maintenance performance is required at the switching centers in the distance dialing network. This is 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 not only react unfavorably on the customers, who may be the first to detect them, but also result in inefficient use of the network.

2.16 Means have been developed for the automatic detection and recording of trouble so that most trunk and equipment troubles may be cleared before they can cause serious service reactions. Section 8 describes automatic testing equipment, test lines, and various other testing facilities suited to the needs of distance dialing together with suggestions for their application.

WIDE AREA TELECOMMUNICATIONS SERVICE (SECTION 9)

2.17 To meet the needs of telephone users who make or receive substantial volumes of DDD calls, WATS service was established. Within the United States, WATS service may be subscribed to on an outward or inward basis. Since the operations are somewhat different, they are discussed separately.

2.18 Section 9 describes in some detail the WATS serving area, line numbering, administrative considerations, and routing both interstate and intrastate service.

INTERNATIONAL DIALING (SECTION 10)

2.19 International Direct Distance Dialing (IDDD) was first introduced in March 1970. At present, IDDD from the US offers access to 20 countries. Section 10 discusses the requirements of IDDD on the communications industry in the areas of numbering, signaling, switching, equipment, transmission, and maintenance.

NETWORK MANAGEMENT (SECTION 11)

2.20 To provide a satisfactory grade of service, an effective network management arrangement is required. Network Management encompasses the techniques and organization to insure optimum use of available facilities under abnormal load conditions or equipment and facility failure.

2.21 Section 11 gives a conceptual description of a Network Management organization as well as descriptions of such controls as Dynamic Overload Controls (DOC) and Directional Reservation Equipment (DRE).

BIBLIOGRAPHY (SECTION 12)

2.22 As mentioned in the beginning of Section 1, it is intended to describe in these Notes the minimum requirements to be met in order to connect with the distance dialing network. For those who may wish to explore, in more detail, subjects related to distance dialing, the Bibliography, Section 12, is furnished for reference.

3. FUNDAMENTAL LONG RANGE PLANNING

3.01 As customer needs and serving arrangements grow in scope and complexity year by year, the need for thorough planning assumes a higher order of significance in insuring good service. In addition to the subjects covered in detail in Sections 2 through 11, it may be worthwhile to consider briefly the fundamental plans which are the keystones to the inclusion of any office or service, large or small, in the distance dialing network.

3.02 Large sums of money are often required to provide for growth and service innovations tailored to customers' needs. Effective planning is the key to insuring that all network components (switchboards, buildings, trunk facilities, switching systems, and the like) fit together in a smoothly working and efficient overall system.

3.03 Service-oriented planners must face up to and answer such questions as "Where are we going?" (Strategic Planning) and "How do we get there?" (Long Range and Implementation Planning). A thorough job must be done in assessing the future and determining possible courses of action. There should be an adequate appraisal of the impact on serving arrangements of new services, of modernized services, and of technological innovations. The best course of action should be chosen to implement selected plans and to do so in harmony with a universe of other plans and without impairment of service.

3.04 Planning objectives may be summarized in these terms.

(1) To provide guidance for systematic, orderly growth of the business and maintenance of the planned quality of service

(2) To provide a summation of industry objectives so that current operations will have direction, and decisions can include considerations of the future as well as present needs

(3) To provide an indication of plant (facilities and equipment), people, and capital requirements to achieve objectives.

3.05 Fundamental planning for accomplishing distance dialing includes the following broad fields:

(1) Analysis of basic traffic data and methods

(2) Plans for equipment to automatically record and process message billing data for direct customer-dialed traffic

(3) Plans and programs for local central offices and customer loops including local numbering

(4) Plans and programs for plant including types of transmission facilities, signaling conditions and switching equipment.

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

(1) Future routings under the switching plan for distance dialing

(2) Estimates of future traffic volumes and possible changes in the characteristics of traffic including:

(a) The portion of traffic that can be dialed by customers

(b) The potential for eliminating cordboard handled traffic.

(c) The portion of traffic to be handled by special service networks.

3.07 Because service improvements and operating economies 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. Factors pertaining to this phase of planning include:

(1) The type of station identification to be used

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

(3) Whether recording systems for person, credit card, and coin traffic should be provided

(4) Traffic volumes to be dialed and the relative proportions of traffic to be detailed or bulk billed

(5) Operating economies which result.

3.08 Fundamental planning for a local exchange to be connected to the distance dialing network includes provision for:

(1) A unique 3-digit Central Office code

(2) A uniform 10-digit telephone number for each station

(3) Segregation of coin boxes (public or semipublic telephones) in certain recommended thousand series to the extent possible

(4) Adequate interception of nonworking station numbers and vacant Central Office codes

(5) Signaling requirements (as outlined in Section 5)

(6) Customer loop design (as described in Section 7) which will establish the lowest loop loss consistent with economy

(7) Automatic Number Identification whenever feasible.

3.09 Fundamental planning for switching equipment, outside plant, and terminal facilities takes the following into account:

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

(2) The most economical transmission facilities which will meet transmission objectives (eg, carrier, radio, voice frequency, etc) should be selected for relief on existing routes and on new routes that may be established. This involves such factors as:

(a) Current and future traffic volumes and trunking requirements for the message network plus requirements for special services.

(b) Transmission design objectives under the switching plan for distance dialing with consideration for future integration of transmission and switching facilities.

(c) Establishment of an approximate but realistic timetable for the programming of the various phases of mechanization for all distance dialed traffic.

(d) Provision of new routes separated from present routes for protection of service.

3.10 Because the sums invested are large and because the service life of most plant is appreciable, it is important that fundamental plans be made well in advance of the time when something must be done. This will help smooth the transition to mechanized operation and the introduction of new services. New plant and equipment can be provided in an orderly manner without incurring unwise or unnecessary expenditures. Flexible plans fitted to conditions at a given location can be developed which will permit adjustments as necessary to meet changed conditions and advances in technology. Fundamental plans need frequent review to reflect such changes and advances as they occur in order to be kept current.

4. NEW SERVICES

DATA SERVICE

4.01 The increased use of computers and automatic data processing systems in the commercial, industrial, and military areas has substantially increased the demand for greater varieties of data services and data transmission channels. This expansion, with its attendant requirements for a variety of speeds and channel usage time, has encouraged development of special service offerings that use the regular switched message telephone network in establishing the communications channels.

4.02 Operationally, data service is quite simple. A regular telephone call is made to establish a connection between two points. Usually, regular voice communication may be carried on if required. Operation of a pushbutton, associated with the telephone set at each end of the connection, disconnects the telephone instruments and connects data sets to the telephone lines. The data set, depending upon the type, accepts analog or digital (usually binary) information at the transmitting end and, if necessary, modulates the baseband signal to a frequency band suitable for use over telephone circuits. At the receiving end, the data set demodulates the line signal and returns it to baseband. At the end of transmission, regular voice communication can be resumed, if desired, or the connection can be terminated by hanging up the telephone.

4.03 The telephone industry is continuing its effort to achieve higher speeds and greater accuracy, to provide more effective means for handling the variety of data transmission requirements, and to broaden the scope of data processing applications by reducing the cost of transmitting information.

MOBILE COMMUNICATIONS SYSTEMS

4.04 Land-mobile telephone service began in 1946 when six channels were made available for this service. Mobile customers have access to the nationwide network through the base station covering the area in which they are traveling. When the base station receives the signal, it relays it instantly to a mobile switching office where the call can be fed into the telephone network or into the dispatch office of a private fleet of vehicles.

4.05 The Telecommunications Industry is continuing its effort to meet the current mobile communications requirements and to broaden the scope of this type of service.

TSPS-REMOTE TRUNK ARRANGEMENT (RTA)

4.06 The Traffic Service Position System-Remote Trunk Arrangement (TSPS-RTA) will be a combination of hardware and software additions to TSPS which will permit the extension of TSPS service to smaller common control toll center areas where individual TSPS base units are not economically viable. The RTA will consist mainly of a scanner, signal distributor, concentrator, and trunks installed at one toll center but under the control of a distant TSPS base unit via data links. Connections to the operators will be over separate voice links via the RTA concentrator to the base unit. The toll-connecting trunks handled by an RTA will connect to its associated toll machine for distribution in the DDD network.

4.07 The primary benefits of the TSPS-RTA will be:

(1) A significant increase in the serving area of a single TSPS

(2) An enhancement of the inherent TSPS large team efficiency

(3) The continued use of the remote toll machine for switching operator-handled traffic.

NOTES ON DISTANCE DIALING

SECTION 3

SWITCHING PLAN FOR DISTANCE DIALING

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1. GENERAL

1.01 The telephone systems in the United States and Canada handle almost 30,000,000 long distance messages a day. These are routed over a comprehensive network of more than 700,000 intercity trunks which interconnect about 2000 long distance switching systems. This network serves, with few exceptions, all of the telephones in the two countries and provides for establishing connections to most other parts of the world as described in Section 10.

1.02 Large volumes of traffic between any two points are generally routed most economically over direct trunks. When the volume of traffic between the two points is small, however, the use of direct trunks is usually not economical. In these cases, the traffic is handled by connecting together, by means of switching systems at intermediate points, two or more trunks to build up the required connection. The places where interconnections are made are generally known as "switching centers" and the process is referred to as a "switch." "Built-up" connections may involve several switching centers if the originating and terminating points are a great distance apart. It is important that telephone plant be designed to provide adequate transmission and service for this multiswitch traffic as well as the large volumes of traffic handled by the less complex direct- and single-switch connections.

1.03 The basic routing arrangements of the Switching Plan for Distance Dialing make possible systematic and efficient handling of customer-dialed and operator-serviced long distance traffic. These arrangements are discussed in this section.

1.04 The basic principles of the Switching Plan for Distance Dialing evolved from the earlier plan for "ringdown" traffic in which the switching was performed manually by operators. The experience gained in handling large traffic volumes on a dialed basis between many separate central offices within metropolitan exchange areas also was applied to the automatic switching of intercity traffic.

1.05 The basic elements of the Network Plan for Distance Dialing are:

(1) A numbering plan. This is discussed in Section 2.

(2) A switching plan. This is discussed in parts 3, 4, and 5 of this section.

(3) Destination code routing. This is discussed in part 6 of this section.

(4) A transmission plan. This is discussed in Section 7.

(5) Standard signaling for the called telephone number and for supervisory information. This is discussed in Section 5.

1.06 The needs of distance dialing are met by switching and trunking arrangements that employ a hierarchical network configuration and the principle of Automatic Alternate Routing to provide rapid and accurate connections while making efficient use of the telephone plant. The hierarchical network configuration provides for the collection and distribution of traffic and permits complete interconnectability of all points. With the automatic alternate routing principle, a call which encounters an "all trunks busy" condition on the first route tested is automatically "route advanced" and offered in sequence to one or more alternate routes for completion. Appendix B of this section, entitled "Alternate Routing," discusses this principle.

1.07 Trends in the telephone industry are toward increasing traffic volumes with a high degree of mechanized switching and billing. Operator service locations are trending toward more centralization with service and assistance functions being provided at greater distances from the switching location. For the most economical arrangement, traffic should route as directly as possible from the point where billing details are recorded to the called destination. Concentration at various switching centers is justified only if overall network economies can be realized. Between any two points, the traffic in both directions should be combined on a 2-way trunk group where meshing of noncoincident hours and improved trunk group occupancy can achieve economies.

2. DEFINITIONS

2.01 Under the Switching Plan for Distance Dialing, each point involved in the completion of long distance calls is classified and designated according to the highest rank switching function performed, its interrelationship with other switching centers, and its transmission requirements. The hierarchical ranking (and associated class number) given to each switching center in the network determines the routing pattern. The standard classification and homing arrangements for two routing chains (sometimes called a routing ladder) are shown in Fig. 1. Possible groupings of various classes of switching centers are shown in Fig. 2. The classification of switching centers, their switching functions, and the switching areas they serve are described in the following paragraphs.

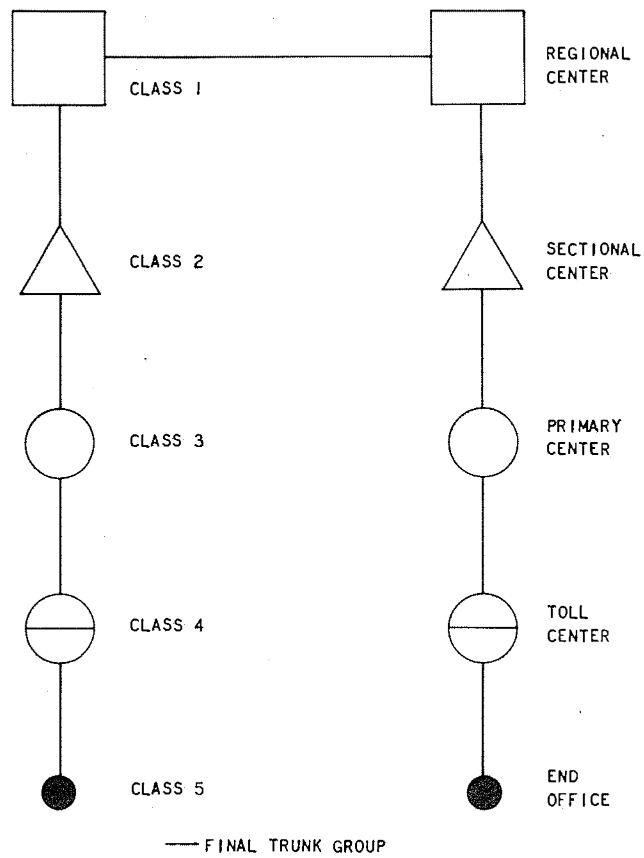


Fig. 1

2.02 The central office trunking entities where telephone loops are terminated for purposes of interconnection to each other and to the network are called "end offices" and are designated as Class 5 offices. A trunking entity is that grouping of central office equipment at which a Central Office code or a group of Central Office codes are trunked in common for network access. A trunking entity may be those step-by-step units served by the same mainframe, a No. 5 Crossbar marker group, a central processor controlled electronic central office, or any equivalent arrangement.

2.03 The switching centers which provide the first stage of concentration for network traffic originating at end offices and the final stage of distribution for traffic terminating at end offices

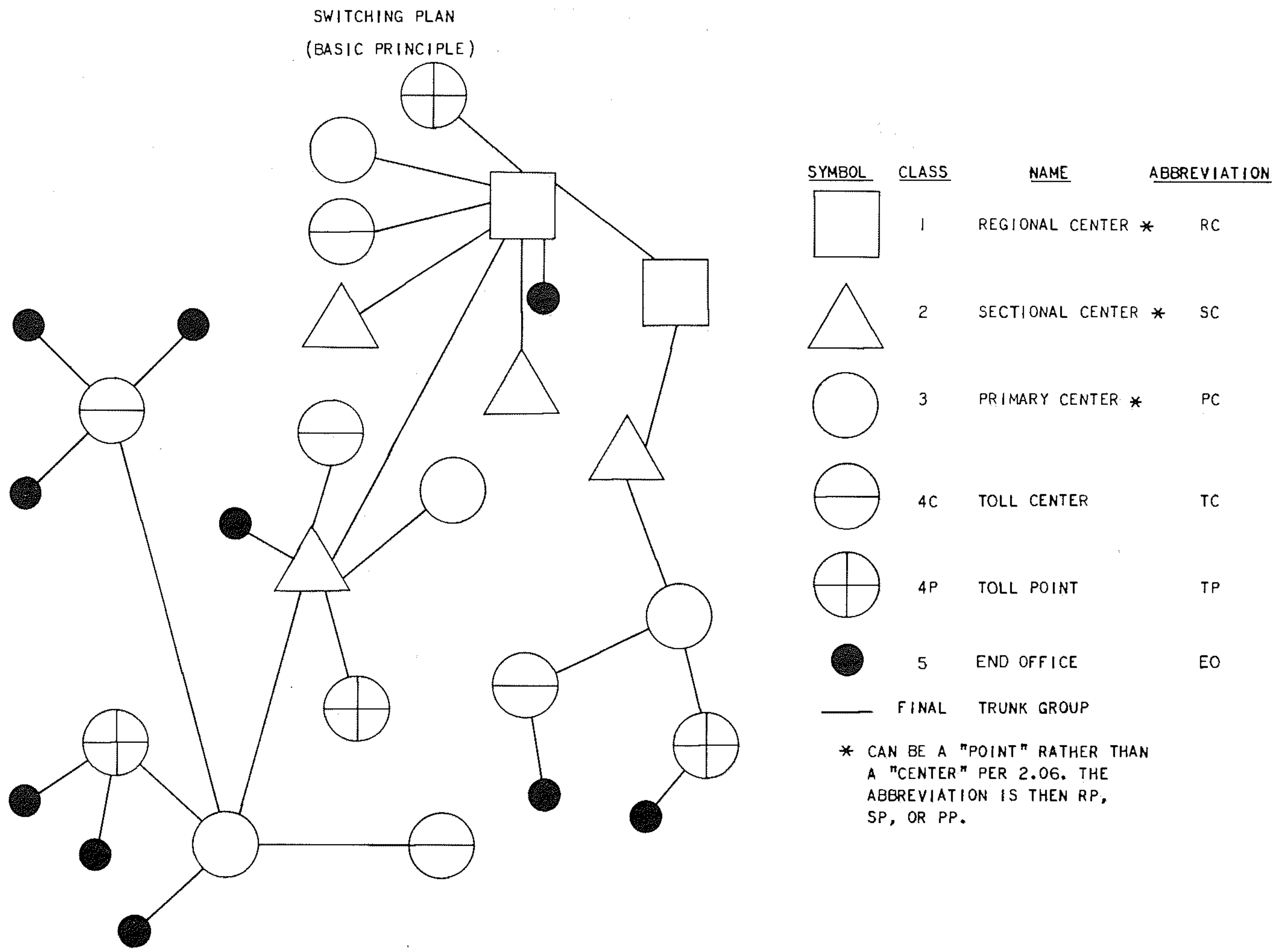


Fig. 2

are called "Toll Centers" or "Toll Points" and are designated as Class 4C or Class 4P switching systems, respectively. The Class 4 switching function connects a grouping of end offices to each other and to the network. A toll center (Class 4C) is a location at which operator assistance in completing incoming calls is provided. A toll point (Class 4P) is a location at which operators handle or service only outward calls or where switching is performed without provision for operator functions. The Class 4P designation is also assigned to such switching systems as outward and terminating toll tandems and some systems with Centralized Automatic Message Accounting (CAMA).

2.04 Operator service locations are designated as "Traffic Toll Centers" if inward assistance operator service code functions are provided. This generic designation is applicable regardless of the classification of the location in the hierarchical configuration. Those end offices which are served by operator service locations without inward assistance operator functions must be provided this service by a toll center or higher ranking switching system which has direct (nonswitched) access to the end offices. Appropriate listings in keeping with these basic considerations will appear in routing documents such as: (1) the Operating Rate and Route Guide, (2) the Traffic Routing Guide, and (3) the Distance Dialing Reference Guide.

2.05 Certain switching systems, in addition to connecting a grouping of end offices to each other and to the network, are selected to serve higher ranking switching functions on the basis of overall network economies thus providing additional hierarchical levels of concentration. These levels are: Primary Centers designated Class 3, Sectional Centers designated Class 2, and Regional Centers designated Class 1. Collectively, the Class 1, 2, and 3 switching systems constitute the Control Switching Points (CSPs) of the switching plan for distance dialing. It is important to note that higher rank switching systems can also perform lower rank switching functions. Where multiple switching functions are performed, the switching system is designated by the highest rank switching function present as tabulated in Table 1.

2.06 In some of the larger metropolitan areas which have two or more toll switching systems, the inward assistance operator function may be served from one of the lower rank switching systems instead of the highest rank system in the area. In these cases, the term "point" instead of "center" is applied to the switching system which does not directly serve the inward assistance operator function, eg, Regional Point, Sectional Point, Primary Point. There are no distinguishing symbols as yet attached to these classifications.

2.07 A Control Switching Point (CSP) is a switching system at which intertoll trunks are connected to other intertoll trunks. Basic requirements for CSPs are shown in Appendix A.

2.08 The backbone hierarchical network of "final" trunk groups, or the final route chain interconnecting the five ranks of switching systems, is shown in Fig. 1. One final trunk group is always provided from each switching system to another switching system of higher rank. That higher rank location to which a given switching system is connected over a final trunk group is called its "home." The lower rank or dependent switching system is spoken of as homing on the higher rank location. The one exception to this principle is the complete interconnection of all Regional Centers with final trunk groups, each with all of the others.

2.09 In determining classification and homing arrangements, designations are always assigned to end offices first based on the results of wire centering studies. In succession, based on overall network economics, designations are made for Classes 4, 3, 2, and 1. The network hierarchy is thus built from the bottom up, each switching system being assigned the lowest possible rank. Additional discussion of network design and switching system classification is contained in part 4 of this section.

2.10 The systematic grouping of switching centers results in a similar grouping of the areas they serve. Each Regional Center (RC) serves a large area known as a Region. (There are ten regional areas in the United States and two in Canada.) Each region is subdivided into smaller areas known as Sections; the principal switching system in the section is the Sectional Center (SC). The section is still rather large 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 centers that do not fall into these

TABLE 1

SWITCHING SYSTEM RANK	DESIGNATED CLASS NUMBER	CLASS NO. OF SWITCHING FUNCTIONS PERFORMED
Regional Center	1	Classes 1, 2, 3, and 4
Sectional Center	2	Classes 2, 3, and 4
Primary Center	3	Classes 3, 4, and sometimes Class 5
Toll Center	4	Class 4; sometimes Class 5
End Office	5	Class 5

Note: Not all toll centers perform a Class 5 switching function. Only a few primary centers perform a Class 5 switching function. Sectional centers and regional centers are of such a large size that the switching system used does not provide a Class 5 switching function.

categories are the Toll Centers (TC) and End Offices (EO).

2.11 Each separate switching system must be assigned its own classification within the hierarchical routing plan. This separate classification is applicable even when more than one system is located in a single building. The one exception is that cord switchboards in the same building with, and handling traffic exclusively for, a single toll switching system are classified as a part of that system. The cord switchboard and its trunks must also meet VNL transmission requirements as covered in Section 7. When a cord switchboard location is not in the same building as the toll switching system, the cord switchboard is treated as a separate switching system and assigned a Class 4P classification.

3. HOMING ARRANGEMENTS AND THE INTERCONNECTING NETWORK

3.01 It is not necessary that Class 5, 4, or 3 offices always home on the next higher ranking (conversely, next lower class number as shown on Fig. 1) switching system. For example, Class 5 offices may be served directly from any higher ranking location. Possible homing arrangements for each class of switching system are shown in Table 2 below and are illustrated in Fig. 2.

TABLE 2

HOMING ARRANGEMENTS

RANK	CLASS OF OFFICE	MAY HOME AT OFFICES OF THE FOLLOWING CLASSES
End Office	5	Class 4, 3, 2, or 1
Toll Center	4	Class 3, 2, or 1
Primary Center	3	Class 2 or 1
Sectional Center	2	Class 1
Regional Center	1	All regional centers mutually interconnected

3.02 Each final trunk group in the network is engineered individually to a low probability of blocking so that, on the average, no more than a small fraction of the calls offered to such a trunk group in the busy hour will encounter a "No Circuit" (NC) condition. Current Bell System service objectives for final trunk groups call for not more than one call in 100 being blocked by an NC in the average time consistent busy hour in the busy season. Final trunk groups are required to mutually interconnect all Regional Centers.

3.03 In addition to the final route network, direct high-usage trunk groups are provided between switching systems of any class wherever the volume of traffic and economics warrant and automatic alternate routing equipment features are available. High-usage trunk groups carry most but not all of the offered traffic in the busy hour. As discussed in Appendix B, overflow traffic is offered to an alternate route. The proportion of the offered traffic that is carried on a direct high-usage trunk group ordinarily is determined, in part, by the relative costs of the direct route and the alternate route (including the additional switching costs on the alternate route). High-usage trunk groups are provided when they are shown to be economically desirable. Due to service considerations, trunk groups which would normally be in the high-usage category may in some instances be engineered on a no-overflow basis with the same service objective as a final trunk group. This does not change homing arrangements and these trunk groups are called "full groups." Full groups effectively eliminate further alternate routing and truncate or limit the hierarchical final route chain for the items of traffic offered to them. Full groups can seldom be justified on the basis of economic considerations alone.

3.04 In general, trunks in both high-usage and final trunk groups between toll centers and higher rank switching systems are operated to combine traffic in both directions, ie, 2-way. Within the normal range of traffic load characteristics, 2-way trunk groups present opportunities for meshing of noncoincident traffic in either direction as well as improvement of trunk group occupancy relative to one-way trunk groups. Where there is a significant cost differential between one-way and 2-way trunk terminations on switching systems, there may be opportunities to trade off trunk termination savings against the lower occupancy of one-way trunk groups. This usually is possible with electromechanical switching systems. A large 2-way trunk group may be subgrouped into two one-way segments (for each direction) and one 2-way segment to which the one-way subgroups would overflow. (In metropolitan local networks, large trunk groups are often provided as one-way only in either direction with no 2-way subgroup.) Where DDD is not provided, the final trunk groups between a small Community Dial Office (CDO) and its toll center are sometimes consolidated on a 2-way basis called a 2-way operator office trunk group. For larger end offices and CDOs with DDD, it is common practice to provide one-way trunk groups to and from the home toll center.

3.05 Individual final groups are usually used as a service protection measure for traffic which might otherwise be routed on a final trunk group in excessive competition with alternate routed traffic. Individual final groups are engineered in a manner comparable to high-usage trunk groups and are for exclusive use of first routed traffic loads which overflow to the final trunk group. Individual final groups are engineered for high occupancy to assure adequate utilization.

3.06 The "routing pattern" for a call between any two points is established by the final route path (or final route chain) between the originating and terminating locations. Where two or more trunks must be connected to complete traffic, the intermediate switch establishing such a connection must be on the final route path. One or more intermediate switches on a final route path may be bypassed by a high-usage trunk group as long as the traffic thus routed always progresses in the direction toward its destination subject to the constraints of the one-level inhibit rule discussed in Appendix D. Referring to Fig. 1 and 2, a call originating in one final route chain and entering a second chain, say at Class 2 switching system, must progress down the second chain through Class 3 and Class 4 switching systems if necessary to the Class 5 destination. Any routing path which involves three final route chains is not permissible since standard routing involves only two chains.

3.07 Appendix C illustrates typical standard routing patterns within the switching plan. It should be noted that the maximum number of trunks connected in the final route chains from a Class 4 location to another Class 4 location cannot exceed seven. These, plus the trunk to the Class 5 office at each end, result in a maximum of nine trunks in tandem. The probability of a call traversing all of the final route links in two complete routing chains is estimated to be only a few calls out of millions. Calls between high-volume points are completed on direct trunks regardless of distance; relatively few encounter multiple switches. Multiple switching is the rule, however, between infrequently called locations.

4. SELECTION OF CONTROL SWITCHING POINTS

4.01 The use of intermediate switching (CSPs) can sometimes increase the efficiency of trunk plant. For example, Plan II, shown in Fig. 3, will effect savings in transmission facilities as compared to Plan I. However, a CSP must be provided with additional capacity for the increased switched traffic load along with features which are not ordinarily required if the switching center serves only a Class 4 switching function. This tends to offset, and in some cases will exceed, the transmission facility savings. It is necessary, therefore, to carefully evaluate these plus other related factors to determine the location, rank, and number of CSPs which will result in the most economical overall network configuration over a reasonably long time span.

4.02 CSP location studies have been made by the Bell System and Independent Operating Companies and must be reviewed from time to time as required by changing conditions. Studies currently being made often indicate the need for fewer CSPs. Such studies reflect the relative costs of transmission facilities and switching equipment suitable for the CSP functions. They recognize the changes in traffic flow occasioned by growth. They include the effect of more common control switching systems at lower levels in the hierarchy which permit additional high-usage trunking to develop with the passage of time. The combined effects of these influences reduce the need for CSP switching functions and are expected to lower the hierarchical rank of some existing switching systems.

EFFECT OF ESTABLISHING A CSP

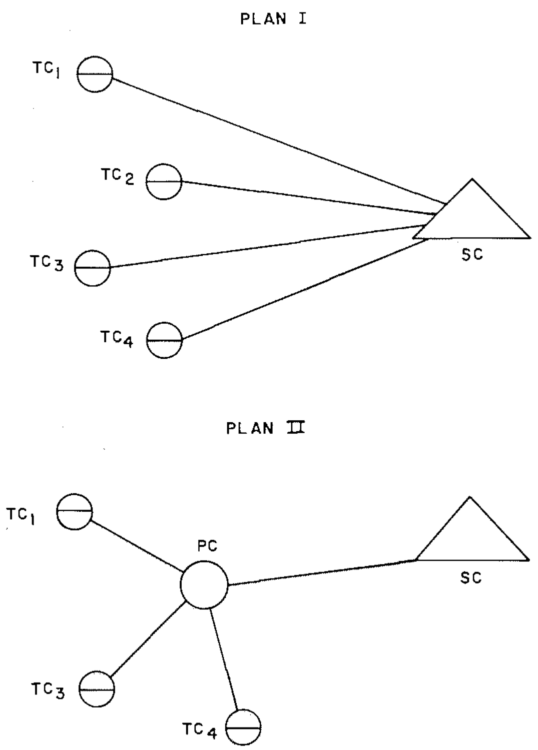


Fig. 3

5. EFFECTS OF THE SWITCHING PLAN ON PLANT LAYOUT

5.01 Alternate routing permits a more efficient (lower cost per carried CCS) network than would be obtained if the trunk groups were all engineered to objective service levels with no overflow. Most growth in an alternate routing network is accommodated by adding new high-usage trunk groups or by adding trunks to existing high-usage trunk groups. Final trunk groups thus tend to grow at a lower rate than the overall growth rate for the total area involved. Appendix B provides more detail on the principles of alternate routing.

5.02 It is essential that these concepts be considered when planning and engineering plant additions. By so doing, the most advantageous plant layout for distance dialing may be obtained and, at the same time, the needs during transition periods can be cared for adequately.

5.03 The final trunk groups between any switching system and its "home" switching system should be engineered for low probability of blocking. (See part 3 of this section.)

5.04 Switching systems of different classifications may be located in the same building. If they are physically different entities, each switching system retains its own classification according to the function(s) it performs in accordance with Table 1.

5.05 Customer-dialed station sent paid traffic must be provided with automatic recording of call billing details at the originating local office (LAMA) or at a centralized point (CAMA). With centralized operation, each end office must be connected directly to the centralized recording system which serves it. There can be ***no*** intermediate switch or concentration of transmission facilities to serve more than one local office entity. The reasons for this are:

(1) Transmission impairment will result from the addition of another switch and transmission link. Some calls could be subjected to more than the permissible nine links end to end.

(2) The traffic probability of blocking will increase from the addition of another one percent blocking link. It may cost more to obviate this impairment than the potential savings from the proposed concentration.

(3) Calling number identification signals are not readily switched intact to the recording location.

For the same reasons, customer-dialed operator serviced or handled traffic (dial 0+ or 0−) likewise must be routed over direct trunks from each end office to the Traffic Service Position System (TSPS) or cord switchboard ***without*** any intermediate switch or concentration.

6. DESTINATION CODE ROUTING

6.01 By providing flexibility and logic in switching systems and by following the numbering plan described in Section 2, whereby every telephone connected to the distance dialing network is identified by a unique 10-digit number, a call can be routed from any point on the network to any other point using the 3-digit NPA code and the 3-digit Central

Office code of the called telephone. For a specific called destination, the same address is employed regardless of where a given call may originate and enter the network. This is called "Destination Code Routing."

6.02 When a call is to be set up between two telephones in the same Numbering Plan Area, the 3-digit Central Office code plus the 4-digit station number are sufficient for completing the connection. The absence of an NPA code is the indication that the call either originates and terminates within the same NPA (home NPA) or that it has arrived from another NPA at a switching system which is capable of completing the connection within the "home" NPA of the called destination. The connection is completed over a final route to the end office which serves the called telephone number. This will require four, five, six, or seven digits as dictated by the capabilities of the central office equipment and local numbering arrangements which are discussed in Section 2.

6.03 It may be necessary to switch a call at one or more intermediate switching systems within the NPA of the called destination before the final trunk group to the desired end office is reached. This is always done within the standard hierarchical routing chain, the intermediate switching systems being of successively lower rank until the final trunk group to the terminating end office is reached. This routing chain is called the "down" chain with reference to completing calls and is represented as the right-hand segment of the routing ladder of Fig. 1. The left-hand segment in Fig. 1 is called the "up" chain with reference to originating calls. Of course, high-usage trunk groups will be used, where provided, to bypass one or more intermediate switching systems as discussed in part 3 of this section. (Also see Appendixes C and D.)

6.04 Connections between switching systems for calls between different NPAs are handled similarly using the full 10-digit destination code. Both originating and intermediate switching systems make use of the 3-digit NPA code to route each call over its particular first choice or alternate route to or toward the called Numbering Plan Area. The entire ten digits are sent forward if the next switching system in the routing ladder cannot complete the connection within the NPA of the called destination. Only seven digits are needed if the trunk route used terminates in the called NPA. Once a call reaches the called NPA, only the last seven digits are needed to advance the call to its destination as discussed above.

6.05 To complete calls to customers where the end office is served by a toll switching system across an NPA boundary, the NPA dialed must be the same as the NPA in which the end office is physically located. Similarly, where customers are served by an end office across an NPA boundary, the NPA dialed is the NPA in which the customers are located and they are assigned a theoretical office code within that NPA. Standard dialing procedures should be established at each individual end office in accordance with the procedures discussed in Section 2 for maintaining uniformity for the NPA and the entire network.

6.06 The code received by a switching system must contain sufficient information to advance the call to or toward its destination. In many instances, a 10-digit call for a distant NPA can be routed at a switching system from the translation of the NPA code alone; this is "3-digit translation." In other instances, involving calls to a distant NPA, the first three digits (NPA code) may not provide sufficient information. When this occurs, the switching system obtains the additional information it requires by also translating the 3-digit Central Office code thus using the first six digits to properly advance the call; this is "6-digit translation."

6.07 If from a particular switching system there is one first choice route to reach some end offices in a given distant NPA and a different first choice route to reach other end offices in that same distant NPA, the switching system must 6-digit translate to determine which route to select to reach the desired end office for the call destination.

6.08 For each Numbering Plan Area, there is a switching system (usually a CSP) which is designated as the "principal city" for that NPA. A CSP may be designated as the principal city for more than one NPA. A principal city is defined as that lowest ranking switching system which can complete to every end office within an NPA on a final route basis, direct or switched. The principal city accommodates those distant locations which cannot provide 6-digit translation to or toward a given NPA. A call from such a location is routed over the network on the 3-digit NPA code to the principal city. If the principal city is within the NPA, the call is completed with the 7-digit destination code. If the principal city is outside the NPA, it performs the necessary 6-digit translation for completion of the call.

6.09 The routing digits sent forward to a given switching system depend upon the requirements of the distant point to which it connects. For example, extra digits, dialed by an operator or prefixed and sent forward by a preceding switching system, may be required to switch calls through a direct control switching system. Appendix A of this section outlines digit prefixing, code conversion, and other features required at CSPs for destination code routing. The digit and translation capabilities of various types of switching systems used in the Bell System are discussed in Section 4 and are summarized in Tables 2 and 3 of that section.

7. ROUTING CHANGES

7.01 From time to time, new high-usage trunk groups and new switching systems must be added to the network to provide for growth. These additions usually require routing changes to be put into effect in many existing switching systems. In order to minimize the frequency of reproducing switchboard bulletins and first reference lists, routing changes are combined for implementation on specified dates. The scheduled time and dates for network switching system cutovers and routing changes are 2 PM Eastern Time, generally on the first and third Saturdays of each month. Exceptions occur when the tentative "cutover" weekend includes Easter, Mother's Day, or Father's Day. To avoid these heavy traffic days, the scheduled date is either advanced or deferred one week. The "after midnight hours" are not precluded when the changes involve rearrangements such as local office replacement or wire center boundary changes and can be controlled between the end office and the switching system on which it homes.

APPENDIX A—BASIC REQUIREMENTS FOR CONTROL SWITCHING POINTS (CSPs) (ALL CLASS 1, 2, AND 3 OFFICES)

1. HOMING ARRANGEMENT REQUIREMENTS

1.01 There must be at least one switching system of the next lower rank homing on a CSP, ie, a Class 2 switching system must have at least one Class 3 switching system homing on it.

2. TRANSMISSION REQUIREMENTS FOR A CSP (Also see Section 7.)

ANALOG TRANSMISSION

(1) VNL operation of intertoll trunks.

(2) VNL plus 2.5-dB operation of toll-connecting trunks.

(3) Terminal balance objectives must be met by actual measurement on all toll-connecting trunks.

(4) Through balance requirements must be met at 2-wire switches between intertoll trunks for through switched traffic. Any CSP which does not meet through balance requirements is classified as deficient.

DIGITAL TRANSMISSION

2.01 Network objectives for digital transmission are covered in Section 7.

3. SWITCHING SYSTEM REQUIREMENTS

(1) Storing of digits

(2) Variable spilling—deletion of certain digits when not required for outpulsing

(3) Prefixing of digits when required

(4) Code conversion—a combination of digit deletion and prefixing (also termed substitution)

(5) Translation of three or six digits (also translation of four or five digits for WH calls, ie, calls to operators coded 11XX or 11XXX)

(6) Automatic alternate routing.

3.01 Where step-by-step switching equipment is employed at a Class 3 location, requirements of parts 1 and 2 can be met. The switching requirements delineated in part 3 can be provided only with common control equipment. Any Class 3 step-by-step installation not provided with common control features is, therefore, deficient in these equipment capabilities. It follows that only equipment with the common control capabilities listed can be permitted to route traffic items through a noncommon control step-by-step switching system providing a Class 3 switching function.

APPENDIX B—ALTERNATE ROUTING

1. GENERAL

1.01 The successful completion of long distance traffic dialed by operators and customers depends upon a high-speed trunking network so that "No Circuit" (NC) conditions are rarely encountered under engineered conditions. Alternate routing is one of the techniques that makes this possible with reasonable trunk efficiency. It is the purpose of this appendix to explain alternate routing and why it is employed.

1.02 Definitions:

(1) Alternate Routing—The feature of a switching system by which a call, after encountering "NC" in the first choice route, is offered another route to or toward its destination.

(2) Multialternate Routing—Alternate routing with provision for advancing a call to more than one alternate route tested in sequence within the hierarchical routing discipline.

(3) High-Usage Trunk Group—A group of trunks for which an engineered alternate route is provided.

(4) Final Trunk Group—A group of trunks to the next office on the final route and in which the number of trunks is engineered to result in a low probability of blocking. A final trunk group provides the last choice route for all traffic using it, including traffic from high-usage groups overflowing to it.

(5) Full Trunk Group—A group of trunks which ordinarily would be a high-usage group but is engineered like a final trunk group with low probability of blocking for the traffic offered to it. The normal alternate routing capability is not employed for this traffic. A full trunk group may receive overflow traffic but is not permitted to overflow to an alternate route.

2. THEORY OF ALTERNATE ROUTING

2.01 The principle of alternate routing is applied to telephone traffic by providing a first choice (high usage) route for a given item of traffic and a second choice (alternate) route when the call fails to find an idle trunk on the first choice route. Additional alternate routes may be provided subject to certain routing restrictions discussed later.

FUNDAMENTALS

2.02 Alternate routing is advantageous for two reasons: (1) it creates the potential for meshing traffic streams which have differing peak periods (busy hours) and (2) it provides the opportunity to minimize the cost per CCS for carried traffic.

MINIMIZING THE COST PER CARRIED CCS (HUNDRED CALL SECONDS)

2.03 Figure B1 depicts an alternate routing arrangement.

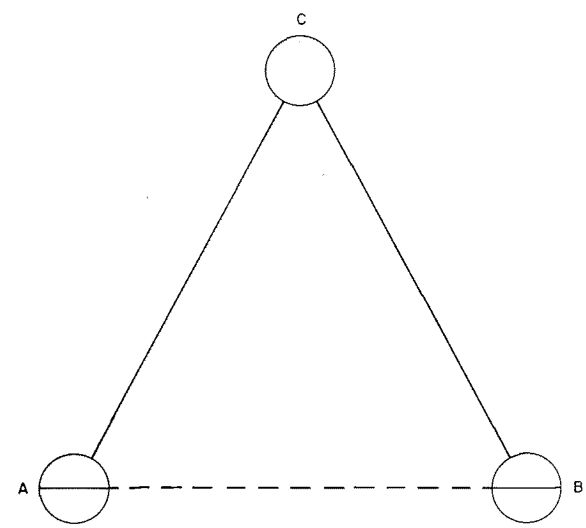


Fig. B1

2.04 This figure illustrates a high-usage (HU) trunk group connecting Toll Centers A and B with an alternate (final) route via a Primary Center C. In general, the direct or high-usage route is shorter and cheaper than the alternate route path. However, because each leg of the alternate route is used by other calls, a number of traffic items can be combined for improved efficiency on that route.

2.05 The basic engineering problem is to minimize the cost of carrying the offered load. (How much of the offered load should be carried on the direct route and how much on the alternate route?)

2.06 The graph in Fig. B2 shows the relationships involved. The graph shows, as a function of the number of trunks in the HU trunk group, the cost of the direct route, the cost of the alternate route, and total cost for serving the given offered load. HU trunk group cost, of course, increases in direct proportion to the number of HU trunks.

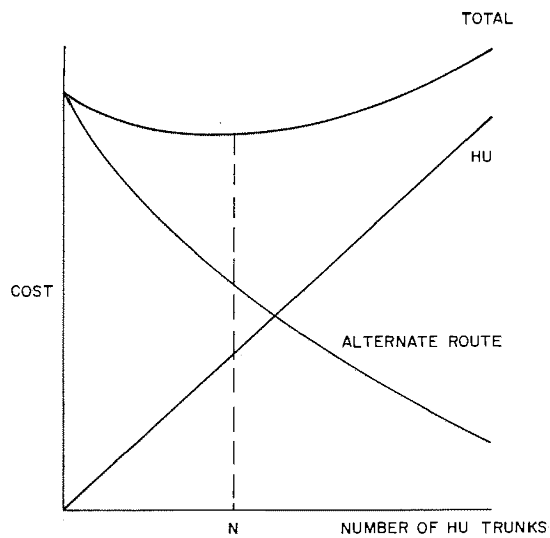


Fig. B2

If there are no HU trunks, then all of the offered traffic must be carried on the alternate route so that alternate route cost is high. As trunks are added to the HU trunk group, less of the offered traffic is overflowed to the alternate route so that the alternate route cost decreases. This cost decreases very rapidly as the first trunks are added to the HU trunk group since each of these trunks is very efficient,* thereby relieving the alternate route of a substantial amount of load. As more HU trunks are added, each successive HU trunk carries less traffic while each alternate route trunk continues to carry a significant amount of traffic and eventually it becomes undesirable to add any more HU trunks. The point at which this threshold occurs is where the total cost (the sum of the two curves) is minimized. This point is designated as N in Fig. B2.

*This principle may be illustrated by assuming the case of a step-by-step switching system offering a call to a group of ten one-way outgoing 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; and trunk No. 3 will be used less than No. 2 and so on to the tenth trunk which is called into use only when all prior trunks are busy.

2.07 A method commonly used to determine N is called Economic CCS (ECCS) engineering. This method determines the maximum number of HU trunks for which the cost per CCS carried on the "last" trunk of the HU trunk group is less than or equal to the cost per CCS on an additional alternate route trunk.

2.08 This relationship can be expressed in equation B1:

$$\frac{\text{CALT}}{\text{CHU}} = \frac{28}{\text{ECCS}} \qquad \text{(B1)}$$

This equation is the basis of ECCS engineering. The equation is solved for the ECCS which is the load to be carried by the "last" or least efficient trunk in the high-usage trunk group. Given the ECCS and the offered load, standard trunking tables can be entered to determine the number of trunks required so that the load carried on the last trunk is equal to the ECCS. (In actual practice, the cost ratio may be such that an integer number of trunks will not result in the last trunk CCS equaling the ECCS. In this case, the usual procedure is to select the number of trunks such that the load carried on the last trunk is as close as possible to but not greater than the ECCS.)

2.09 Since equation B1 is solved for the ECCS, the other elements of the equation must be known. The left part of the equation $\left[\frac{\text{CALT}}{\text{CHU}}\right]$ is the cost ratio or the relationship of the cost of a path on the alternate route to the cost of a trunk on the direct route. Cost ratios used for alternate route engineering are always greater than unity (1).

2.10 The "28" shown in the equation is the incremental capacity of the alternate route (that capacity which would be added to the alternate route by the addition of one path). This value is usually assumed to be a constant of 28 CCS, thereby permitting calculation of the ECCS as a function of a single variable, the cost ratio.

2.11 It can be seen, thus, that with low cost ratios, the ECCS will be high and fewer high-usage trunks will be provided. Conversely, a low ECCS would result from a high cost ratio and a greater number of HU trunks will be provided. Simply, the more expensive the alternate route relative to the high-usage trunk group, the less traffic will be overflowed to it.

2.12 It will be noted on Fig. B2 that the total cost curve has a rather broad minima. As a result, errors in ECCS which might result from inaccurate cost ratios or incremental CCS values will not have a significant impact on network costs.

EFFECT OF LOAD VARIABILITY

2.13 The number of high-usage trunks to be provided in a group depends not only on the ECCS and offered load but on the variability of the offered load as well. This variability can be either within the hour, usually peakedness, or day to day. Such variability can be the result of traffic patterns as in the case of day-to-day variations or it may be system induced as is usually the case with peakedness. In either event, the effect of such variability is a reduction of the capacity of a group of trunks below that predicted by standard Erlang or Poisson trunking tables. Where such variability is present, equivalent random engineering techniques are required and special capacity tables are used to size probability engineered trunk groups.

NONCOINCIDENT BUSY HOURS

2.14 Traffic volumes reach peaks during certain hours. Transmission facilities are usually provided to care for average time consistent busy hour loads in the busy season of the year.

2.15 Where only one outlet (trunk group) is available, facilities must be provided for the group busy hour load. If two routes (a direct and an alternate route) are available, however, the busy hours on each of the two routes frequently will be different. Where this is the case, facilities need only be provided in the direct route to care for that portion of its busy hour offered load which cannot be carried on idle trunks in the alternate route which is sized for a different busy hour and, thus, is not fully loaded in the busy hour of the direct route.

ALTERNATE ROUTE SELECTION

2.16 Often there are two or more potential alternate routes for a high-usage trunk group. The selection of alternate routes may be based on a routing discipline if overall cost differences are not significant or the choice may be based on the economics of each individual case, ie, selection of the least expensive alternate route. In general, overall network economics are not highly sensitive to variation in alternate routes.

MINIMUM TRUNK GROUP SIZE CONSIDERATIONS

2.17 New high-usage trunk groups are ordinarily established when offered loads are large enough to justify them. Cost ratio techniques alone will prove in groups with as few as one trunk. Other factors, however, such as the administrative costs associated with data collection, trunk forecasting, and trunk servicing, usually preclude establishing these groups until at least three trunks can be efficiently loaded. With the longer intertoll groups, the administrative costs are higher and larger minimum group sizes may be necessary. There can also be cases where the cost of certain central office equipment should be considered.

3. APPLICATION OF ALTERNATE ROUTING

LOCAL DIALING (COMMON CONTROL OFFICES ONLY)

3.01 In large multioffice cities, direct trunks are provided from each local office to every other local office where there is sufficient traffic to economically justify such trunks. Also, each local office has trunks to and from one or more common tandem points. Calls between offices not directly connected are completed through a tandem center. Since every local office is connected to a tandem, the tandem network may be used to provide an alternate route for each of the direct groups. Therefore, fewer direct trunks are needed. Furthermore, with the ability to alternate route through a tandem, it generally becomes economical to accommodate growth by establishing new direct groups of small size between offices not previously served by direct groups and thus reduce requirements for tandem switching.

3.02 Because alternate routing can be done automatically, it is used extensively to provide economies and service advantages. Calls may be offered in succession to a series of alternate routes via one or more tandem centers.

3.03 In an emergency situation of limited impact and extent such as a cable failure, the ability to use an alternate route provides a measure of protection to service. However, if there is a heavy surge of traffic over an entire area (as in a major disaster such as a hurricane), there is little margin to absorb surges in load and the service may not be as good as it would be with a nonalternate route network.

DISTANCE DIALING—AUTOMATIC SELECTION OF ALTERNATE ROUTE

3.04 The principle of alternate routing is basic in the design of the distance dialing network. Switching equipment automatically seeks out the alternate routes. The field of application in distance dialing is more extensive than in the case of local dialing since a call may be subject to routing through more switching systems in the 5-level hierarchy.

3.05 At each switching system, all of the trunk groups to which a call may be offered, except the last, are kept very busy (high usage) with a portion of the traffic overflowing to other routes. The final trunk groups are fewer in number and are low blocking groups so that the engineered level of service is good. The overall chance of completing a call is improved by the fact that it can be offered to more than one trunk group. The switching equipment operates rapidly and there is no significant change in speed of service between the selection of direct and alternate routes.

3.06 In addition to the final trunk groups which connect switching systems to their home switching centers, direct high-usage trunk groups to other switching systems are provided wherever it is economical to do so. However, there are no direct routes for calls to many low-volume points. The first route for such calls is a switched route over two or more trunk groups of the network using the cheapest routing combination possible in the standard routing pattern.

3.07 Since the 50 states, Canada, and the Caribbean area are integrated into the switching plan, the employment of an alternate routing network on such a large scale requires an orderly and prearranged routing plan. The routing plan is described under "Homing Arrangement and the Interconnecting Network" in this section. Appendix C of this section, entitled "Routing Patterns Under the Switching Plan," describes how alternate routing is used.

APPENDIX C—ROUTING PATTERNS UNDER THE SWITCHING PLAN

1. GENERAL

1.01 This appendix discusses routing patterns that are permissible within the framework of the switching plan for distance dialing. Economic and other considerations determine various individual patterns. Examples are included.

1.02 Figure C1 illustrates many (although not all) permissible high-usage trunking patterns within the framework of the standard routing plan. It should be understood that the traffic items permitted to traverse high-usage trunk groups between switching systems which are not the same rank or which have more than one rank order of difference are limited by the one-level inhibit rule discussed in Appendix D.

2. TYPICAL ROUTING PATTERNS

2.01 Figure C2 and the following discussion illustrate a particular routing pattern that might be involved in completing a call that appears at End Office A served from Toll Center B destined for End Office P served from Toll Center Q. In this example, B has trunks to C only; hence, the call must be routed to that Primary Center.

2.02 At C, the call would be offered first to the high-usage trunk group to R. Finding a trunk in this group idle, the call would be routed to R where the switching system would look for an idle trunk in the final trunk group to Q. At this toll center, the call would be completed to the called customer served from P over an idle trunk in the final trunk group to P.

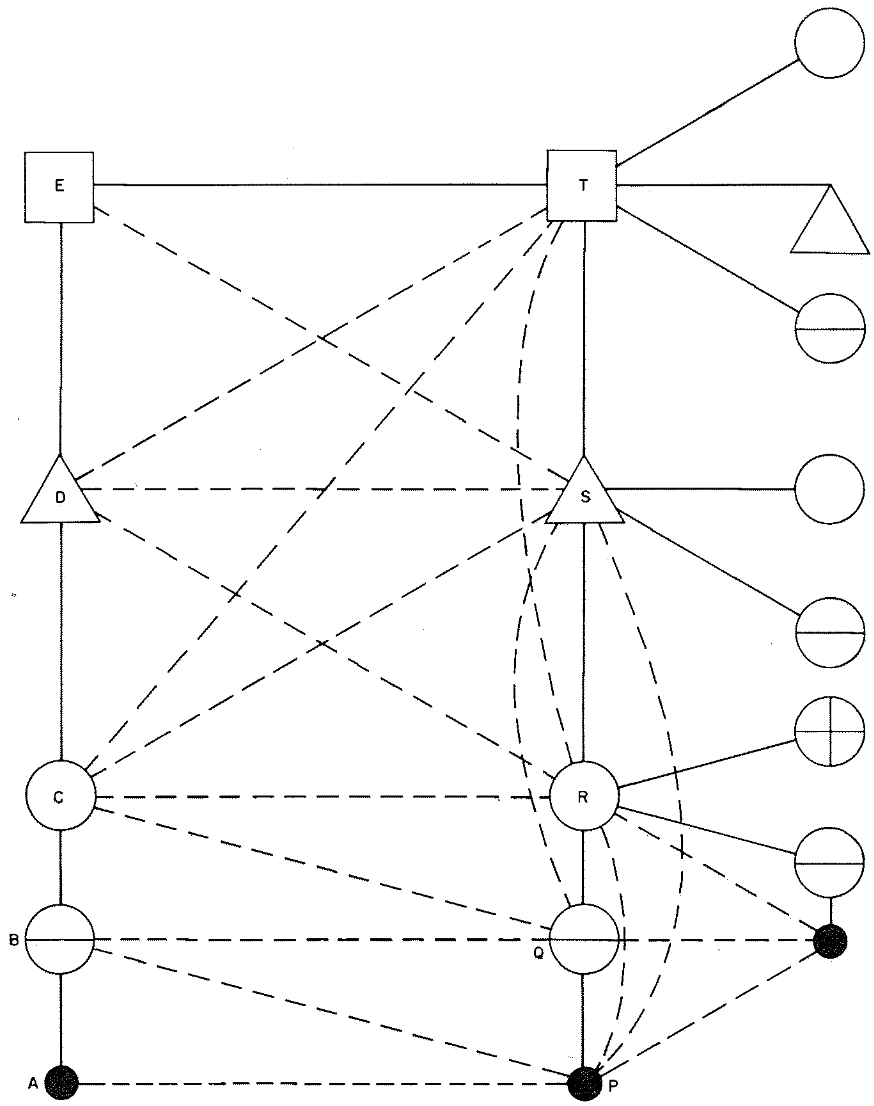
2.03 If, however, all of the trunks in the first choice high-usage trunk group (between C and R) were busy, the call would next be offered to the high-usage trunk group between C and S assuming C - S - R is the alternate route. At S, the call would have a choice of two routings: (1) via the direct high-usage trunk group to Q or, if all trunks in this group were busy (2) over the final route chain S - R - Q.

> ***Note:*** The routing S - Q is an apparent violation of the one-level inhibit rule covered in Appendix D. It must be remembered however, that if no trunk groups can be justified other than those shown in Fig. C2, such routing is desirable and necessary to bypass a switch at R for all but alternate routed traffic to Q.

2.04 In the event that all trunks in the group between C and S are busy, the call should next be offered to the final trunk group to D. The other high-usage trunk groups at C are not permissible routes for this illustrative call under the one-level inhibit rule. At D, all high-usage trunk groups shown are permissible routes.

2.05 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 offer different configurations of high-usage trunk groups.

SWITCHING PLAN
(ROUTING PATTERN)



NOTE:
AN HU TRUNK GROUP MAY BE ESTABLISHED BETWEEN ANY TWO OFFICES REGARDLESS OF LOCATION OR RANK, WHENEVER THE TRAFFIC VOLUME JUSTIFIES, SUBJECT TO THE ONE-LEVEL INHIBIT RULE.

——— FINAL GROUP
— — — POSSIBLE HIGH-USAGE GROUP

Fig. C1

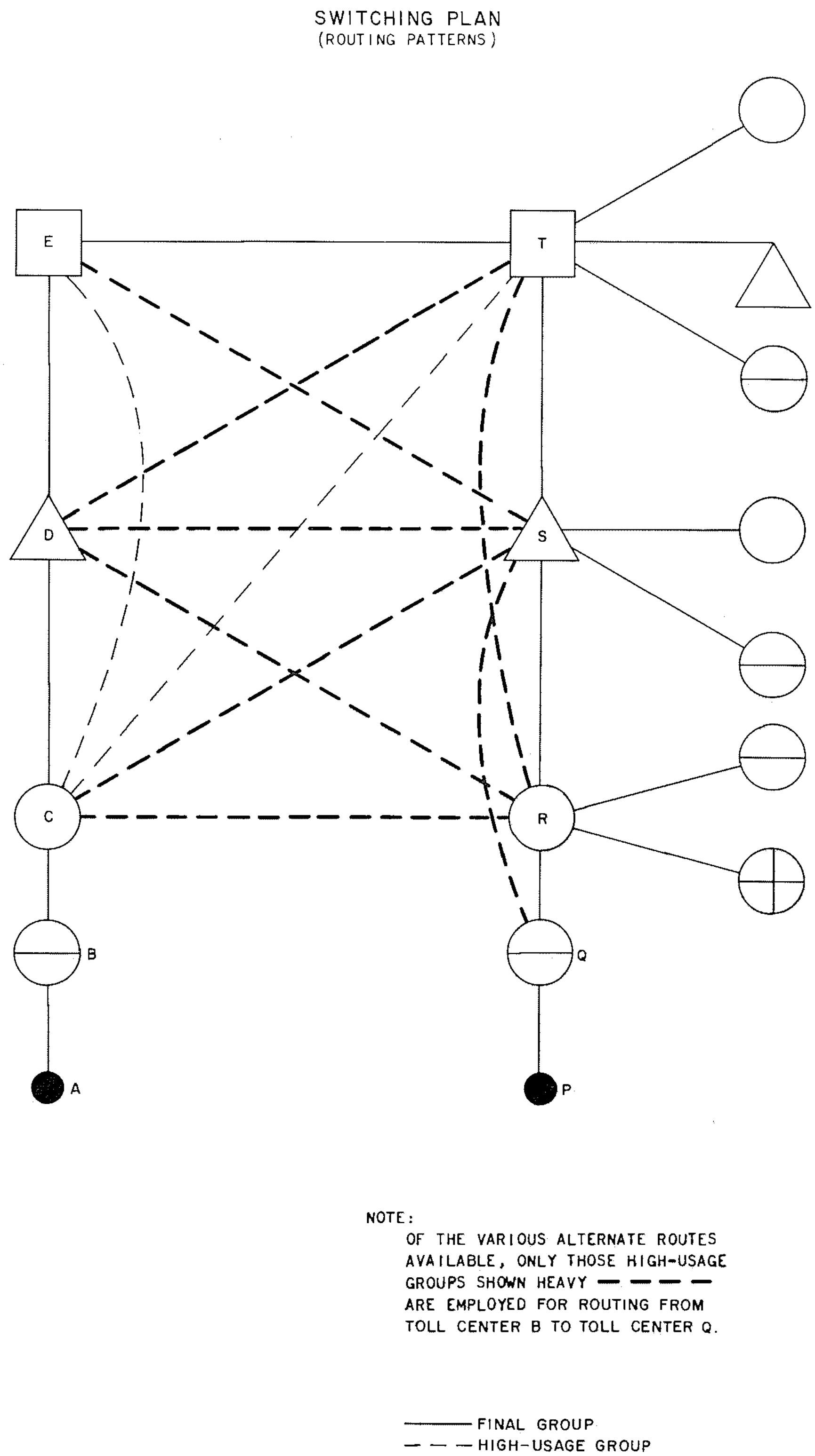

SWITCHING PLAN
(ROUTING PATTERNS)
E
T
D
S
C
R
B
Q
A
P
NOTE:
OF THE VARIOUS ALTERNATE ROUTES AVAILABLE, ONLY THOSE HIGH-USAGE GROUPS SHOWN HEAVY — — — — ARE EMPLOYED FOR ROUTING FROM TOLL CENTER B TO TOLL CENTER Q.
FINAL GROUP
HIGH-USAGE GROUP

Fig. C2

APPENDIX D—ONE-LEVEL INHIBIT RULE

1. GENERAL

1.01 In general, a high-usage trunk group may be established between any two offices if the volume of traffic and economics justify it. High-usage trunking should be developed to the maximum economical extent to reduce the requirements of intermediate switching and thereby route traffic at as low a level in the hierarchy as possible. To accomplish the objective of keeping the traffic as low as possible in the hierarchy on an equitable basis, the "one-level inhibit rule" has been established.

2. DEFINITION

2.01 The basic purpose of the one-level inhibit rule is to avoid the use of a high ranking switching system in a distant final route chain as a concentrating point for traffic to locations below it in its final route chain. Such use has the disadvantage of forcing more switching at a higher level in the switching hierarchy than is really necessary. Under the one-level inhibit rule, the switching ***function*** performed for the ***first routed*** traffic by the switching system at either end of the high-usage trunk group ***may be of the same class number of switching function or may differ by only one class number of switching function.*** This rule is based on the assumption that a route will be available along a path with switching systems whose ranks differ by no more than one class number. Illustrations of proper application are discussed below.

3. SPECIFIC APPLICATIONS

3.01 The following are specific applications of the one-level inhibit rule. In Fig. D1, Toll Center B (Class 4 switching function) may have high-usage trunk groups for first routed traffic to:

(1) Toll Center Q (Class 4 switching function ***same*** as B)

(2) End Office P (Class 5 switching function—one ***class number*** of switching function greater than B)

(3) Primary Center R (Class 3 switching function—one ***class number*** of switching less than B).

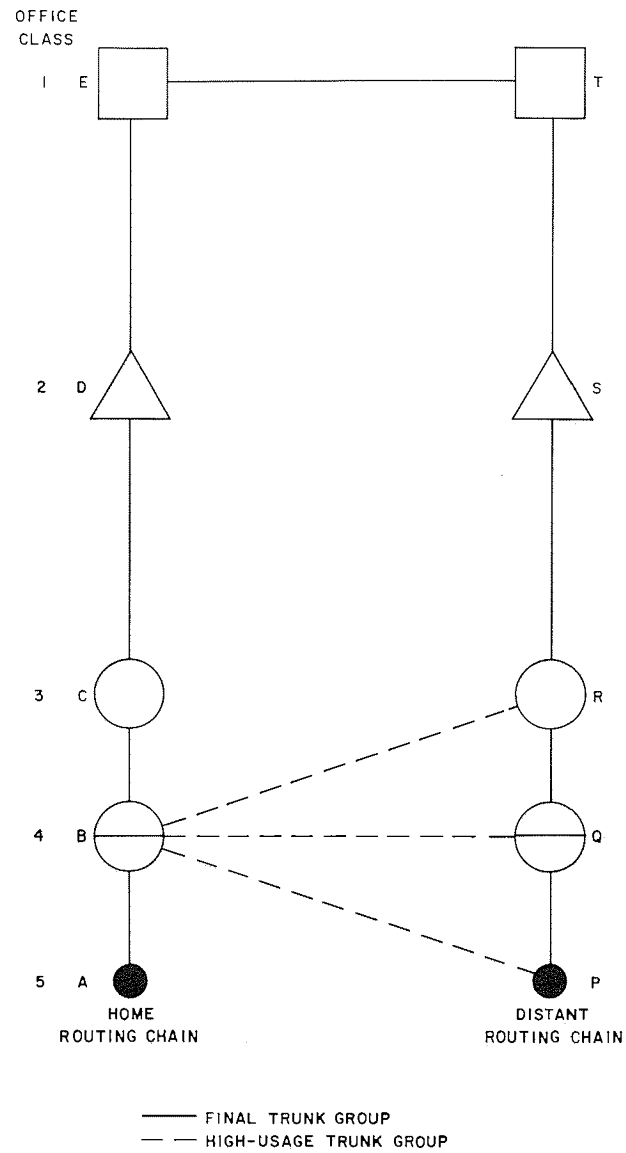


Fig. D1

3.02 If trunk groups from Toll Center B to P, Q, or R cannot be justified because of insufficient traffic loads, these traffic items are routed to the home Primary Center C. Since this Primary Center more than likely serves as a concentrating point for other Class 4 offices in addition to B, trunk groups can probably be justified between C and Q or R. Should this not be the case, a C - S trunk group may be established utilizing the Class 2 switching function at S. In no case does the one-level inhibit rule permit a high-usage trunk group between B and S to be established for the Class 2 switching function of Sectional Center S.

3.03 Another application of the one-level inhibit rule is shown in Fig. D2. In this case, the B - S trunk group is justified by the traffic load utilizing the Class 3 and Class 4 switching functions of the Sectional Center S. In this illustration, there is insufficient traffic to justify high-usage trunk groups from either B or C to Q or R. Therefore, B and C traffic to the sectional area served at S must switch at S. Under these conditions, it is permissible and desirable to route traffic between B and P, Q, and R over the B - S trunk group. In like manner, calls arriving at S for completion within its final route chain will use the most direct route available to the call destination. It is most important to note, however, that this "skip-level" routing imposes an obligation to establish the "missing" direct high-usage trunk groups at lower hierarchical levels just as soon as traffic volumes and costs can justify them.

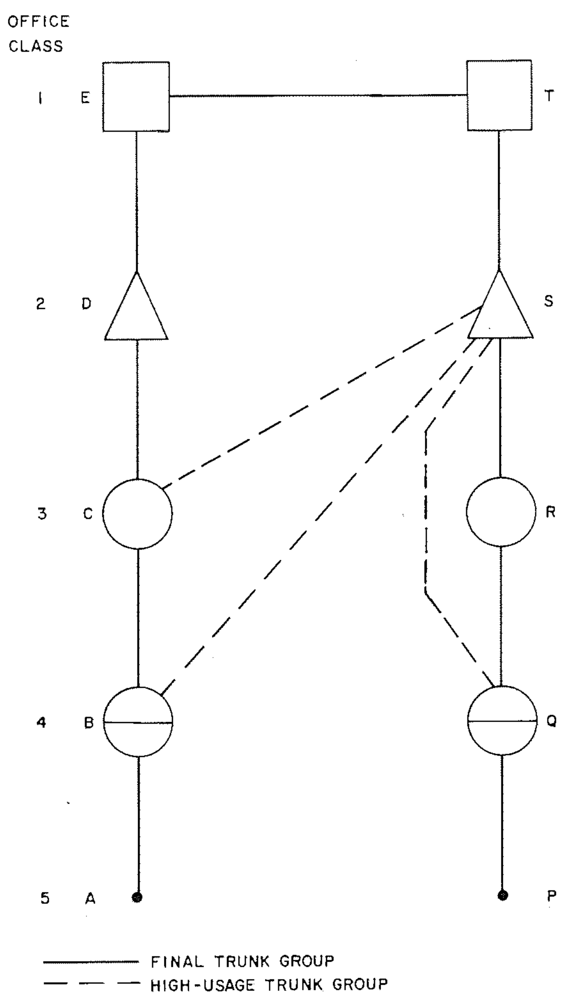


Fig. D2

3.04 As an illustration of an unusual case, a trunk group may be established between an end office (Class 5 switching function) and a distant Regional Center, but only for the Class 4 switching function performed by that Regional Center switching system (Fig. D3), that is, the switching function by which end offices are connected to each other and to the network via an intermediate switch. A Regional Center acts as an ordinary toll center for the end offices homed on it. It should be noted that, if the trunk group A-T is arranged for 2-way traffic, items of traffic from anywhere in T's routing chain destined for A will use this trunk group. This follows the principle of utilizing the most direct high-usage trunk group when no trunk group can be justified at lower levels in the routing chain to the terminating location.

3.05 The one-level inhibit rule applies also to the home routing chain in a manner similar to that for a distant routing chain. In Fig. D4, for example, a high-usage trunk group may be established between End Office A and Sectional Center D, but only for the end offices homed on D for which it performs a Class 4 switching function. Similar high-usage routes can be established for the various ranks of switching systems and classes of switching functions within the home routing chain. Traffic from End Office A to distant routing chains may use the A - D high-usage trunk group to bypass intermediate hierarchical levels in the home routing chain to the extent that trunk groups cannot be justified to any distant routing chain at these lower levels.

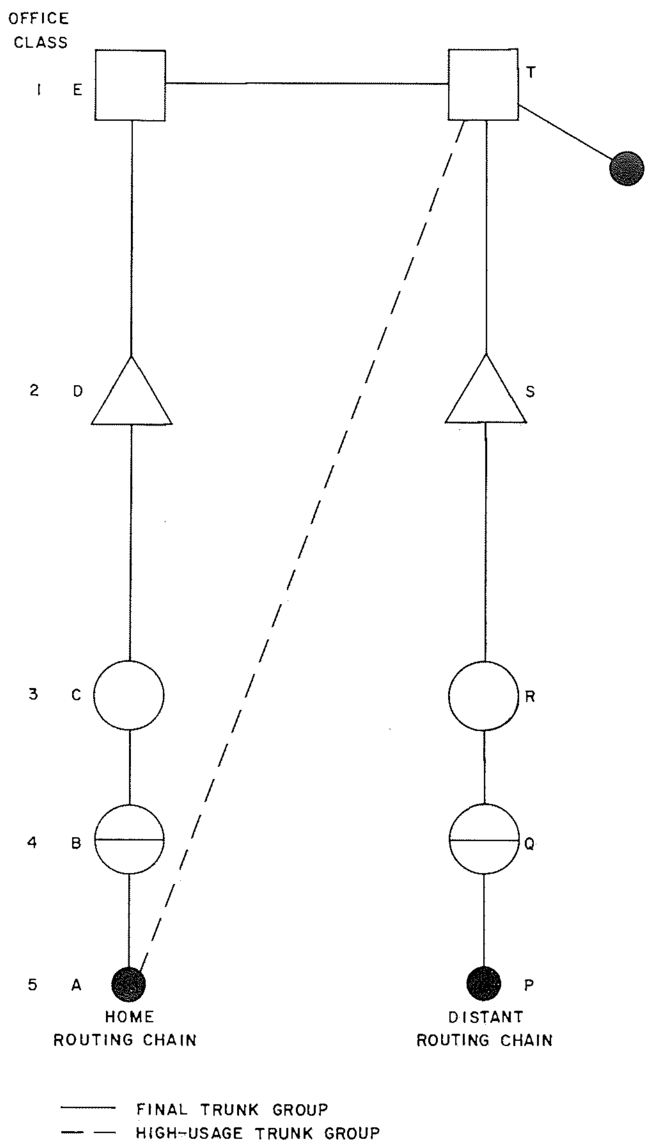

OFFICE
CLASS
1 E
T
2 D
S
3 C
R
4 B
Q
5 A
P
HOME
ROUTING CHAIN
DISTANT
ROUTING CHAIN
FINAL TRUNK GROUP
HIGH-USAGE TRUNK GROUP

Fig. D3

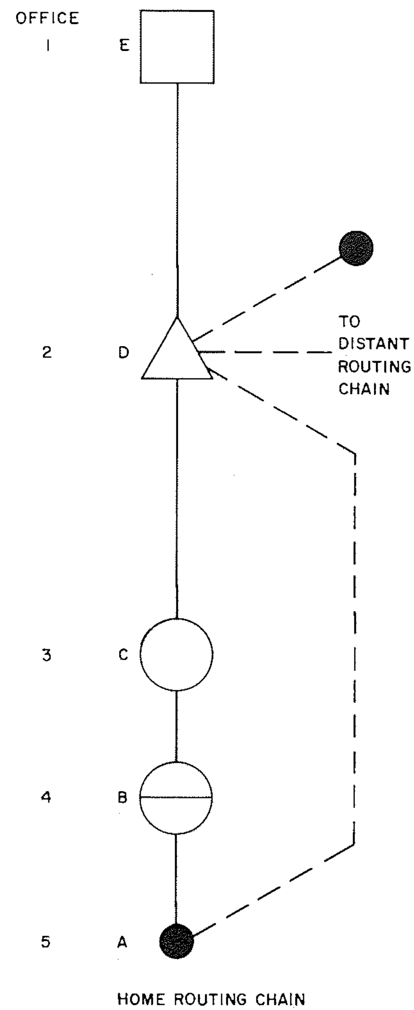

OFFICE
1 E
2 D
TO
DISTANT
ROUTING
CHAIN
3 C
4 B
5 A
HOME ROUTING CHAIN

Fig. D4

NOTES ON DISTANCE DIALING

SECTION 10

INTERNATIONAL DIALING

CONTENTS PAGE

1. GENERAL

1.01 Customer International Direct Distance Dialing (IDDD) from the United States was first introduced in March 1970. It has been expanded to include up to 20 countries and has been implemented in certain exchanges in many US cities. Many foreign countries also permit customer dialing to the USA. IDDD is expected to expand rapidly during the next decade as central office modifications, modernization, and TSPS make it available to more customers.

1.02 The term IDDD applies to calls which terminate outside the North American integrated DDD network, world zone 1. (See Fig. 1.) Calls to Canada are international but are handled via the integrated network. Mexico, although geographically part of North America, elected to be in world zone 5. Calls to Mexico from the North American integrated network are not handled via IDDD but by other arrangements. Certain Caribbean points also are in world zone 5 and require individual arrangements.

1.03 International Originating Toll Center (IOTC) operation provides the capability for local operators to complete international calls. It is discussed in this section so that a complete overview of the services available to international callers can be treated.

1.04 Calls from certain North American locations, where IDDD or IOTC service is not available, are transferred to an International Operating Center (IOC) where an operator dedicated to the handling of international calls establishes the connection on a manual basis or by operator dialing. All calls to countries where IDDD and IOTC are not authorized are handled by the IOC method.

1.05 The term "overseas" has been in common usage for many years but is subject to misinterpretation since Hawaii, Alaska, the Virgin Islands, and other points in world zone 1 are included in this category but are actually part of the North American integrated DDD network. Basically, this section will deal with points outside world zone 1.

1.06 In other parts of this section, reference is made to the "Recommendations of the CCITT" or "Green Books." The following paragraphs contain a capsule description of the ITU, the CCIR, and the CCITT, as well as the ordering information for the books containing the Recommendations of the CCIR and CCITT.

ITU-CCIR-CCITT

1.07 The international organizations which relate to telecommunications are:

(1) ITU—International Telecommunication Union

(2) CCIR—International Radio Consultative Committee

(3) CCITT—International Telegraph and Telephone Consultative Committee.

The CCIR and CCITT are the technical study branches of the ITU. The aim of the work being done in the CCIR and CCITT is to facilitate improvements in international telecommunications. The duties of the International Radio Consultative Committee (CCIR) are to study technical and operating questions relating specifically to radio communications and to issue recommendations on them. The duties of the International Telegraph and Telephone Consultative Committee (CCITT) are to study technical, operating, and tariff questions and to issue recommendations relating to telegraphy and telephony including data and program services.

1.08 Membership in the ITU is limited to governments and includes the United States. However, private telephone operating agencies can be members of the CCIR and CCITT and manufacturers and research organizations can be advisory members of the CCIR and CCITT. The United States Government as a member of the ITU is automatically a member of the CCIR and CCITT. Because of the breadth of the membership, a CCIR or CCITT meeting can be described as an assembly of engineers and specialists representing most of the telecommunication administrations and organizations of the world, both governmental and private.

1.09 Work in both the CCIR and CCITT is divided among study groups and is based upon a study program approved by the membership of each at their respective Plenary Assemblies held at 3- to 4-year intervals. Between Plenary Assemblies, members submit contributions on the study items and representatives of the members meet at scheduled intervals to study the questions and prepare recommendations dealing with the international aspects of communications.

1.10 The CCIR and CCITT work mainly as separate entities having different timetable or study meetings and Plenary Assemblies. They publish their approved Recommendations and Plenary Reports periodically.

1.11 Although the Recommendations of the CCIR and CCITT are not considered as binding regulations, they represent a common reference for telephone operating organizations around the world for technical and operating uniformity in international telecommunication services. The CCITT Recommendations are contained in a series of volumes published by the International Telecommunication Union in Geneva, Switzerland. The latest series (1973) has green covers and are, therefore, designated "Green Books" of the CCITT. The CCIR Recommendations are also published by the International Telecommunications Union in Geneva, Switzerland. The latest series reflects work completed at the 1970 New Delhi Plenary Assembly and the series reflecting work completed at the 1974 Plenary Assembly should be available in late 1975.

1.12 The CCIR and CCITT books may be purchased from:

General Secretariat
The International Telecommunication Union
Place des Nations
CH 1211—Geneva—20, Switzerland

The UN Book Store in New York also maintains a supply and will fill orders. The address is:

United Nations Book Store
UN Plaza GA32
New York, New York 10017

The ITU also publishes a monthly magazine in English, French, and Spanish titled "Telecommunications Journal." Schedules for forthcoming meetings and announcements of other publications are contained in each issue. A complete list of the publications of the ITC can be obtained free of charge from the ITU address in Geneva, Switzerland listed above.

2. WORLD NUMBERING PLAN

2.01 The worldwide numbering plan provides each customer with a unique telephone number. Each world telephone number consists of a country code followed by the national number. International agreement applies the restriction that the country code plus the national number shall not exceed 12 digits. If the number exceeds 12 digits, it is not dialable from the North American network.

2.02 The number of digits in a dialable number can vary up to and including the limit of 12 depending on the requirements of a particular country. With a few exceptions, a world number can be held to 11 digits. In addition to the world telephone number, the originating customer must dial an international prefix. The prefixes for the North American integrated network are discussed in 2.09 of this section.

2.03 For numbering purposes, the world is divided into zones and every country is assigned a distinctive country code. Each country within a particular world numbering zone has the zone number as the first digit of its country code. The country codes may be one, two, or three digits. For example, USSR has been assigned the one-digit code 7; Belgium has the 2-digit code 32; Portugal has the 3-digit code 351. The European region has a very large requirement for 2-digit country codes; therefore, this region has been assigned both world zones 3 and 4.

2.04 The variable number of digits in the country code permits some national numbers to be longer than others while still limiting to 12 the total number of digits in a customer's world number. The total number of country codes available from this choice of a one-, 2-, or 3-digit code is adequate for requirements as foreseen to the year 2000 A.D.

2.05 North America has an integrated numbering plan. The single digit 1 is used as the country code by all the countries in the North American zone. A list of countries included in world numbering zone 1, as well as the countries included in other world numbering zones, and the codes assigned to each country as of 1973 may be found in Chart 1. Detailed examples for Europe are shown in Fig. 3.

2.06 The general boundaries of the world numbering zones are illustrated in Fig. 1. The numbering zones are:

(1) North America (integrated numbering zone)

(2) Africa

(3) Europe

(4) Europe

(5) South America, Central America, Mexico, and Cuba

(6) South Pacific (Australasia)

(7) USSR

(8) North Pacific (Eastern Asia)

(9) Far East and Middle East.

2.07 The world telephone number of a customer in North America (United States or Canada, for example) is comprised of the digit 1 and the national number. The following is an example of a letterhead for a customer located in the North American integrated network:

Telephone	National	(311)555 XXXX
	International +1	311 555 XXXX

The + sign before the international number indicates that an international prefix must be dialed. (See 2.09.)

Examples of world telephone numbers in other world zones are as follows:

United Kingdom	+ 44 plus 7 to 9 digits
Switzerland	+ 41 plus 7 to 8 digits
Japan	+ 81 plus 8 to 9 digits
Israel	+ 972 plus 6 to 7 digits
Hong Kong	+ 852 plus 6 to 8 digits

2.08 To implement IDDD, national telephone systems must be arranged to:

(1) Recognize and handle international prefixes to overcome the ambiguity when national and foreign numbers employ the same initial digits.

(2) Accept and handle the increased number of digits. It may require expansion of the digit capacity of registers in local and toll offices.

(3) Route calls from the originating local office to the appropriate international switching center.

2.09 The Bell System plan for IDDD is compatible with the world numbering plan. The following two international prefixes are in use within the North American integrated network:

(1) 011 + for international station-to-station unassisted calls

(2) 01 + for international customer-dialed and operator-serviced calls, such as person-to-person, credit card, collect calls, etc.

To place an IDDD call, a customer calling from an end office with IDDD capability will dial the appropriate prefix, then the country code (one, two, or three digits), followed by the national number of the called station.

2.10 The Bell System's plan for customer dialing to Mexico varies from the world interzonal plan because of the high community of interest between the US and Mexico and because of certain technical arrangements developed prior to the establishment of a world dialing plan. The Mexican national network has an 8-digit numbering plan used for both address and routing purposes. The routing codes employed to complete long distance calls within the Mexican network are one, two, or three digits long. Central Office codes and station numbers of varying length complete the string of eight digits. The North American numbering plan uses a fixed 7- and 10-digit format with unique 3-digit area and office codes.

2.11 An interim arrangement has been developed in the US to provide customer dialing to Mexico City. This arrangement uses the special Area code 905. To dial Mexico City direct, a customer would dial 90 (5) plus seven digits. The 8-digit number required to complete the call consists of the 5, which is the routing code assigned to Mexico City in the Mexican network plus seven digits. When 90 is prefixed to the Mexico City routing code of (5) and the 7-digit Mexico City subscriber number, it completes the 10-digit number required in the North American DDD network. Calls dialed in this manner appear as directed to NPA code 905, thus providing a valid and unique North American telephone address.

2.12 Another portion of Mexico can be reached with NPA code 903. In this particular case, 7D numbers compatible with the North American numbering plan have been assigned. The long-range plan for customer-dialed traffic from the US to Mexico will utilize the 52X NPA code series after the North American network converts to NXX-type NPA codes. (See Section 2 for the description of the NXX codes.)

3. SWITCHING

3.01 Traffic between the Bell System and points beyond the boundaries of the integrated North American numbering zone (world numbering zone 1) is presently switched through at least one of seven specially equipped switching centers. While domestic toll switching constitutes the predominant load at each of these centers, they are given the status of an International Switching Center (ISC) in recognition of the special international function performed. The designation CT (from the French for "centre transit") is also in general use to identify switching locations where international circuits are switched. The seven switching systems filling the ISC role at the end of 1974 are all No. 4 Crossbar 4-wire systems. Electronic switching systems are being designed to meet future ISC needs. Present ISC locations are as follows:

Denver 3, 4A/ETS
Jacksonville 2, 4A/ETS
New York 4, 4M/Card Translator
New York 10, 4A/ETS
Oakland 3, 4M/ETS
Pittsburgh 2, 4A/ETS
White Plains 2, 4A/ETS

3.02 Direct switching to the destination country is the dominant routing procedure. Satellite and submarine cable circuits, equipped with CCITT Signaling System No. 5, are assigned in approximately equal numbers. Some "via" (transit) switching is performed along routes determined by multilateral agreement among the administrations involved but alternate routing is not yet widely practiced. Service to a particular country may be concentrated at a particular ISC or dispersed among two or more. Generally, countries with large traffic volumes are served through more than one ISC. Most ISCs are interconnected with dedicated trunk groups reserved for international traffic.

3.03 The CCITT has recommended a formal international routing plan based on hierarchical principles similar to those employed in many national networks. This plan is described in detail in the CCITT Green Book, Volume VI, Recommendation Q.13. Applicable elements of the plan are reflected in current operating practices with a view that is consistent with the plan. The intent is to facilitate an orderly transition to the world routing plan when service needs dictate.

3.04 Access to the specialized equipment at the ISC differs for incoming and outgoing traffic. Incoming traffic is directly associated with equipment such as overseas senders because the trunks involved carry international traffic only. Outgoing traffic, however, arrives at an ISC on trunks shared with domestic toll traffic. Thus, routing codes are needed to steer the international traffic to appropriate switchboards or specialized dial equipment. A 2-stage outpulsing arrangement is, therefore, used for calls dialed to and through an ISC. See Fig. 2.

3.05 Two-stage outpulsing eliminates the need to distinguish between domestic and international addresses and for expanding the digit capacity at the intermediate toll offices between the originating entity (local office, TSPS, TSP, or switchboard) and the ISC. The first stage of outpulsing provides for either a 3- or 6-digit routing code. The 3-digit code uniquely specifies a particular ISC for which the call is destined. The 6-digit code describes the country for which the call is destined but requires translation at intermediate toll offices to determine the ISC. A 6-digit code can be converted to a 3-digit code where required but flexibility for possible network management is lost. When a 3- or 6-digit code, uniquely associated with international dialing, arrives at an ISC, it signifies the need to connect specialized international digit-receiving equipment for the international address. When this international digit-receiving equipment (in No. 4 Crossbar systems, this is an overseas sender) is attached, a supervisory wink and a distinct tone is transmitted through the built-up toll connection to the originating entity.

3.06 Upon receipt of the supervisory signal, the originating entity MF outpulses the international called number by multifrequency pulses, end-to-end, over the built-up connection, thereby eliminating digit reception at intermediate offices. With the reception of the international address digits at the ISC, the call can progress through international call processing at the ISC and into the international network.

3.07 CCIS is being designed with 12-digit capacity. In the future, it will be possible (if CCIS links exist from the local entity to the ISC) to send the full international number to the ISC on a link-by-link basis without 2-stage outpulsing.

4. SIGNALING

4.01 Since the signaling systems used in various parts of the world differ both in principle and detail, the CCITT has standardized signaling systems for international use. These signaling systems provide the interface between switching systems and networks of widely different design.

4.02 The signaling system used in the Bell System toll network has been standardized by the CCITT for use as a regional international signaling system and is known as Signaling System R1. It is not compatible with TASI (6.03 of this section) transmission facilities. The specification for this system can be found in Volume VI, Part XV of the Green Book. System R1 is used internationally to Canada, various countries in the Caribbean, and to Mexico.

4.03 The signaling system that was designed for use in the European region has also been standardized by the CCITT as Signaling System R2. It uses 2-way multifrequency (not the same code as System R1) fully compelled interregister signaling and outband (tone or PCM) line or supervisory signaling. It is not compatible with satellite or TASI transmission facilities. The specification of System R2 can be found in Volume VI, Part XVI of the Green Book. System R2 is used as a regional system within Europe, South and Central America, Africa, Australia, and in other locations. It is not used in the North American integrated numbering region and there are no plans to provide System R2 in US International Switching Centers.

4.04 CCITT Signaling System No. 4 is an older European signaling system not used in the United States. It is not compatible with TASI or satellite transmission systems. The specifications may be found in Volume VI, Part IX of the Green Book.

4.05 CCITT Signaling System No. 5 was the first system standardized for intercontinental use. System No. 5 is an inband signaling system which is compatible with the transmission facilities used for intercontinental trunks, ie, 3-kHz spaced channel banks, PCM channel banks, satellite channels, and the TASI system. Detailed specifications for System No. 5 can be found in Volume VI, Part X of the Green Book. The address signals are coded in the multifrequency code used by the Bell System (same as System R1) and are transmitted en-bloc at a rate of ten digits per second. Address signals are sent link by link between registers only. Line or supervisory signals are sent using a 2-frequency continuous compelled arrangement. This system provides more signals than does System R1, eg, language or discriminating digit, forward-transfer, and busy-flash signals. In the United States, equipment for System No. 5 is limited to International Switching Centers. It is the system used today for nearly all intercontinental dial trunks.

4.06 CCITT Signaling System No. 5bis utilizes the line signaling arrangement of System No. 5 with a 2-way multifrequency interregister system. The detail specification of System No. 5bis can be found in Volume VI, Part XII of the Green Book. System No. 5bis is not presently in use anyplace in the world. There are no plans to provide System No. 5bis in US International Switching Centers.

4.07 The most advanced international signaling system is CCITT Signaling System No. 6. System No. 6 is the international common channel interoffice signaling system. Domestic CCIS (Section 6) was designed in parallel with System No. 6 and was designed to be compatible with it. As with CCIS, there is a rapid transfer of signals and capacity for many new signals in both directions. The data link operates at 2400 bits per second over analog channels (including 3 kHz spaced). Both associated and nonassociated modes of operation are provided. Since the signal path is independent of the transmission path of the trunks, trunks on any type of transmission facility can be served. A continuity check of the speech path of the trunks is provided during call setup. The specification of System No. 6 is given in Volume VI, Part XIV of the Green Book. The specification is also published as a separate pamphlet available from the ITU. Although not in service at the present time, many administrations expect to put it in service in the latter half of the 1970s as stored program control international switching machines are added. System No. 6 equipment will be installed in ISC locations in the United States.

4.08 System requirements for Demand Assignment Signaling Systems (6.04 in this section) for demand assigned multiple access satellite systems were approved by the CCITT in 1972. They may be found in Volume VI, Part II, Recommendation Q.48 of the Green Book.

5. OPERATING METHODS

5.01 The following is a description of present and planned international call handling arrangements, ie, operator and customer methods for completing international calls. The call handling arrangements are part of an overall plan to improve international service by moving call control and access to the international network closer to the caller and ultimately resulting in most calls being completed by the customer dialing on an IDDD basis.

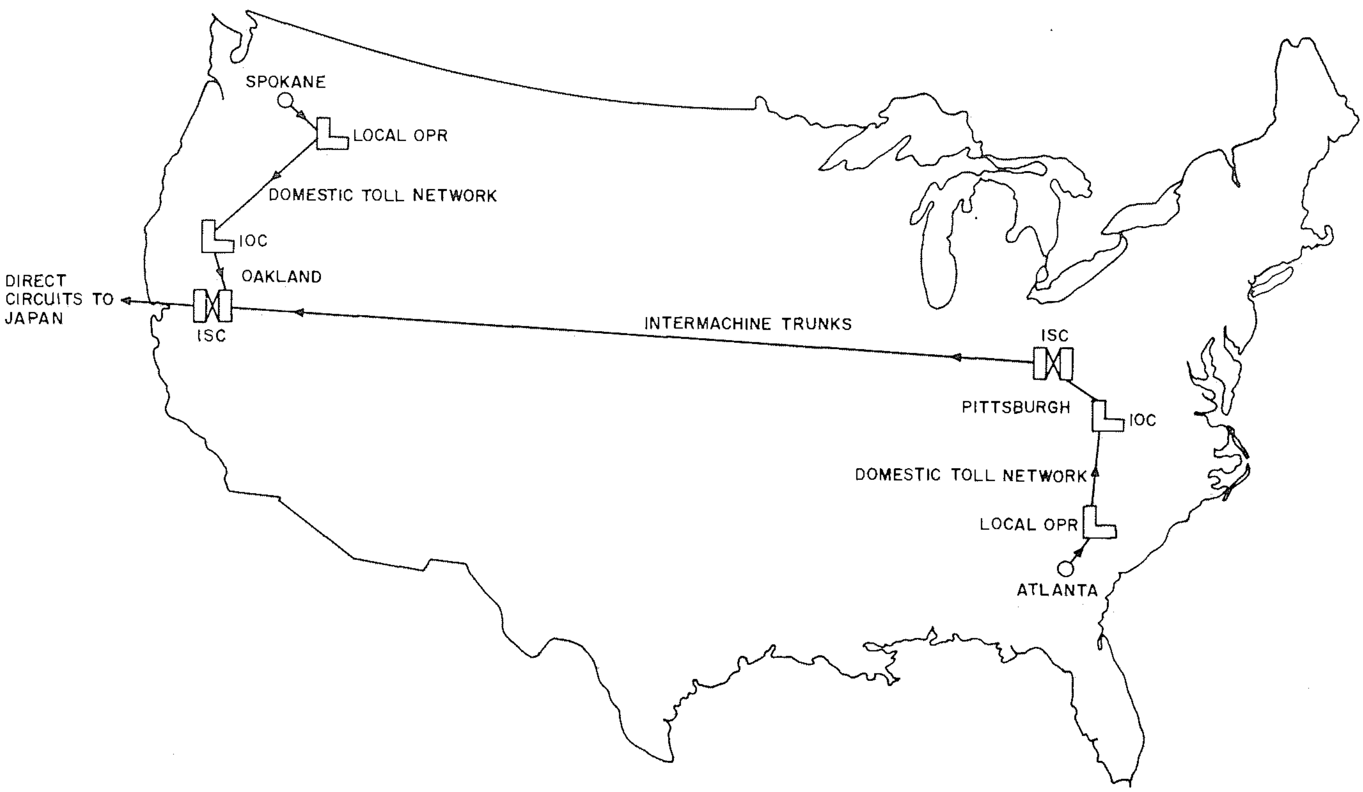
5.02 The three call handling arrangements used to complete international calls may be classified as International Operating Center (IOC), International Originating Toll Center (IOTC), and International Direct Distance Dialing (IDDD). An increasing percentage of calls are being handled on an IOTC and IDDD basis. A number of customers served by Traffic Service Position Systems (TSPSs) are also able to dial operator-assisted international calls (person, credit card, etc). Following are descriptions of these arrangements.

INTERNATIONAL OPERATING CENTER (IOC)

5.03 IOC handled traffic originating within a given North American region is routed via the domestic network to the IOC handling that particular service (country) from that region.

5.04 The IOC operator completes the call by connecting to an international circuit either in the multiple or via a tandem trunk, if the IOC and International Switching Center (ISC) are collocated, or via an Intermachine Trunk or Remote Operator Access Trunk if they are not collocated. Remote Operator Access Trunks are special trunks developed for certain switching systems and switchboards to maintain transmission standards where the switchboard and switching system are not collocated.

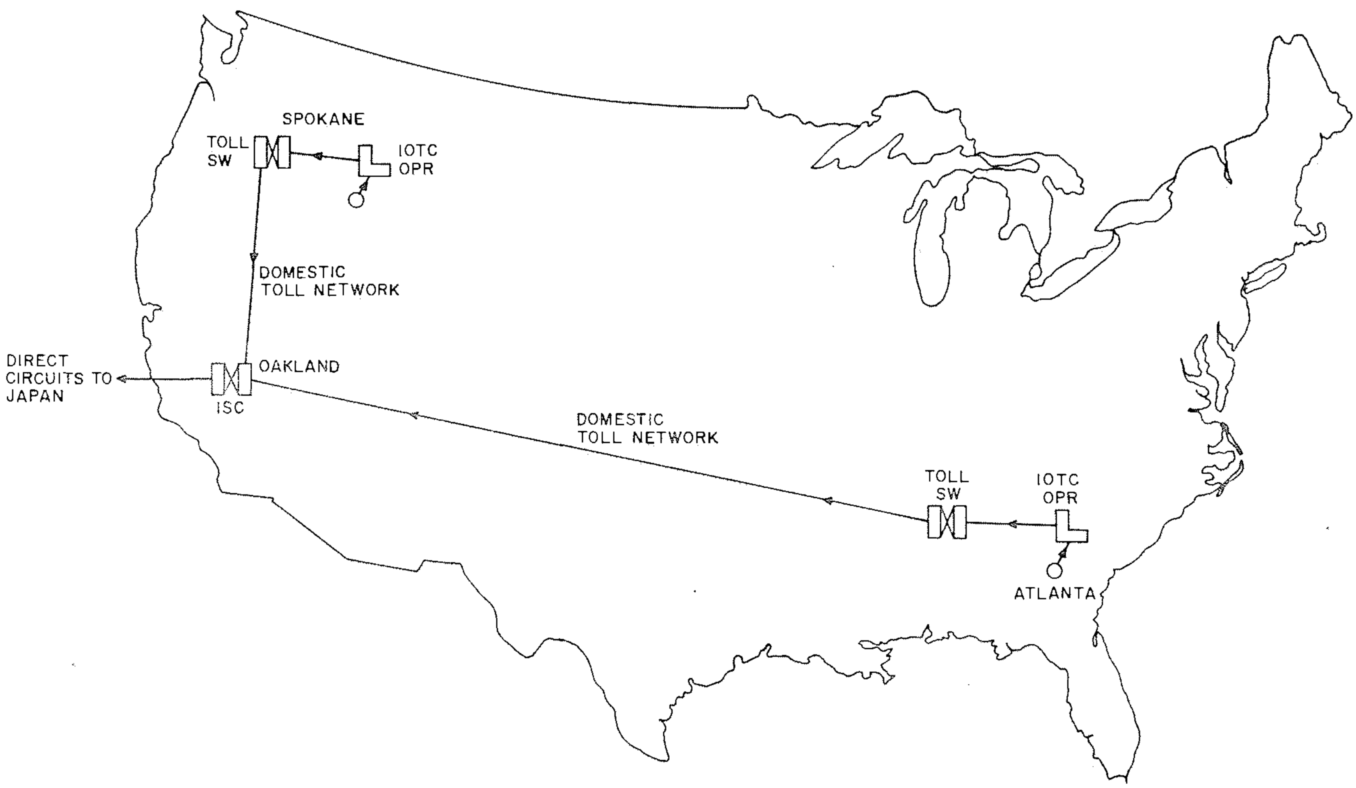
INTERNATIONAL OPERATING CENTER (IOC) TRAFFIC ROUTING
(EXAMPLE – CALLS TO JAPAN FROM ATLANTA, GEORGIA AND SPOKANE, WASHINGTON)



INTERNATIONAL ORIGINATING TOLL CENTER (IOTC)

5.05 IOTC type traffic originating within a region is normally routed the same as IDDD traffic. These calls are characterized by a domestic routing code outpulsed in the first stage of the 2-stage pulsing sequence. The 2-stage outpulsing is accomplished as described in part 3 of this section.

INTERNATIONAL ORIGINATING TOLL CENTER (IOTC) TRAFFIC ROUTING
(EXAMPLE – CALLS TO JAPAN FROM ATLANTA, GEORGIA AND SPOKANE, WASHINGTON)

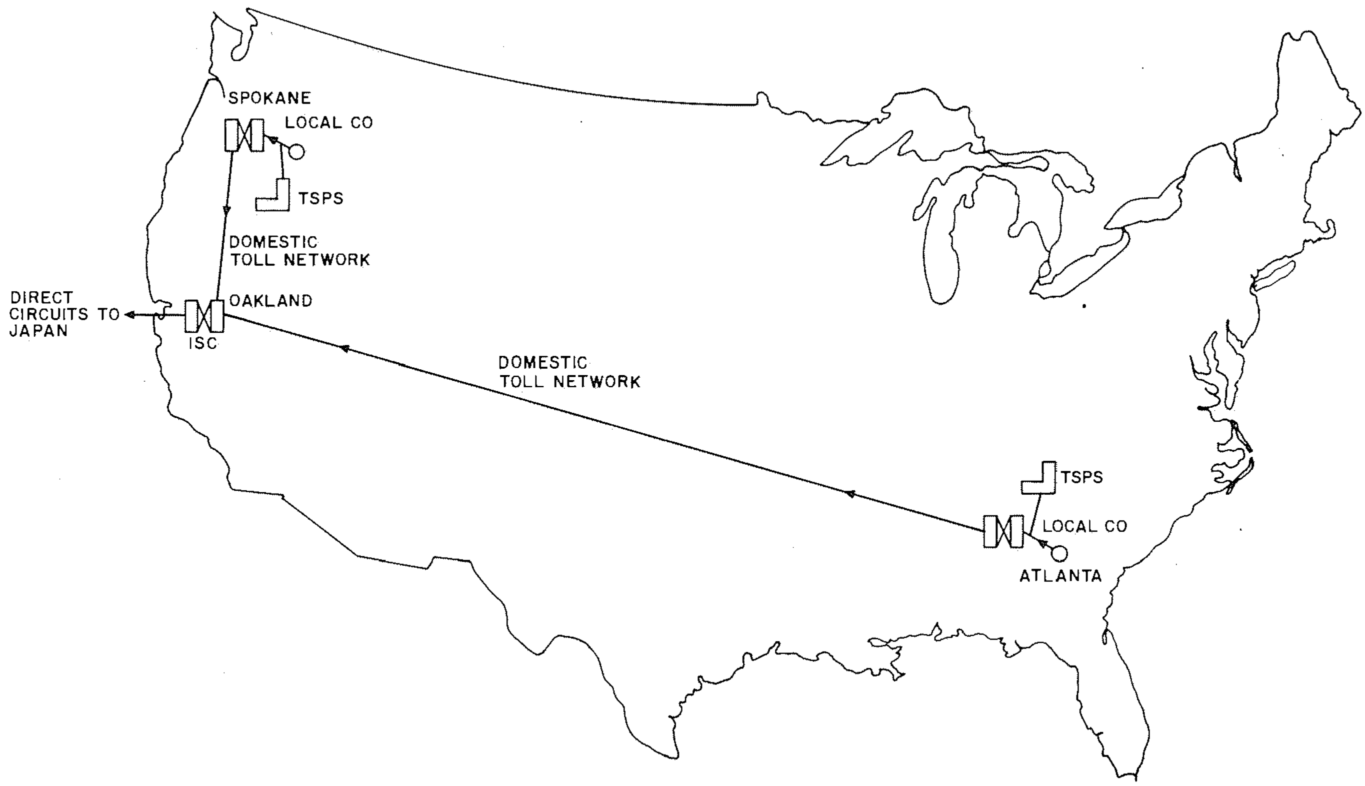


INTERNATIONAL DIRECT DISTANCE DIALING (IDDD)—011 RECORDED AT END OFFICE AND 011 AND 01 RECORDED AT TSPS

5.06 IDDD type traffic originating within a given region is routed, via the domestic network, to the same ISC that handles IOC traffic from that region. This routing scheme is likely to change with the introduction of ISCs which are not associated with an IOC.

5.07 These calls are characterized by domestic routing codes outpulsed in the first stage of a 2-stage sequence outpulsed by the local office. Two-stage outpulsing will be performed by the TSPS in the majority of cases in the future.

INTERNATIONAL DIRECT DISTANCE DIALING (IDDD) TRAFFIC ROUTING
(EXAMPLE – CALLS TO JAPAN FROM ATLANTA, GEORGIA AND SPOKANE, WASHINGTON)
011 RECORDED AT END OFFICE



5.08 To place IDDD calls, customers with the capability would dial an international prefix, a country code, and the national number. Customers may obtain dialing information from customer instruction material or from the operator. Customers cannot dial Directory Assistance in a foreign country directly. They must pass these requests to the operator.

5.09 IOTC operators at a number of 3C-type cordboards may complete international calls using the following methods. (IOC procedures are not described.)

(1) Recording—Operators follow special procedures in preparing standard toll type tickets.

(2) Securing Routes, Rates, and Numbers—Operators secure this information from rate and route operators who refer to the IDDD-IOTC portion of the Operating Rate and Route Guide (ORRG) or from position information which is constructed from the ORRG. All routing directions are entered on the ticket.

(3) Advancing the Call—The operator operates the KP key, keys the 6-digit routing code to secure a sender to the foreign country at the ISC, operates the START (ST) key, and waits for a distinctive tone. After hearing the tone, the operator depresses the KP key, keys the address code, operates the ST key, and may wait up to 30 to 40 seconds for the ring if necessary.

(4) Language Assistance—The operator may obtain language assistance by ringing forward on the connection.

(5) Leave Word—Operators leave word by using special call back numbers. All call back reports from a foreign country are handled by the operator at the IOC.

(6) Special Types of Calls—There are modifications to standard operating practices to some countries for third number, credit card, collect, conference, and other type calls. These are necessary because of facility limitations, language problems, service agreements, and other limitations.

5.10 There are significant advantages over cordboard operation with TSPS, whether customers dial their own calls (01) or (011) with compatible end offices or dial 0— and the TSPS operator handles as IOTC. TSPS:

(1) Does 2-stage outpulsing

(2) Can float international calls for timing

(3) Allows automatic recall for charge due coin collections, Time and Charges (T and C) notification

(4) Performs automatic rating and computing on paid international coin and hotel calls with T and C

(5) Obtains calling number where end offices are equipped with ANI

(6) Times call and records disconnect

(7) Records billing details on magnetic tape.

6. OVERSEAS FACILITIES

SUBMARINE CABLES

6.01 There are a variety of submarine cable systems in use. At the end of 1973, all such cables use analog multiplex systems and are usually provided with 3-kHz spaced voiceband channels which terminate in channel banks that are specially designed for such purpose. Cables with more than 800 voiceband channels are in use and higher capacity cables are planned.

SATELLITE

6.02 Satellites are used to establish intercontinental and other international circuits. Since these communications satellites are in synchronous orbit about 22,000 miles above the earth's equator, there is a transmission delay of at least 260 milliseconds (earth station to earth station) in each direction on a circuit utilizing a satellite. At present, all channels are 4-kHz spaced analog channels.

TIME ASSIGNMENT SPEECH INTERPOLATION (TASI)

6.03 TASI is a system which permits an increase in the capacity of submarine cables. The system takes advantage of pauses and listening periods in 2-way telephone conversations to interpolate or interweave other speech signals. This results in an increase in the number of conversations supported and the effective number of circuits developed from a given number of channels.

DEMAND ASSIGNMENT SATELLITE

6.04 A demand assignment satellite system called SPADE has been tested and is in limited use. SPADE is derived from the words *S*ingle Channel Per Carrier *P*ulse Code Modulation Multiple *A*ccess *D*emand Assigned *E*quipment. It permits the assignment of satellite links on a per-call basis as controlled by a data transmission network linking the participating earth stations. The system is intended to provide communications between any pair of participating entities where the use of permanent preassigned circuits is not justified.

7. TRANSMISSION AND MAINTENANCE

7.01 International dialing has the possibility of developing connections with as many as 14 links in tandem. International trunks which are also intercontinental can be expected to be longer than most domestic circuits. The resulting number of circuits and distances involved in many international connections increases the overall net loss and the probability of significant level variation as compared to those encountered domestically. These elements will also tend to increase the noise, distortion, and transmission time in the resulting transmission path. Achieving performance objectives within the domestic network and in the international circuits is, therefore, vital to support the best possible international service.

7.02 The circuits in tandem may include trunks on submarine cables and satellites. The limits placed on the range of acceptable transmission transmit time (delay) on a call require control measures to prevent the inclusion of more than one satellite circuit in the overall connection where such control is feasible. These limits are defined in a current CCITT Recommendation and include all transmission time including that resulting from any domestic use of satellite systems.

7.03 The larger number of trunks in tandem in international connections increases the probability of having several echo suppressors in tandem. The extent of degradation that results from suppressors in tandem has not been quantitatively established. It appears reasonable to apply strategies to minimize the number of echo suppressors in tandem, whenever such action is feasible, as for example on international traffic traversing North America. (See CCITT Green Book, Volume VI, Recommendation Q.115.)

7.04 The procedures involved in the establishment and maintenance of international trunks which extend beyond the North American network have been and are, on a continuing basis, the subject of study by members of the CCITT. Recommendations of the CCITT cover all aspects of such international trunks from the exchange of information concerning the facility routing to detailed responsibilities of control and other requirements for the establishment, routing, testing, and fault sectionalization of international trunks. Noise limits and test tone levels are also prescribed by the CCITT. For example, there is international agreement to utilize test tone at −10 dBm0 for all test purposes on international public telephone circuits. All such trunks terminate at locations that are especially equipped to maintain them called International Transmission Maintenance Centers (ITMCs). Recommendations concerning transmission maintenance are in the M and O series in the Green Books, Volume IV and trunk maintenance are in the Q series, Volume VI.

7.05 One of the more important maintenance mechanisms related to international circuits is an automatic circuit loss and noise measurement and signaling test system called ATME No. 2. The details of the automatic test frame as specified by the CCITT make it compatible with international signaling and those international circuits which may be utilizing TASI. (See CCITT Volume IV, Recommendation Q.22 and Volume VI, Recommendation Q.49.)

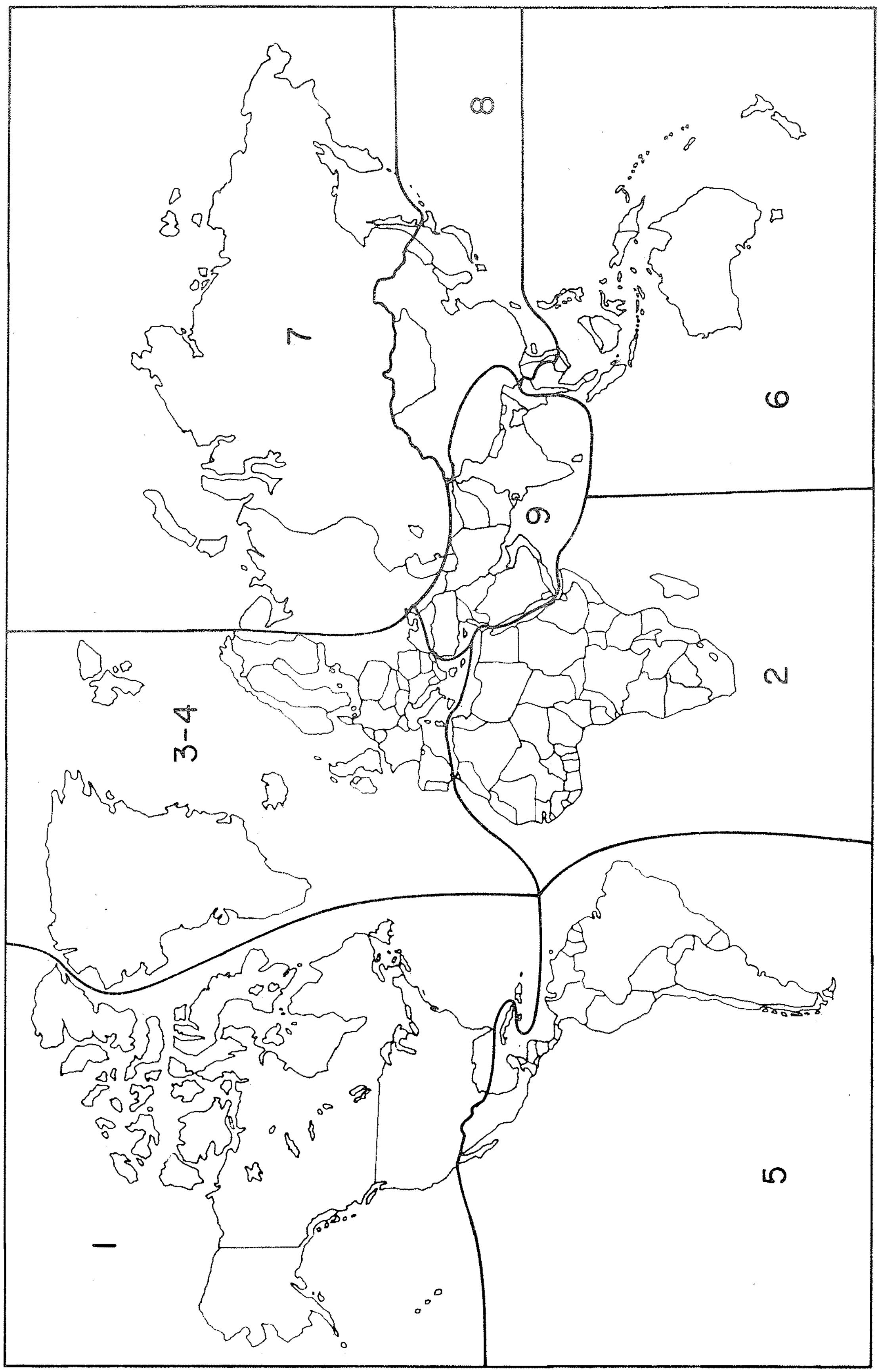


Fig. 1—World Numbering Zones

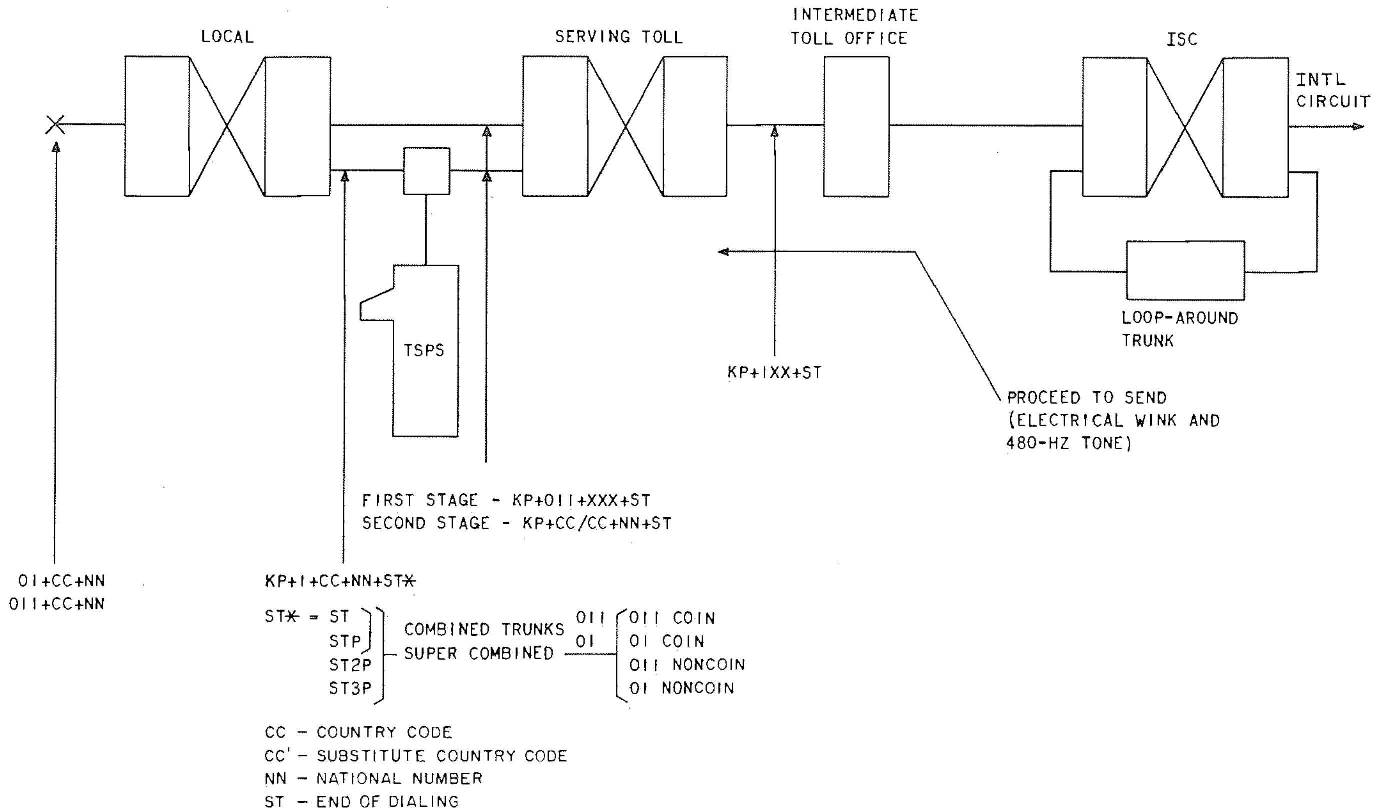


Fig. 2—IDDD 2-Stage Outpulsing ESS or TSPS

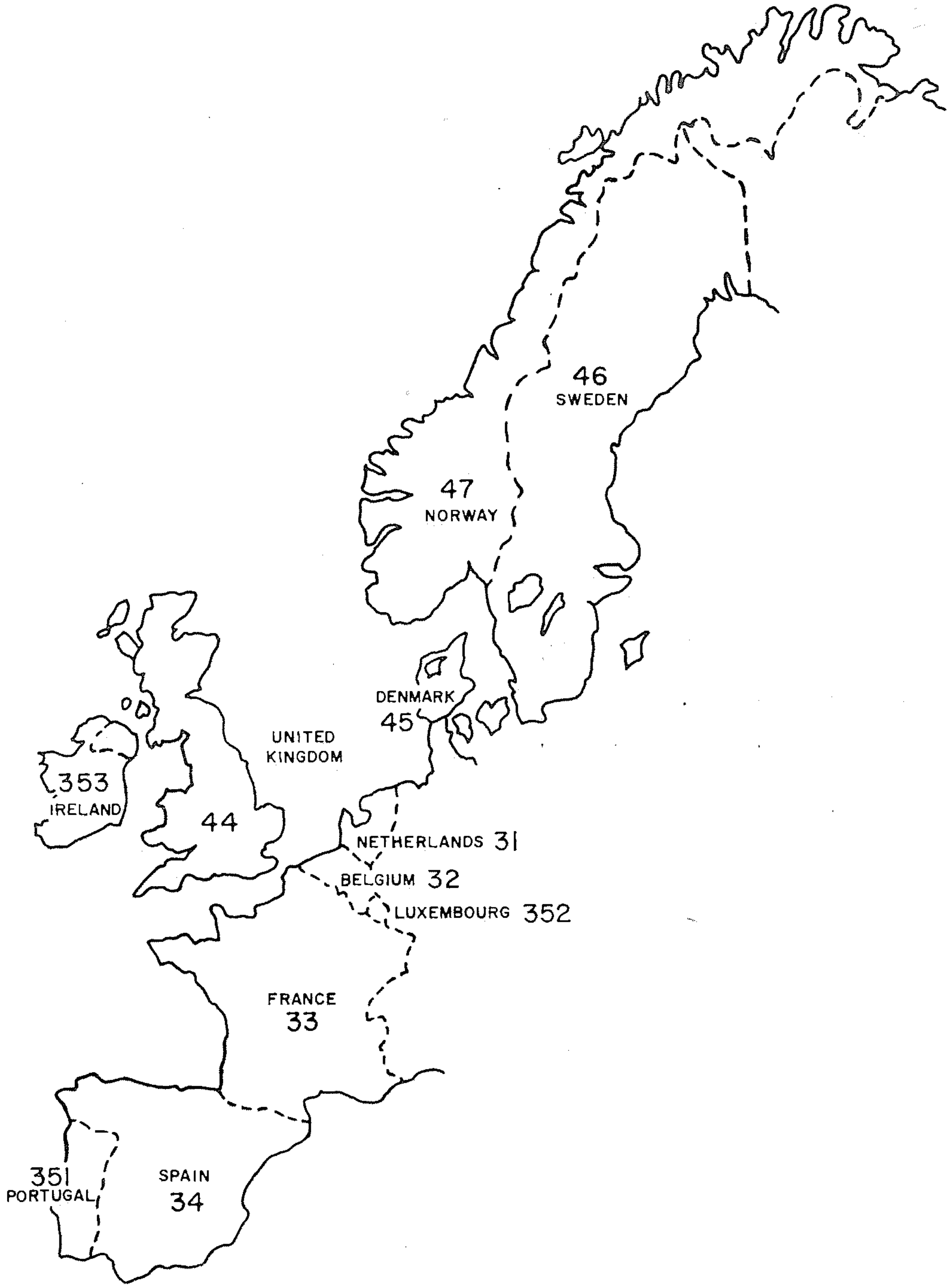


Fig. 3—Country Codes

REVISED LIST OF COUNTRY CODES INCORPORATING AMENDMENTS PROPOSED BY THE WORLD PLAN COMMITTEE, MEXICO CITY, 1967; VENICE, 1971

WORLD NUMBERING ZONE 1
(INTEGRATED NUMBERING AREA)

Canada	British Virgin Islands (5)
St Pierre and Miquelon (1)	Bermuda (5)
United States of America including Puerto Rico and the Virgin Islands	Bahamas (5)
	Dominica (5)
Jamaica	Grenada (5)
	Montserrat (5)
Barbados	St Kitts (5)
Antigua (5)	St Lucia (5)
Cayman Islands (5)	St Vincent (5)

WORLD NUMBERING ZONE 2

Egypt (Arab Republic of)	20	Congo (People's Rep of the)	242
Morocco (Kingdom of)	210	Zaire (Republic of)	243
Morocco (Kingdom of)	211	Angola (3)	244
Morocco (Kingdom of)	212	Portuguese Guinea (3)	245
Algeria (Algerian Dem and Pop. Rep)	213	Sudan (Democratic Rep of the)	249
Algeria (Algerian Dem and Pop. Rep)	214	Rwanda (Republic of)	250
Algeria (Algerian Dem and Pop. Rep)	215	Ethiopia	251
Tunisia	216	Somali Democratic Republic	252
Tunisia	217	Afars and Issas (Fr Ter) (1)	253
Libyan Arab Republic	218	Kenya	254
Libyan Arab Republic	219	Tanzania (United Rep of) (mainland)	255
Gambia	220	Uganda	256
Senegal (Republic of the)	221	Burundi (Republic of)	257
Mauritania (Islamic Republic of)	222	Mozambique (3)	258
Mali (Republic of)	223	Zanzibar (Tanzania)	259
Guinea (Republic of)	224	Zambia (Republic of)	260
Ivory Coast (Republic of the)	225	Malagasy Republic	261
Upper Volta (Republic of)	226	Reunion (France)	262
Niger (Republic of the)	227	Rhodesia	263
Togolese Republic	228	Territory of South-West Africa	264
Dahomey (Republic of)	229	Malawi	265
Mauritius	230	Lesotho (Kingdom of)	266
Liberia (Republic of)	231	Botswana (Republic of)	267
Sierra Leone	232	Swaziland (Kingdom of)	268
Ghana	233	Comoro Islands (1)	269
Nigeria (Fed Rep of)	234	South Africa (Republic of)	27
Chad (Republic of the)	235		
Central African Republic	236	Spare codes:	246
Cameroon (United Rep of)	237		247
Cape Verde Islands (3)	238		248
St Thome and Principe (3)	239		28
Equatorial Guinea (Republic of)	240		29
Gabon Republic	241		

Chart 1—Revised List of Country Codes

WORLD NUMBERING ZONES 3 AND 4

Greece	30	Denmark	45
Netherlands (Kingdom of the)	31	Sweden	46
Belgium	32	Norway	47
France and Monaco	33	Poland (People's Republic of)	48
Spain	34	Germany (Federal Rep of)	49
Hungarian People's Republic	36	Gibraltar (5)	350
German Democratic Republic	37	Portugal	351
Yugoslavia (Fed Rep Soc of)	38	Luxembourg	352
Italy	39	Ireland	353
Roumania (Soc Rep of)	40	Iceland	354
Switzerland (Confederation of)	41	Albania (People's Republic of)	355
Czechoslovak Socialist Republic	42	Malta	356
Austria	43	Cyprus (Republic of)	357
United Kingdom of Great Britain and		Finland	358
Northern Ireland	44	Bulgaria (People's Republic of)	359

WORLD NUMBERING ZONE 5

British Honduras (5)	501	Chile	56
Guatamala	502	Colombia (Republic of)	57
El Salvador (Republic of)	503	Venezuela (Republic of)	58
Honduras (Republic of)	504	Guadeloupe	590
Nicaragua	505	Bolivia	591
Costa Rica	506	Guyana	592
Panama	507	Ecuador	593
Peru	51	French Guiana (France)	594
Mexico	52	Paraguay	595
Cuba	53	Martinique	596
Argentine Republic	54	Surinam (Netherlands)	597
Brazil (Federative Rep of)	55	Uruguay (Oriental Republic of)	598
		Netherlands Antilles (Netherlands)	599

Spare codes: 500, 508, 509

WORLD NUMBERING ZONE 6

Malaysia	60	Papua New Guinea (Australia)	675
Australia (Commonwealth of)	61	Tonga	676
Indonesia (Republic of)	62	Solomon Islands (5)	677
Philippines (Republic of the)	63	New Hebrides (5)	678
New Zealand	64	Fiji	679
Singapore	65	Wallis and Futuna (1)	681
Thailand	66	American Samoa (4)	684
Guam and Trust Territory of the		Gilbert and Ellice Islands (5)	686
Pacific Islands (4)	671	New Caledonia (1)	687
Portuguese Timor (3)	672	French Polynesia (1)	689

Spare codes: 69, 670, 673, 674, 680, 682, 683, 685, 688

Chart 1—Revised List of Country Codes (Cont)

WORLD NUMBERING ZONE 7

Union of Soviet Socialist Republics	7

WORLD NUMBERING ZONE 8

Japan	81	Macao (3)	853
Korea (Republic of)	82	Khmer Republic	855
Viet-Nam (Republic of)	84	Laos (Kingdom of)	856
Hong Kong (5)	852	China (People's Rep of)	86
Spare codes: 80, 83, 87, 88, 89, 850, 851, 854, 857, 858, 859			

WORLD NUMBERING ZONE 9

Turkey	90	Yemen Arab Republic	967
India (Republic of)	91		968
Pakistan	92	Yemen (People's Dem Rep of) (Aden)	969
Afghanistan	93		971
Sri Lanka (Ceylon) Republic of	94	Israel (State of)	972
Burma (Union of)	95		973
Lebanon	961		974
Jordan (Hashemite Kingdom of)	962	Mongolian People's Republic	976
Syrian Arab Republic	963	Nepal	977
Iraq (Republic of)	964	Iran	98
Kuwait (State of)	965		
Saudi Arabia (Kingdom of)	966		
Spare codes: 99, 960, 970, 975, 978, 979			

Note: Some countries and territories are represented in the Union by members specifically empowered for this purpose. These countries and territories are followed by (1), (2), (3), (4), or (5), meaning:

(1) Territory represented by the French Overseas Post and Telecommunication Agency
(2) Spanish Province in Africa
(3) Portuguese Overseas Province
(4) Territory of the United States
(5) Overseas Territory for the international relations of which the Government of the United Kingdom of Great Britain and Northern Ireland is responsible.

Chart 1—Revised List of Country Codes (Cont)

NOTES ON DISTANCE DIALING

SECTION 11

NETWORK MANAGEMENT

CONTENTS PAGE

1. GENERAL

1.01 The North American DDD Network is engineered to provide a satisfactory grade of service during the average busy hour of the busy season. However, there may be periods when overloads or a surge in traffic will exceed the capacity of the plant provided. These traffic peaks are sometimes focused on a small number of switching systems and circuit groups and are caused by abnormal local events such as severe storms, facility or switching system failures, or other overloads on the network such as those occurring on some holidays and during times of major disasters or events of national interest. Network Management encompasses the techniques and organization to insure optimum use of available facilities in the face of abnormal loads or equipment or facility failure.

1.02 One of the characteristics of abnormal peaks of traffic is repeated attempts of incompleted calls. This results in an unusually heavy demand on common control switching systems which leads to congestion and delays in common control switching offices. Such delays tend to spread rapidly throughout the network with delays in one office causing delays in distant offices. Without effective and prompt control measures, the call-carrying capacity of the network or portions of the network can be substantially reduced below engineered capacity as calls queue up waiting for common control equipment to become available. Similarly, overloads in a metropolitan area tandem machine may cause traffic to back up into originating local offices and cause slow dial tone to subscribers.

1.03 Effective network management depends on the prompt availability of data indicating when and where an overload is occurring, alert administration by a trained organization, and immediate application of available controls to isolate and contain the overload. Descriptions of the Network Management organization and the controls available are given in the following paragraphs.

2. NETWORK MANAGEMENT ORGANIZATION

2.01 Effective network management depends on a cooperative organizational scheme which crosses traditional company and organizational boundaries and which can identify incipient overloads and respond rapidly with effective counteraction. The Bell System has established Network Management Control Centers at strategic locations around the country. Overall coordination is performed by the National Control Center in New York. Each Regional Center in the network switching hierarchy also maintains a regional Network Management Control Center which, in turn, coordinates with other Network Management Centers established at sectional centers and in some major metropolitan areas. These centers automatically receive network status indications which are displayed and used in directing the application of controls. Coordination in the field is maintained over a collection of dedicated voice and teletypewriter circuits, operated as party lines, and arranged to conform to the network switching hierarchy.

2.02 The role of a Network Management Center is to maintain maximum call-handling capacity in the network under adverse or overload conditions.

Its responsibilities include:

(1) Continuous surveillance of the status of the network at all levels of the hierarchy to

insure early detection of network congestion and identification of its cause.

(2) Coordination and initiation of required controls to optimize use of existing facilities and prevent spread of congestion through other sections of the network.

(3) Coordination with operating, maintenance, and engineering units for correction of conditions detected by Network Management.

(4) Collection and analysis of data required for advance planning and for "after the fact" critique. Such analysis often results in changed Network Management procedures or recommending additions or modifications to the network.

2.03 One of the techniques of Network Management which has proven to be very effective is preplanning for the administration of the network during predictable overload situations. This includes the plans made to handle peak day traffic occurring on Christmas and Mother's Day as well as preplans for imminent storms or hurricanes when there is sufficient advance notice. The development of contingency preplans for major switching machine or facility failures is also coordinated by Network Management Centers.

2.04 Network Management is a cooperative effort and its success depends upon a high degree of understanding and cooperation among several hundred people responsible for Network Management in the Bell System and the connecting independent telephone companies. This requires a common knowledge of Network Management philosophy, objectives, terminology, and techniques. To accomplish this, the Bell System provides a training course in Network Management taught by experienced Network Managers. It is available to both Bell System and non-Bell Operating Companies.

3. NETWORK MANAGEMENT CONTROLS

3.01 Network Management Controls can be categorized into two basic types "expansive controls" and "protective controls." Expansive controls include manipulation of routing to divert traffic from its normal route to other facilities which have spare capacity. For example, heavy morning Christmas traffic loads between New York and Miami might be rerouted via the Sacramento office to take advantage of lightly loaded New York-Sacramento and Sacramento-Miami trunks. Protective controls, on the other hand, usually involve the blocking or restriction of certain categories of traffic in order to prevent overloading of switching systems and the delay caused by senders in one switching system queuing for senders in other systems.

DYNAMIC OVERLOAD CONTROLS (DOC)

3.02 Network Management Controls can also be categorized in terms of controls which are initiated automatically and those imposed manually. DOC provides an automatic system of internal overload controls governed by the length of sender or marker/decoder queues in No. 4 Crossbar and Crossbar Tandem switching machines.

3.03 The types of internal controls activated by DOC are:

(1) Automatic Cancellation of Short Sender Timing—This feature conserves common control usage during periods of switching congestion by reducing the number of calls routed to sender overload announcement following sender time-out.

> ***Note:*** Short Sender Timing (SST) is an internal overload control but is not part of the DOC system. SST is activated by an all-sender busy condition and, upon activation, the sender time-out interval is reduced from about 30 seconds to about 5 seconds. The result of SST is more effective sender usage and reduction in the regenerative sender delay described in 1.02.

(2) Automatic Cancellation of Second Trial—During overload periods, the probability that a call which failed on the first attempt will complete on second trial is relatively small. Cancellation of the second trial reduces unproductive common control equipment usage.

3.04 The DOC system also provides features to automatically restrict traffic routed to a Crossbar Tandem or No. 4 Crossbar. These features are ***external*** controls as opposed to the internal controls described above. The switching system receiving controls can be other XBTs or 4XBs or can be a 5XB, 1XB, panel, or ESS. The control signal is of the simple on/off type and contains no coded information; the response of the receiving office is strictly a function of how that office has been wired or programmed to respond. Each DOC signal will stimulate a unique response. The signaling mechanism can be wire pair, telegraph channel, E&M leads, or ground return.

3.05 Congestion in the DOC sending switching system is sensed by a sender queue indicator circuit which monitors the level of waiting attempts on sender link frames and, at a preset threshold, causes the DOC signal to be transmitted to subtending offices. During the interval that the signal is "on," the DOC equipment at the subtending offices restricts access to the office sending the control signal. The restriction can be arranged to cancel access of certain alternate routed traffic and/or deny access to a part of the direct routed traffic. The fact that this type control is dynamic permits routings to be restored to normal whenever the load level drops below the threshold.

3.06 This dynamic regulation of offered loads tends to contain the congestion without reducing the tandem common control occupancy below maximum capacity. DOC also improves the throughput of the subtending system since its senders/transmitters are not held up (or timed out) while waiting for service from the congested system. The programmed responses sent to the subtending system depend on routing and the network design but generally include the following:

(1) Automatic Cancellation of Alternate or Direct Routing—In response to a DOC signal, alternate routed traffic is generally denied access to the congested system and routed directly to an announcement. Alternate routed traffic is controlled before direct routed traffic because it has outlets other than the congested system. If denial of alternate routed traffic provides insufficient "control leverage," direct routed traffic may be controlled. For DOC to be effective, it is important that enough traffic be controllable to rapidly reduce congestion in the controlling system.

(2) Automatic Trunk Make Busy—This feature provides for a predetermined portion of the trunks to a congested switcher to appear busy at a lower ranking office thus reducing its access to the congested system. The trunk group involved may be either one way or two way.

(3) Skip Route—In response to a DOC signal, a subtending office may deny alternated routed traffic access to a high-usage group to the congested office and "skip" it to the next route in the chain. During periods of congestion in the higher ranking office, "skip route" reduces attempts on the congested office and allows the traffic to attempt completion via the trunk layout of the next office in the routing chain.

DIRECTIONAL RESERVATION EQUIPMENT (DRE)

3.07 DRE is used at lower ranking offices on 2-way final trunk groups to higher ranking offices. When traffic volumes reach a level where only a predetermined number of trunks (one to five) are idle in a subgroup of 40 trunks, an all-trunks-busy indication is given to the common control equipment at the lower ranking office. This, in effect, reserves these one to five trunks for traffic already in the network so that those calls can be completed to or via the lower ranking office. In periods of widespread overload conditions, DRE reduces the number of multilink calls originating from lower offices and reduces the number of ineffective call attempts that get into the network.

3.08 Network Management Controls which may be manually activated include the following:

(1) Cancellation of alternate routed traffic from a specific trunk group (Selective) or to cancel overflow traffic to a specific trunk group from all groups overflowing to it (Regular).

(2) Traffic Overload Reroute Control (TORC)—Used at Regional Centers only under direction of the National Center. Permits rerouting of all or a percentage of the overflow traffic between two Regional Centers via another Regional Center. This expansive-type control permits utilization of the via point's high usage as well as final group layout to the congested region and can often take advantage of circuit availability due to time zone difference.

(3) Temporary Alternate Routes (Key Reroutes)—Preselected out-of-chain alternate routes are used when idle capacity exists on the groups to and from the temporary alternate route point. It is similar to TORC but not confined to Regional Offices.

(4) Code Blocking—Code blocking provides capability for restricting or blocking calls destined for a specific NPA or NXX code. Code blocking may be applied to all traffic or to a specified percentage of the traffic destined for the affected NPA or NXX. Code blocking is an effective control for a focused overload where a large volume of calls are directed toward one destination. Code blocking at or near the originating point prevents the overloading of the terminating switching system and allows calls destined for other locations to go through.

(5) Recorded Announcements—Used to advise customers and operators why calls failed to complete, to space attempts and, in connection with Circuit Busy Announcement (CBA) trunks, to reduce alternate routing from those groups not equipped with selective alternate route cancellation.

(6) Operator Attempt Limiting—Operators may be instructed to limit the number of attempts on each call for an area experiencing congestion. The Network Management organization uses its communication network to disseminate such instructions rapidly when needed.

(7) Directionalization of Circuits—This technique is used to prevent abnormally heavy traffic in one direction from using circuit capacity to the detriment of traffic in the opposite direction. Directionalization is particularly useful when the heavy calling is into an area where there is little chance of completion such as in a disaster situation. It also insures circuit availability for customers calling out of the disaster area.

(8) Line Load Control—Local offices may be arranged so the nonessential subscriber lines can be restrained from originating calls in a general emergency situation. When local calling volumes exceed the capacity of the office and threaten to disrupt service to all subscribers, controls may be selectively actuated to restrict calling by denying dial tone to some nonessential-type lines until traffic volumes subside and the restraints can be safely removed. This preserves service to essential subscribers but does not affect incoming calls or calls already in progress.

4. NEW DEVELOPMENTS

4.01 When the No. 1 ESS is introduced into the network as a tandem switcher, it will have DOC sending capabilities consistent with existing toll/tandem machines. It will also be equipped with DRE controls. Plans for the No. 4 ESS include all of the features available on existing toll switching machines plus a capability to automatically determine hard-to-reach codes in real time. The hard-to-reach code information is then used to refine the automatic control responses. Where DRE directionalizes against all traffic, the analogous No. 4 ESS control (Selective Trunk Reservation) will directionalize against only traffic to hard-to-reach points; where DOC will cancel alternate routing for all traffic to a group, Selective DOC will cancel only alternate routing for hard-to-reach codes.

4.02 New developments in the field of Network Management are closely allied with the development of improved methods of collecting, processing, and displaying data on the network. The Engineering and Administration Data Acquisition System/Network Management (EADAS/NM) is a new computerized system which will allow centralized, real-time surveillance and control of all levels of the switching hierarchy—from Regional Centers to selected end offices—within predefined segments of the network. By analyzing traffic data as it is being gathered from all types of switching systems via basic data collection systems, EADAS/NM will monitor the status of critical switching machines and trunk group functions and report immediately when congestion is imminent. This capability will provide more effective and more responsive Network Management action, when required, to maintain the network's switching efficiency.

4.03 EADAS/NM will employ a minicomputer and peripherals to provide the following features:

(1) Real-time surveillance of switching machine and trunk group interaction. This function will be accomplished by performing calculations at 5-minute intervals on the most recently acquired register data, by analyzing the status of selected discretes and alarms, and then by reporting any specific exceptions to the Network Manager for possible action.

(2) A new network status display system which will be driven by the calculated exceptions

found in the 5-minute data and by the status of selected discretes and alarms. This display system will be in the form of a high-speed line printer, Cathode Ray Tube (CRT) terminal devices, and modular wall display board which will be organized along the lines of the network hierarchy under surveillance by the respective EADAS/NM.

(3) Centralized remote Network Management control capability using the interactive mode of the CRTs which will enable the responsible Network Manager to institute control measures quickly, when required, to maintain and protect the network's call carrying capacity.

NOTES ON DISTANCE DIALING

SECTION 12

BIBLIOGRAPHY

CONTENTS PAGE

1. GENERAL

1.01 A considerable number of articles dealing with distance dialing have been written by Bell System people and published either in Bell System publications or in trade journals. This bibliography lists a number of these articles which, although treating principally Bell System problems in distance dialing, may have industry-wide applications. In general, this material will be available at most technical reference libraries and may be of some assistance to those who wish to explore, in further detail, subjects related to distance dialing.

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 textbooks 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 1950. 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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NOTES ON DISTANCE DIALING

SECTION 2

NUMBERING PLAN AND DIALING PROCEDURES

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1. GENERAL

1.01 An essential element of distance dialing is a numbering system wherein each main station has a unique number which is convenient to use, readily understandable, and identical in its format to those of all other telephones connected to the network. With such a numbering system, operators or customers, wherever located, may use this number to reach the desired telephone through the local or distance dialing network. This is called "destination code" routing and is described more fully in Section 3.

1.02 The routing codes for distance dialing within the North American Numbering Plan consist of two basic parts:

(1) A 3-digit Area or Numbering Plan Area (NPA) code

(2) A 7-digit telephone number made up of a 3-digit Central Office (CO) code plus a 4-digit station number.

1.03 Together, these ten digits comprise the network "address" or "destination code" for each telephone. This arrangement is shown below as it was used at the end of 1973 prior to the introduction of "Interchangeable codes" discussed in part 4 of this section.

AREA CODE	TELEPHONE NUMBER
N 0/1 X *	NNX-XXXX

Where X = Any number from 0 through 9

N = Any number from 2 through 9

0/1 = The number 0 (zero) or 1

* Excluding N11 codes

1.04 When the distance dialing plan was first envisioned in the 1940s, a numbering plan was designed whereby any telephone within the area encompassed by the "North American Numbering Plan" would be identified by a unique 10-digit address slightly different from that shown previously. While the 3-digit Area code was identical, the 7-digit telephone number was in 2-letter-5-numeral (2L-5N) form. The two letters used were usually the first two of the serving exchange or building name. This initial arrangement provided 152 Area codes each with a capacity of 540 Central Office codes.

1.05 The growth in telephones experienced in the 1950s was sufficient to indicate that the life of many Area codes would be unsatisfactorily short if the 2L-5N arrangement was perpetuated. As a result, "All Number Calling" (ANC) was introduced and all companies providing service within the North American Network were requested not only to avoid the use of any new 2L-5N numbers but also to convert all such existing numbers to ANC as soon as practical. The latter task is well along with about 95 percent of all telephones assigned ANC numbers at the end of 1974 and 100 percent planned by the end of 1978. With ANC, the Central Office code universe was expanded from 540 to 640. The increase resulted from the added availability of number combinations previously obviated by the lack of names that could be structured from the letters associated with the digit combinations 55, 57, 95, and 97 together with the addition of the originally reserved NN0 code group.

1.06 It has been apparent for many years that additional code relief would be required to extend the life of the North American Numbering Plan to the end of the twentieth century. The relief plan adopted requires that codes previously reserved for only NPA code assignment be used as CO codes also and vice versa. This arrangement, called "Interchangeable codes" necessitates certain special equipment arrangements and dialing procedures that are discussed in this section.

2. AREA CODES

2.01 The entire United States and Canada, certain Caribbean Islands, and parts of Mexico have been divided geographically into Numbering Plan Areas (NPAs) and assigned NPA codes. In addition, a few NPA codes have been assigned for special purposes and are known as Special Area Codes (SACs). These special purposes include Inward WATS service, TWX service, and mass calling arrangements (such as telethons and elections). Charts 1 and 2 list the NPA codes assigned through 1974 numerically and alphabetically by areas served, respectively. Charts 3 and 4 show the geographic boundaries of NPAs as of June 1973 and May 1974, respectively. The assignment of Area codes is controlled by the AT&T Assistant Vice President—Network Operations.

2.02 The initial group of 152 codes reserved for NPA use was in the N 0/1 X format whereas, CO codes were in the NNX format. These two groups of codes were completely nonambiguous in that the second digit of an NPA code was always either "0" or "1" and the second digit of a CO code was always within the series "2" through "9". This arrangement made it possible in common control systems to distinguish between NPA and CO codes by examination of the second digit dialed, for switching equipment to advance a call only on a 10-digit basis if a "0" or "1" was in the second position, and to advance it on a 7-digit basis in all other cases. (In the special case of N11 codes, screening of the third digit received for the digit "1" permits call advance after receiving only three digits.) Equipment economies are achieved by this simple screening process when home NPA calls are completed on a 7-digit basis and foreign NPA calls on a 10-digit basis in all but exceptional cases.

2.03 Some time after 1995, it is estimated that the 21 NPA codes still unassigned (end of 1974) will have been used and that it will be necessary to start using NNX type codes as NPA codes. In the interest of minimizing ambiguity, it is planned to assign the NN0 codes first in accordance with the sequence shown in Chart 5. (The NN0 codes have been designated as the last to be assigned as CO codes and a sequence that is the reverse of that for NPA code assignment is recommended.) Ultimately, it will become necessary to assign the remaining NNX codes for NPA code purposes.

2.04 Numbering Plan Areas have been created in accordance with principles that tend to maximize customer understanding while minimizing both dialing effort and telephone plant cost. Boundaries are established to last for long periods of time and their locations are based on estimates of future requirements at the time they are drawn. Reevaluation of boundaries created many years in the past sometimes suggests that better ones could have been selected. However, making changes after the passage of time would often cause both massive customer disruption, numerous number changes, and expensive plant rearrangements. Principles to be considered in planning NPA boundary changes resulting from either the creation of new

NPAs or the realignment of existing ones are as follows:

(1) Boundaries must not extend across state lines.

(2) Boundaries should coincide with other political subdivision boundaries where practical.

(3) When (2) above is impractical, boundaries should follow recognizable physical geographic features or structures, ie, rivers, large lakes, mountain ranges, and major highways.

(4) Boundaries should be drawn so as to minimize the splitting of communities of interest or recognized metropolitan areas looking both at the present and the future.

(5) All of the tributaries of a toll center or toll point should be within the same NPA where practical.

(6) Network planning should recognize the economics of alternative boundary alignments. Since the network costs of introducing Interchangeable codes for NPA designation are substantial, boundary alignment studies should acknowledge the differences between plans in future network costs.

(7) Any customers affected by a boundary realignment should not be affected by a subsequent realignment for at least ten years.

2.05 The 152 N 0/1 X codes originally designated for NPA use will have to be supplemented with NNX codes to meet NPA requirements. This will require the introduction of Interchangeable code arrangements throughout the North American Numbering Plan in accordance with 4.03 of this section. Since equipment arrangements are fundamentally the same for either Interchangeable CO codes or Interchangeable NPA codes, minimal changes will be required when the latter are introduced in those NPAs where Interchangeable CO codes have already been implemented.

3. CENTRAL OFFICE CODES

3.01 The universe of NNX codes available for CO code use (prior to the introduction of Interchangeable codes) numbers 640. However, within the universe are seven codes that have been reserved on a network-wide basis for special uses as follows:

Toll Directory Assistance	555
Future New Services	950 and 976
Plant Test	958 and 959
Time	844
Weather	936

This leaves 633 codes actually available for central office purposes.

3.02 Inasmuch as the provision of CO code relief for any NPA involves substantial expenditures for both plant rearrangements and additions, it is essential that CO codes not be utilized when such use is either for convenience alone or for minor or temporary economic advantage. Further, CO codes already in use often can be recaptured for better use. Failure to utilize CO codes carefully and fully would advance the exhaust dates of individual NPAs and require the premature assignment of the remaining spare codes designated for NPA use. The consequence of such assignments would be advancement of the date when major expenditures would be incurred throughout the nationwide network for the introduction of NNX type codes as NPA codes. Following is a list of CO code conservation measures recommeded for CO code administration:

(1) The establishment of new wire centers is often predicated on economics to be achieved in outside plant construction. It should be recognized that each new wire center requires a CO code which also has a significant cost, though a future one, that must be considered in economic evaluations of alternative plans.

(2) The use of multiple CO codes in the same wire center for rate discrimination purposes is discouraged unless reasonably full use of the codes is anticipated within the expected life of the CO code universe of the NPA involved. Typical situations where this problem arises include the provision of foreign exchange service from a wire center other than the one serving the foreign exchange, the consolidation of small

exchanges served by multiple-wire centers into a single-wire center without the merging of exchanges, and the provision of 2-way optional extended area service.

(3) With the continuing reduction of multiparty service, terminal-per-line equipment in step-by-step offices is inefficient in its use of telephone numbers and of CO codes. Plans for new central office units and replacement units should be based on terminal-per-station equipment with its larger number fill potential.

(4) Code protection is an arrangement wherein a CO code assigned in one NPA is excluded from assignment in an adjacent NPA in order to permit 7-digit dialing across the common boundary. This is a permissible arrangement and has advantages where a community of interest bridges the boundary in question but is acceptable only as long as it can be continued without causing the exhaustion of the CO code universe in the NPA protecting the code. Before undertaking a code protection arrangement, the problems of undoing it should be thoroughly evaluated.

(5) CO codes should not be dedicated to individual Centrex customers, but shared with other Centrex or non-Centrex customers. The single exception would be a Centrex customer whose anticipated number requirement will approach the administrative maximum number fill for a CO code. This can be accomplished by the use of a combination of 5-digit intra-Centrex dialing and 2-digit access codes for tie lines, dial dictation, paging services, Centrex attendant, etc.

(6) The multiline hunting feature provided in crossbar and ESS central office equipment precludes the necessity of assigning individual consecutive telephone numbers to each line in a hunting line group. (Of course, customer functions identified by number, including night connections, may still require individual line numbers.) The replacement of Step-by-Step and Panel Systems offers number conservation opportunities through this feature.

(7) As common control offices utilizing multiple CO codes diminish in station capacity due to limited call carrying capacity, it is often possible through careful number administration to recapture a code for reuse in another entity.

(8) CO codes reserved for growth in specific areas of step-by-step oriented NPAs should be reviewed frequently for possible recapture by virtue of either changes in the forecasted growth patterns or a reduction in routing restrictions resulting from the replacement of step-by-step equipment with common control units.

(9) Special CO codes dedicated for miscellaneous purposes such as customer instruction, special billing, mass calling announcement services, etc, should be kept to a minimum.

(10) In some cases, 3-row TWX stations are assigned theoretical codes for rating purposes. This inefficient use for CO codes can be eliminated by using the "Basket Code" concept consisting of changing the involved TWX station numbers to new ones utilizing a small number series within a regular working CO code.

(11) Paging service should be provided on an end-to-end signaling basis rather than assigning a discrete telephone number per paging receiver, primarily in the interest of conserving central office numbers and codes. Under this end-to-end arrangement, a telephone number is dialed by the calling party to reach the paging control terminal. The caller then selects the particular receiver to be signaled by dialing a supplemental multidigit number using TOUCH-TONE® station equipment.

(12) CO codes dedicated for plant test and communication purposes should be minimized. While certain types of older common control central office equipment require as many as 20 dedicated codes and certain coexisting combinations as many as 21, it is expected that, by the 1980s, this number will be reduced to five codes of the CO code type including 958 and 959.

4. CODE RELIEF

4.01 It has been necessary in recent years to augment the supply of CO codes for some NPAs and this activity will continue as long as telephone number growth continues. Once the CO code conservation measures discussed in 3.02 have been exploited, the only means of achieving CO code relief is to:

(1) Realign NPA boundaries (applies only to multi-NPA states)

(2) Introduce Interchangeable codes within NPA requiring relief

(3) Split existing NPA and introduce a new Area code.

4.02 Basic economic consideration and design in the initial switching machines have made it possible for the equipment to readily distinguish between NPA codes and CO codes; but, since the introduction of Interchangeable codes precludes the ability of central office equipment to determine whether to expect a 7-digit or a 10-digit call based on the presence of a "0" or "1" in the "B" or second-digit position, a new methodology is required to distinguish 7-digit calls. Two basic means of accomplishing this have been known for many years.

(1) The ***"Timing Method"*** requires that central office equipment be arranged to wait for a period of 3 to 5 seconds after receiving seven digits (excluding the prefix digit 0 or 1) to distinguish between 7-digit and 10-digit toll calls before routing a call on a 7-digit basis. If one or more additional digits are received within this critical 3-to-5-second "time-out" interval, the equipment expects a 10-digit call. With the use of pretranslation, however, timing will be restricted to only those calls having code ambiguity and will preclude timing on all local station calls.

(2) The alternative arrangement, called the ***"Prefix Method,"*** would utilize the presence of either a "1" or "0" prefix to identify the call being dialed as having a 10-digit format. This arrangement has mixed virtues in that it would require all customer-dialed, operator-serviced traffic to be dialed on a "0"+10-digit basis and that, in areas with step-by-step equipment, Home NPA station toll calls would have to be dialed on a "1"+10-digit basis until the equipment is replaced. On the other hand, there are the advantages that the larger cost of providing for timing and customer irritation arising from both increased post-dialing delay and reaching wrong numbers due to inadvertent time-out are precluded.

4.03 It is recommended that both methods be carefully evaluated in all cases and that method selection be based on an appropriately balanced evaluation of costs and customer preference, not only initially, but in the long term. Extensive studies conducted by the Bell Laboratories indicate that, on an individual call basis, customers prefer to dial three additional digits rather than waiting for a call to time out. Bell Laboratories also points out that the advantages of new technology in decreasing post-dialing delay are more readily achieved under the "prefix method." In areas without step-by-step equipment, the "prefix method" imposes the incremental 3-digit dialing requirement on only "0+" Home NPA traffic; but in areas with step-by-step equipment, the additional three digits also would be required for all Home NPA station toll traffic. On the other hand, the "timing method," which utilizes pretranslation capability to limit timing to only those calls involving an ambiguous code in the first three digits dialed, will be relatively innocuous when first introduced but will become increasingly noticeable as code ambiguity expands.

4.04 The customer irritation that would occur as a result of the introduction of either method within an NPA is difficult to quantify because it is not solely attributable to irritation associated with a particular type of call multiplied by the frequency of that type of call. It is complicated by the diversity of call placing experiences. Unusual experiences, such as waiting occasionally for "time-out," can overshadow numerous experiences where "time-out" does not occur. In the long term, step-by-step equipment will be replaced with common control or ESS equipment and only Home NPA "0+" traffic, a very small portion of all traffic, will be affected by either method. Evidence indicates that the "prefix method" will unquestionably be preferable in that time frame.

4.05 Although plan selection will be a matter of individual local company decision, it is recommended that the "prefix method" be given preferential consideration and its near-term penalties be carefully weighed against its long-term benefits. In at least one large metropolitan area, Home NPA station toll calls have been placed on a 1+10-digit basis for many years without any substantial level of customer complaints. Aside from the problems of transition, there is no reason to expect different customer reaction elsewhere. Transition problems can be eased through early introduction of the Interchangeable code dialing procedures while retaining the existing procedures as permissive until actual code ambiguity is introduced.

4.06 The ramifications of both methods of introducing Interchangeable codes are shown in Chart 6 of this section.

5. TERMINATING TOLL CENTER AND OPERATOR CODES

5.01 A Terminating Toll Center code (TTC) is normally assigned to each Control Switching Point (CSP) and toll center whether it be Class 1, 2, 3, or 4C as defined in Section 3. One switching office per NPA, usually the principal city, is identifiable without a TTC code from points external to the NPA. The principal use of these codes is to enable outward operators to reach inward, directory assistance, "leave word," and other specific operators in distant city toll centers. A secondary use is by maintenance personnel to reach test equipment in distant offices. Although most TTCs are within "0XX" series, some may be within the "1XX" series. (Two specific exceptions to this, "011" and "010", are discussed in 6.05.)

5.02 Operator Codes (OpCs) are used exclusively by outward operators to designate specific operator groups associated with toll centers. Most operator codes are 3-digit only, eg, "121" for inward and "131" for directory assistance. "Leave Word" codes are either four or five digits and are in the "11XX" or "11XXX" series. Switching offices with nationally published TTCs operate with 11XX Leave Word codes. All toll centers without a discrete TC code assigned must use 11XXX Leave Word codes.

5.03 Outward operator dialing procedures are typified by the following examples of calls placed to inward operators:

ORIGINATING LOCATION	TERMINATING LOCATING	CODES DIALED	DIGITS DIALED (EXAMPLE)
Foreign NPA	Nonprincipal City	NPA+TTC+OpC	216+046+121
Foreign NPA	Principal City	NPA+OpC	216+121
Home NPA	Nonprincipal City	TTC+OpC	046+121
Home NPA	Principal City	OpC	121 or a locally assigned 0XX+121

5.04 In order to prevent customers from dialing directly to special groups of operators and as a protection against fraudulent use of the service, it is necessary to arrange the equipment in all recording offices to block all customer-dialed calls with a "0" or a "1" in the fourth-digit position of 10-digit calls and certain calls with a "0" or a "1" in the first-digit position.

5.05 Special use of 3-digit codes in the "0XX" and "1XX" series is made within the network on a machine-generated basis for discrete routing purposes such as Inward WATS and international services.

6. CUSTOMER DIALING PROCEDURES

6.01 The ultimate dialing format assumes all switching systems throughout the country to be ESS or common control and use the prefix method described in part 4 for machine identification of Interchangeable codes as follows:

(1) Seven digits for all local calls, including those to an FNPA where there is code protection, and toll calls within the HNPA

(2) 1+10 digits for all FNPA customer-dialed station toll calls

(3) 0+10 digits for all HNPA and FNPA customer-dialed toll calls requiring operator assistance.

6.02 It would be ideal if the dialing procedures for each type of call were identical in all areas. This, however, is impossible as long as the capabilities of the switching equipment in use differ. It is expected that multiple dialing procedures will be a practical necessity for many years to come because of the variety of equipment expected to be in use. Chart 6 shows recommendations for the dialing procedures for all types of direct dialed calls placed within the network except for those utilizing N11 codes. It is urged that the recommendations outlined be followed in the interest of minimizing customer confusion and that any necessary changes in working toward the ultimate arrangement be made as early as practical.

6.03 For several years, some of the Bell Operating Companies have used the "611" code for access to Repair Service and the "811" code for access to the Business Office. The universal adoption of these previously recommended procedures has been impractical because of the high costs involved in activating these codes in some areas. Recently, the Bell Operating Companies have been expanding their use of different Business Offices for different classes of service and Repair Service Centers have been similarly divided in some locations. While additional N11 codes could probably be assigned to accommodate these changes, the expenditures required for modifying the switching equipment would be excessive in most areas. The resulting long-term impracticality of making N11 codes universal for these purposes suggests the use of 7-digit numbers for any future splintering of these services and the gradual phasing out of "611" and "811" as opportunities present. In the interim, the use of these N11 codes should be considered as optional but their use should be uniform within metropolitan or directory serving areas.

6.04 All N11 codes, exclusive of "411" and "911", should be kept available for future special services but may be used as temporary test codes provided that such use can be stopped on short notice. Public emergency service should always be dialed as "911". The use of a "1" prefix is unacceptable.

6.05 International Direct Distance Dialing (IDDD) was first introduced in 1970 and is being expanded to many locations in the network. The codes "01", "011", and "010" have been reserved for customer-dialing purposes although only "011" is in use (late 1973). See Section 10 for details.

6.06 The dialing code for operator assistance is "0" (zero).

6.07 Directory Assistance calls should be dialed in accordance with the following:

DIRECTORY ASSISTANCE DIALING PROCEDURES

SERVICE PROVIDED	PREFIX	SERVICE CODE	AREA CODE	CO CODE	TERM. DIGITS	NOTES
HNPA-Local	-	411	-	-	-	1
	1	411	-	-	-	2,3
HNPA-Toll	-	-	-	555	1212	4
	1	-	-	555	1212	5
	-	-	N0/1X	555	1212	6,10
	1	-	N0/1X	555	1212	7,10
FNPA-Local	-	411	-	-	-	1,9
	1	411	-	-	-	1,3,9
FNPA-Toll	-	-	N0/1X	555	1212	8,10
	1	-	N0/1X	555	1212	10,11

Notes:

1. Standard for all areas.
2. Acceptable alternative for small SXS offices.
3. Acceptable alternative in areas with SXS equipment where it is necessary to record Directory Assistance calls at CAMA tandems.
4. Standard for areas without SXS equipment.
5. Standard for areas with SXS equipment.
6. Deny procedure.
7. Permit in addition to standard or acceptable alternative procedure.
8. Standard for areas without SXS equipment prior to Interchangeable codes.
9. The number of practical applications should be minimized.
10. Area codes will be in NXX form rather than N0/1X after Interchangeable Area codes are introduced.
11. Standard for areas with SXS equipment prior to Interchangeable codes and for all areas thereafter.

6.08 In areas where optional Extended Area Service (EAS) is offered, calls to certain points are local (not detailed billed) for customers who select the optional EAS plan whereas, they are toll for the remaining customers. In these areas, the dialing procedures for ALL customers should be identical because of the gross awkwardness and impracticality of instructing customers to use differing procedures. In addition, the equipment and trunking arrangements would in many instances be inordinately costly. The single group of procedures used must be that required for the recording of toll calls made by customers who select the most limited service offering.

6.09 Local equipment arrangements in some locations permit the dialing of local calls on less than a 7-digit basis. However, all telephone numbers must actually be formatted in accordance with 1.01 in order to be directly dialable from other network points. Thus, with regular 10-digit numbers assigned to telephones in these locations, standard dialing procedures as shown on Chart 6 must be adopted even though less than 7-digit dialing of local calls is possible due to the use of "digit-absorbing" selectors or equivalent equipment.

7. CENTRAL OFFICES SERVING SEVERAL NPAs

7.01 A central office location near the boundary of an NPA may furnish service to customers in one or more adjacent NPAs. In such cases, it is necessary to assign separate and different CO codes to the groups of customers within each NPA and to arrange the central office equipment so as to route all calls properly and record appropriately for billing. The dialing procedures to be used must be selected on the basis of whether or not code protection exists.

8. NUMBERING OF COIN STATIONS

8.01 Coin stations (public or semipublic telephones) should be numbered in the 9000 series, eg, 225 through 9XXX. The present operating practices provide for checking coin telephones on collect calls in the 9000 series only. Use of other numbers for coin stations should be avoided. On collect calls, the outward or originating operator must determine whether or not a coin station is being called. If the called telephone number is in the 9000 series, the operator will determine either from a switchboard bulletin or DA operator if the called central office has coin stations.

8.02 The larger Bell and Independent exchanges, for the most part, have their coin numbers segregated in the 9000 series. In small exchanges employing digit-absorbing selectors, such segregation may make certain Central Office codes unusable or may require another stage of selectors. Nevertheless, segregation of coin stations in all exchanges is desirable to gain overall operating efficiency by reducing operator work time on collect calls.

ASSIGNED NUMBERING PLAN AREAS AND CODES BY AREA OR SPECIAL AREA CODE IN NUMERICAL ORDER

AREA CODE	STATE/PROVINCE OR OTHER SPECIAL USE
201	New Jersey
202	District of Columbia
203	Connecticut
204	Manitoba
205	Alabama
206	Washington
207	Maine
208	Idaho
209	California
212	New York
213	California
214	Texas
215	Pennsylvania
216	Ohio
217	Illinois
218	Minnesota
219	Indiana
301	Maryland
302	Delaware
303	Colorado
304	West Virginia
305	Florida
306	Saskatchewan
307	Wyoming
308	Nebraska
309	Illinois
312	Illinois
313	Michigan
314	Missouri
315	New York
316	Kansas
317	Indiana
318	Louisiana
319	Iowa
401	Rhode Island
402	Nebraska
403	Alberta
404	Georgia
405	Oklahoma
406	Montana
408	California
412	Pennsylvania
413	Massachusetts
414	Wisconsin
415	California
416	Ontario
417	Missouri
418	Quebec
419	Ohio
501	Arkansas
502	Kentucky
503	Oregon
504	Louisiana
505	New Mexico
506	New Brunswick
507	Minnesota
509	Washington
510	TWX (USA)
512	Texas
513	Ohio
514	Quebec
515	Iowa
516	New York
517	Michigan
518	New York
519	Ontario
601	Mississippi
602	Arizona
603	New Hampshire
604	British Columbia
605	South Dakota
606	Kentucky
607	New York
608	Wisconsin
609	New Jersey
610	TWX (Canada)
612	Minnesota
613	Ontario
614	Ohio
615	Tennessee
616	Michigan
617	Massachusetts
618	Illinois
701	North Dakota
702	Nevada
703	Virginia
704	North Carolina
705	Ontario
707	California
709	Newfoundland
710	TWX (USA)
712	Iowa
713	Texas
714	California
715	Wisconsin
716	New York
717	Pennsylvania
800	Inward WATS
801	Utah
802	Vermont
803	South Carolina
804	Virginia
805	California
806	Texas
807	Ontario
808	Hawaii
809	Bermuda, Puerto Rico, Virgin Islands, and other Caribbean Islands
810	TWX (USA)
812	Indiana
813	Florida
814	Pennsylvania
815	Illinois
816	Missouri
817	Texas
819	Quebec
900	Mass Calling
901	Tennessee
902	Nova Scotia and Prince Edward Island
903	Northwest Mexico
904	Florida
905	Mexico City
906	Michigan
907	Alaska
910	TWX (USA)
912	Georgia
913	Kansas
914	New York
915	Texas
916	California
918	Oklahoma
919	North Carolina

Chart 1—Numeric List of NPAs Assigned at the End of 1974

ASSIGNED NUMBERING PLAN AREAS AND CODES BY GEOGRAPHICAL LOCATION OR SPECIALIZED USE IN ALPHABETICAL ORDER

STATE/PROVINCE OR OTHER SPECIAL USE	AREA CODE	STATE/PROVINCE OR OTHER SPECIAL USE	AREA CODE	STATE/PROVINCE OR OTHER SPECIAL USE	AREA CODE
Alabama	205	Illinois	312	New York	518
Alaska	907	Illinois	618	New York	607
Arizona	602	Illinois	815	New York	716
Arkansas	501	Indiana	219	New York	914
Bermuda, Puerto	809	Indiana	317	North Carolina	704
Rico, Virgin Is-	809	Indiana	812	North Carolina	919
lands, and other	809	Inward WATS	800	North Dakota	701
Carribbean Islands	809	Iowa	319	Ohio	216
California	209	Iowa	515	Ohio	419
California	213	Iowa	712	Ohio	513
California	408	Kansas	316	Ohio	614
California	415	Kansas	913	Oklahoma	405
California	707	Kentucky	502	Oklahoma	918
California	714	Kentucky	606	Oregon	503
California	805	Louisiana	318	Pennsylvania	215
California	916	Louisiana	504	Pennsylvania	412
Canada:		Maine	207	Pennsylvania	717
Alberta	403	Maryland	301	Pennsylvania	814
British Columbia	604	Massachusetts	413	Rhode Island	401
Manitoba	204	Massachusetts	617	South Carolina	803
New Brunswick	506	Mass Calling	900	South Dakota	605
Newfoundland	709	Mexico:		Tennessee	615
Nova Scotia and	902	Mexico City	905	Tennessee	901
Prince Edward	902	Northwest Mexico	903	Texas	214
Island	902	Michigan	313	Texas	512
Ontario	416	Michigan	517	Texas	713
Ontario	519	Michigan	616	Texas	806
Ontario	613	Michigan	906	Texas	817
Ontario	705	Minnesota	218	Texas	915
Ontario	807	Minnesota	507	TWX:	
Quebec	418	Minnesota	612	Canada	610
Quebec	514	Mississippi	601	USA	510
Quebec	819	Missouri	314	USA	710
Saskatchewan	306	Missouri	417	USA	810
Colorado	303	Missouri	816	USA	910
Connecticut	203	Montana	406	Utah	801
Delaware	302	Nebraska	308	Vermont	802
District of Columbia	202	Nebraska	402	Virginia	703
Florida	305	Nevada	702	Virginia	804
Florida	813	New Hampshire	603	Washington	206
Florida	904	New Jersey	201	Washington	509
Georgia	404	New Jersey	609	West Virginia	304
Georgia	912	New Mexico	505	Wisconsin	414
Hawaii	808	New York	212	Wisconsin	608
Idaho	208	New York	315	Wisconsin	715
Illinois	217	New York	516	Wyoming	307
Illinois	309				

Chart 2—Geographical Areas Served by NPAs Assigned at the End of 1974

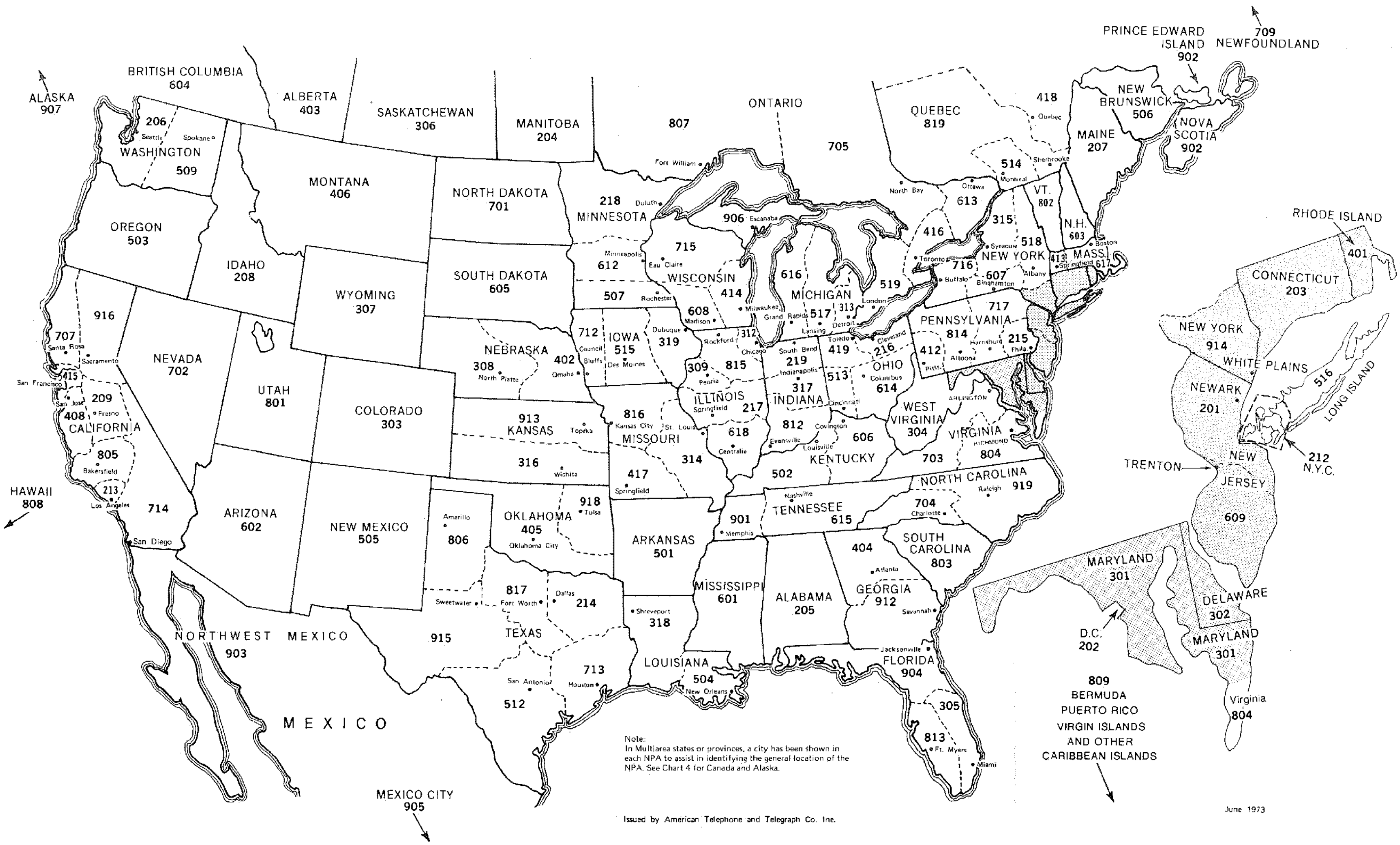


Chart 3—NPA Map of the Continental United States

Chart 4—NPA Map of Canada and Alaska

ASSIGNMENT OF THE 63* NNO CODES

There are 36 NNO codes which should be assigned as Central Office codes, to the extent practical, in the following sequence:

TABLE I

SEQUENCE NUMBER	NNO CODE	SEQUENCE NUMBER	NNO CODE
1	530	19	640
2	420	20	280
3	870	21	790
4	780	22	370
5	440	23	320
6	360	24	890
7	920	25	770
8	830	26	690
9	620	27	840
10	390	28	820
11	340	29	540
12	330	30	350
13	560	31	970#
14	670	32	990
15	630	33	960
16	430	34	860
17	270	35	980
18	750	36	460

When these 36 NNO codes are used, the remaining 27 NNO codes should be assigned, to the extent practical, as Central Office codes in the following sequence:

TABLE II

SEQUENCE NUMBER	NNO CODE	SEQUENCE NUMBER	NNO CODE
37	380	51	850
38	570	52	730
39	880	53	720
40	760	54	680
41	450	55	660
42	930	56	490
43	740	57	250
44	580	58	220
45	550	59	650
46	470	60	590
47	290	61	520
48	240	62	480
49	230	63	260
50	940		

When the supply of the 152 N0/1X codes is exhausted, the above codes will be assigned, to the extent feasible, as Area codes in the reverse sequence from that shown; namely, 260 first, 480 second, 520 third, etc, with 530 last.

* The sixty-fourth NNO code (950) is reserved for a future network-wide service.

\# This code is temporarily used network-wide as a Plant Test code.

Chart 5—NNO Code Assignment Sequence List

RECOMMENDED CUSTOMER DIALING PROCEDURES

TYPE OF CALL	AREAS WITH SXS EQUIPMENT						AREAS WITHOUT SXS EQUIPMENT					
	PREFIX REQ'D	AREA CODE	CO CODE	TERM. DIGITS	USE RECOM	NOTES	PREFIX REQ'D	AREA CODE	CO CODE	TERM. DIGITS	USE RECOM	NOTES
				WITHOUT INTERCHANGEABLE CODES								
STATION PAID												
HNPA-Local			NNX -	XXXX	S	5			NNX -	XXXX	S	5
	1+		NNX -	XXXX	D	2,3	1+		NNX -	XXXX	D	3,6
								N0/1X +	NNX -	XXXX	D	3,6
	1+	N0/1X +	NNX -	XXXX	P	2,4	1+	N0/1X +	NNX -	XXXX	P	4,6
FNPA (Protected Codes)-Local			NNX -	XXXX	S	1,5			NNX -	XXXX	S	1,5
	1+		NNX -	XXXX	D	1,2,3	1+		NNX -	XXXX	D	1,3,6
	1+	N0/1X +	NNX -	XXXX	P	1,2,7	1+	N0/1X +	NNX -	XXXX	P	1,6,7
FNPA (Nonprotected Codes)-Local								N0/1X +	NNX -	XXXX	S	3
	1+	N0/1X +	NNX -	XXXX	S	2,5	1+	N0/1X +	NNX -	XXXX	P	5
HNPA-Toll									NNX -	XXXX	S	5
	1+		NNX -	XXXX	S	3	1+		NNX -	XXXX	D	3,6
								N0/1X +	NNX -	XXXX	D	3,6
	1+	N0/1X +	NNX -	XXXX	P	5	1+	N0/1X +	NNX -	XXXX	P	4,6
FNPA-Toll								N0/1X +	NNX -	XXXX	S	
	1+	N0/1X +	NNX -	XXXX	S	5	1+	N0/1X +	NNX -	XXXX	P	5,6
CUST DIALED-OPER SERVICED												
HNPA-A11	0+		NNX -	XXXX	S	3	0+		NNX -	XXXX	S	3
	0+	N0/1X +	NNX -	XXXX	P	5	0+	N0/1X +	NNX -	XXXX	P	5
FNPA-Protected Codes	0+		NNX -	XXXX	S	3	0+		NNX -	XXXX	S	3
	0+	N0/1X +	NNX -	XXXX	P	5	0+	N0/1X +	NNX -	XXXX	P	5
FNPA-Nonprotected Codes	0+	N0/1X +	NNX -	XXXX	S	5	0+	N0/1X +	NNX -	XXXX	S	5
				WITH INTERCHANGEABLE CO CODES (NOTE 9)								
		- Timing on "1+ and 0+" Calls -						- Timing on "0+" Calls only (Note 8) -				
STATION PAID												
HNPA-Local			NNX -	XXXX	S				NNX -	XXXX	S	
	1+	N0/1X +	NNX -	XXXX	P	2	1+	N0/1X +	NXX -	XXXX	P	6
FNPA (Protected Codes)-Local			NNX -	XXXX	S	1			NNX -	XXXX	S	1
	1+	N0/1X +	NXX -	XXXX	P	1,2,7	1+	N0/1X +	NXX -	XXXX	P	1,6,7
FNPA (Nonprotected Codes)-Local	1+	N0/1X +	NXX -	XXXX	S		1+	N0/1X +	NXX -	XXXX	S	
HNPA-Toll	1+		NXX -	XXXX+TO	S				NXX -	XXXX	S	
	1+	N0/1X +	NXX -	XXXX	P	4	1+	N0/1X +	NXX -	XXXX	P	4,6
FNPA-Toll	1+	N0/1X +	NXX -	XXXX	S		1+	N0/1X +	NXX -	XXXX	S	
CUST DIALED-OPER SERVICED												
HNPA-A11	0+		NXX -	XXXX+TO	S		0+		NXX-	XXXX+TO	S	
	0+	N0/1X	NXX -	XXXX	P	4	0+	N0/1X +	NXX -	XXXX	P	4,6
FNPA-Protected Codes	0+		NXX -	XXXX+TO	S	1	0+		NXX -	XXXX+TO	S	1
	0+	N0/1X +	NXX -	XXXX	P	1,4	0+	N0/1X +	NXX -	XXXX	P	1,6
FNPA-Nonprotected Codes	0+	N0/1X +	NXX -	XXXX	S		0+	N0/1X +	NXX -	XXXX	S	

Chart 6—Recommended Customer Dialing Procedures

RECOMMENDED CUSTOMER DIALING PROCEDURES (Cont)

TYPE OF CALL	AREAS WITH SXS EQUIPMENT: PREFIX REQ'D	AREA CODE	CO CODE	TERM. DIGITS	USE RECOM	NOTES	AREAS WITHOUT SXS EQUIPMENT: PREFIX REQ'D	AREA CODE	CO CODE	TERM. DIGITS	USE RECOM	NOTES
WITH INTERCHANGEABLE CO CODES (NOTE 9) - Using Prefix Method -												
STATION PAID												
HNPA-Local			NXX -	XXXX	S				NXX -	XXXX	S	
	1+	N0/1X +	NXX -	XXXX	P	2	1+	N0/1X +	NXX -	XXXX	P	6
FNPA (Protected Codes)-Local			NNX -	XXXX	S	1			NXX -	XXXX	S	1
	1+	N0/1X +	NXX -	XXXX	P	1,2	1+	N0/1X +	NXX -	XXXX	P	1,6
FNPA (Nonprotected Codes)-Local	1+	N0/1X +	NXX -	XXXX	S		1+	N0/1X +	NXX -	XXXX	S	
HNPA-Toll									NXX -	XXXX	S	
	1+	N0/1X +	NXX -	XXXX	S		1+	N0/1X +	NXX -	XXXX	P	6
FNPA-Toll	1+	N0/1X +	NXX -	XXXX	S		1+	N0/1X +	NXX -	XXXX	S	
CUST DIALED-OPER SERVICED												
All	0+	N0/1X +	NXX -	XXXX	S		0+	N0/1X +	NXX -	XXXX	S	

LEGEND AND NOTES

S — Standard procedure
D — Deny procedure
P — Permit in addition to standard procedure
N — Any digit 2 through 9
0/1 — The digit 0 or 1
X — Any digit 0 through 9
+TO — 3 to 5 second time-out required (on ambiguous codes only)
HNPA — Home Numbering Plan Area
FNPA — Foreign Numbering Plan Area

Notes:

1. Protected codes
2. Unnecessary use of the prefix "1" in SXS equipment involves the unnecessary use of transmission, recording, and switching equipment. The use of these "permitted" procedures is left to the discretion of the local company.
3. This procedure will be denied in the long term.
4. This procedure will be permissive in the long term.
5. This procedure will be standard in the long term.
6. Only minor unnecessary use of local switching equipment is involved.
7. This procedure will be permissive in the long term if code protection is not eliminated and standard if it is eliminated.
8. By utilizing the prefix "1" for all 10-digit station calls, no timing is required on HNPA station calls whether local or toll.
9. When Interchangeable Area codes are introduced, the procedures will be identical to those shown except that NXX codes will replace the N0/1X codes in the Area Code columns.

Chart 6—Recommended Customer Dialing Procedures (Cont)

NOTES ON DISTANCE DIALING

SECTION 1

GENERAL INFORMATION

CONTENTS **PAGE**

1. INTRODUCTION

1.01 The term distance dialing as used in these Notes and as commonly understood within the telephone industry means the completion of long distance calls by either customers or operators dialing from the originating location without any assistance from intermediate operators. CAMA, TSP, or TSPS operators who may enter on the line for momentary assistance are not considered intermediate operators. The phrase "Direct Distance Dialing" is used to describe calls dialed by customers to points outside their local or extended service area. When these calls are dialed by operators, the phrase "Operator Distance Dialing" is sometimes employed. Since the distance dialing method provides for fast, accurate, and dependable telephone service, and at the same time results in overall operating economies, it has been accepted as an industry-wide objective.

1.02 The Notes are intended to serve as a general reference and guide for the telecommunications industry on the principles of distance dialing. They describe minimum requirements and are not intended to provide detailed engineering information. Since the basic plan is designed for both operator and customer dialing, no distinction is made between the two except in instances where requirements differ. Detailed description of circuit operation has been avoided and the requirements for switching systems are covered only to the extent that they affect distance dialing considerations.

1.03 Generally, the Notes describe the requirements that apply when distance dialing has been fully realized and do not cover interim arrangements which may be both expedient and appropriate during transitional periods. Many things dictated by local conditions must be considered before the methods and equipment arrangements for a given office can be properly determined.

1.04 Some references are made to equipment of Bell System manufacture; however, appropriate equipment for other manufacturers with the necessary operating features can be employed.

2. DESCRIPTION OF SECTIONS

NUMBERING PLAN AND DIALING PROCEDURES (SECTION 2)

2.01 A primary concern of the distance dialing plan, first conceived in the early 1940s, was the creation of a numbering system that would uniquely identify each station. It was essential that the numbering plan reflect uniformity, be convenient to use, and be compatible with existing local and extended area dialing arrangements.

2.02 The numbering system that resulted is referred to as "destination code" numbering which utilizes the disciplines of destination code routing. Telephone numbers for distance dialing consist of two basic parts.

(1) A 3-digit Numbering Plan Area (NPA) code identifying a geographical area

(2) A 7-digit telephone number consisting of a 3-digit Central Office (CO) code and a 4-digit station number.

2.03 As the demand for telephone service increases, care must be taken in assigning Area and Central Office codes. Parts 4 and 5 discuss relief plans for these codes. Economical utilization of these codes can be accomplished by careful planning.

2.04 Numbering plan arrangements and dialing procedures for the North American Network are discussed in Section 2. International numbering arrangements are discussed in Section 10.

SWITCHING PLAN FOR DISTANCE DIALING (SECTION 3)

2.05 Another requirement for distance dialing is a switching plan that routes traffic automatically, economically, and rapidly to its destination. This need is met by switching and trunking arrangements that adhere to the rules of a hierarchical network.

2.06 The distance dialing plan takes full advantage of the overall economies offered by alternate routing within the limits of an orderly discipline. Trunk plant is used more efficiently under the alternate routing plan than under manual operation. Section 3 describes the switching plan in considerable detail.

EQUIPMENT REQUIREMENTS (SECTION 4)

2.07 There are several miscellaneous equipment requirements for distance dialing in addition to the signaling requirements detailed in Section 5. Section 4 summarizes these requirements and includes brief discussions of the demands of distance dialing on station equipment, switching systems, long distance switchboards, automatic equipment for recording message billing data, and miscellaneous central office and network administrative facilities.

2.08 Section 4 is confined to those specific central office equipment arrangements which need to be provided to interconnect an office with the distance dialing network. No attempt has been made to cover the many other requirements for local and long distance services. The type of equipment employed is not important from the standpoint of distance dialing as long as the minimum requirements outlined in this section, in Section 5 on signaling, and in Section 7 on transmission are met. For this reason, Section 4 covers a number of fundamental considerations regarding miscellaneous and somewhat unrelated items.

SIGNALING (SECTION 5)

2.09 One of the most important needs for industry-wide information about distance dialing is a statement of the signaling requirements. With automatic switching, a complex system of signals is needed to pass information over the dialing network. These signals include address information and supervisory states. They must be designed to actuate and be recognized by switching systems of different types and manufacture and must be capable of being carried accurately and rapidly over many types of transmission facilities.

2.10 Section 5 discusses the signals required for distance dialing and related matters. Considerable technical information is included to illustrate 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 switching and transmission systems are shown for informational background. A number of charts and schematic diagrams illustrating signaling fundamentals are also included. Since basic signaling requirements are essentially the same for both operator- and customer-dialed traffic, no distinction has been made between the two except where necessary.

COMMON CHANNEL INTEROFFICE SIGNALING (SECTION 6)

2.11 Common Channel Interoffice Signaling (CCIS) is a method of signaling between processor-equipped switching systems. Essentially, CCIS provides 2-way signaling between switching systems independent of the transmission path of the message circuits.

2.12 Section 6 gives details on the advantages, potential, operation, administration, and maintenance of the CCIS system.

TRANSMISSION CONSIDERATIONS (SECTION 7)

2.13 The switching plan for distance dialing contemplates that most calls are to be completed on direct circuits or over two or three intertoll trunks switched together in tandem. A very small portion of the total number of calls may encounter as many as seven intertoll trunks within the United States or Canada. This requires careful transmission design as well as concentrated effort in maintaining transmission values close to design objectives.

2.14 The transmission requirements for distance dialing raise no design problems that differ from the design problems of the telephone industry since its beginning. Design parameters and objectives for trunk plant are covered in some detail in Section 7. The section is organized by transmission parameters. Within each section, a brief description is made of the parameter, its effect on service, and its control in terms of performance and maintenance objectives.

MAINTENANCE REQUIREMENTS (SECTION 8)

2.15 A high level of equipment maintenance performance is required at the switching centers in the distance dialing network. This is 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 not only react unfavorably on the customers, who may be the first to detect them, but also result in inefficient use of the network.

2.16 Means have been developed for the automatic detection and recording of trouble so that most trunk and equipment troubles may be cleared before they can cause serious service reactions. Section 8 describes automatic testing equipment, test lines, and various other testing facilities suited to the needs of distance dialing together with suggestions for their application.

WIDE AREA TELECOMMUNICATIONS SERVICE (SECTION 9)

2.17 To meet the needs of telephone users who make or receive substantial volumes of DDD calls, WATS service was established. Within the United States, WATS service may be subscribed to on an outward or inward basis. Since the operations are somewhat different, they are discussed separately.

2.18 Section 9 describes in some detail the WATS serving area, line numbering, administrative considerations, and routing both interstate and intrastate service.

INTERNATIONAL DIALING (SECTION 10)

2.19 International Direct Distance Dialing (IDDD) was first introduced in March 1970. At present, IDDD from the US offers access to 20 countries. Section 10 discusses the requirements of IDDD on the communications industry in the areas of numbering, signaling, switching, equipment, transmission, and maintenance.

NETWORK MANAGEMENT (SECTION 11)

2.20 To provide a satisfactory grade of service, an effective network management arrangement is required. Network Management encompasses the techniques and organization to insure optimum use of available facilities under abnormal load conditions or equipment and facility failure.

2.21 Section 11 gives a conceptual description of a Network Management organization as well as descriptions of such controls as Dynamic Overload Controls (DOC) and Directional Reservation Equipment (DRE).

BIBLIOGRAPHY (SECTION 12)

2.22 As mentioned in the beginning of Section 1, it is intended to describe in these Notes the minimum requirements to be met in order to connect with the distance dialing network. For those who may wish to explore, in more detail, subjects related to distance dialing, the Bibliography, Section 12, is furnished for reference.

3. FUNDAMENTAL LONG RANGE PLANNING

3.01 As customer needs and serving arrangements grow in scope and complexity year by year, the need for thorough planning assumes a higher order of significance in insuring good service. In addition to the subjects covered in detail in Sections 2 through 11, it may be worthwhile to consider briefly the fundamental plans which are the keystones to the inclusion of any office or service, large or small, in the distance dialing network.

3.02 Large sums of money are often required to provide for growth and service innovations tailored to customers' needs. Effective planning is the key to insuring that all network components (switchboards, buildings, trunk facilities, switching systems, and the like) fit together in a smoothly working and efficient overall system.

3.03 Service-oriented planners must face up to and answer such questions as "Where are we going?" (Strategic Planning) and "How do we get there?" (Long Range and Implementation Planning). A thorough job must be done in assessing the future and determining possible courses of action. There should be an adequate appraisal of the impact on serving arrangements of new services, of modernized services, and of technological innovations. The best course of action should be chosen to implement selected plans and to do so in harmony with a universe of other plans and without impairment of service.

3.04 Planning objectives may be summarized in these terms.

(1) To provide guidance for systematic, orderly growth of the business and maintenance of the planned quality of service

(2) To provide a summation of industry objectives so that current operations will have direction, and decisions can include considerations of the future as well as present needs

(3) To provide an indication of plant (facilities and equipment), people, and capital requirements to achieve objectives.

3.05 Fundamental planning for accomplishing distance dialing includes the following broad fields:

(1) Analysis of basic traffic data and methods

(2) Plans for equipment to automatically record and process message billing data for direct customer-dialed traffic

(3) Plans and programs for local central offices and customer loops including local numbering

(4) Plans and programs for plant including types of transmission facilities, signaling conditions and switching equipment.

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

(1) Future routings under the switching plan for distance dialing

(2) Estimates of future traffic volumes and possible changes in the characteristics of traffic including:

(a) The portion of traffic that can be dialed by customers

(b) The potential for eliminating cordboard handled traffic.

(c) The portion of traffic to be handled by special service networks.

3.07 Because service improvements and operating economies 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. Factors pertaining to this phase of planning include:

(1) The type of station identification to be used

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

(3) Whether recording systems for person, credit card, and coin traffic should be provided

(4) Traffic volumes to be dialed and the relative proportions of traffic to be detailed or bulk billed

(5) Operating economies which result.

3.08 Fundamental planning for a local exchange to be connected to the distance dialing network includes provision for:

(1) A unique 3-digit Central Office code

(2) A uniform 10-digit telephone number for each station

(3) Segregation of coin boxes (public or semipublic telephones) in certain recommended thousand series to the extent possible

(4) Adequate interception of nonworking station numbers and vacant Central Office codes

(5) Signaling requirements (as outlined in Section 5)

(6) Customer loop design (as described in Section 7) which will establish the lowest loop loss consistent with economy

(7) Automatic Number Identification whenever feasible.

3.09 Fundamental planning for switching equipment, outside plant, and terminal facilities takes the following into account:

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

(2) The most economical transmission facilities which will meet transmission objectives (eg, carrier, radio, voice frequency, etc) should be selected for relief on existing routes and on new routes that may be established. This involves such factors as:

(a) Current and future traffic volumes and trunking requirements for the message network plus requirements for special services.

(b) Transmission design objectives under the switching plan for distance dialing with consideration for future integration of transmission and switching facilities.

(c) Establishment of an approximate but realistic timetable for the programming of the various phases of mechanization for all distance dialed traffic.

(d) Provision of new routes separated from present routes for protection of service.

3.10 Because the sums invested are large and because the service life of most plant is appreciable, it is important that fundamental plans be made well in advance of the time when something must be done. This will help smooth the transition to mechanized operation and the introduction of new services. New plant and equipment can be provided in an orderly manner without incurring unwise or unnecessary expenditures. Flexible plans fitted to conditions at a given location can be developed which will permit adjustments as necessary to meet changed conditions and advances in technology. Fundamental plans need frequent review to reflect such changes and advances as they occur in order to be kept current.

4. NEW SERVICES

DATA SERVICE

4.01 The increased use of computers and automatic data processing systems in the commercial, industrial, and military areas has substantially increased the demand for greater varieties of data services and data transmission channels. This expansion, with its attendant requirements for a variety of speeds and channel usage time, has encouraged development of special service offerings that use the regular switched message telephone network in establishing the communications channels.

4.02 Operationally, data service is quite simple. A regular telephone call is made to establish a connection between two points. Usually, regular voice communication may be carried on if required. Operation of a pushbutton, associated with the telephone set at each end of the connection, disconnects the telephone instruments and connects data sets to the telephone lines. The data set, depending upon the type, accepts analog or digital (usually binary) information at the transmitting end and, if necessary, modulates the baseband signal to a frequency band suitable for use over telephone circuits. At the receiving end, the data set demodulates the line signal and returns it to baseband. At the end of transmission, regular voice communication can be resumed, if desired, or the connection can be terminated by hanging up the telephone.

4.03 The telephone industry is continuing its effort to achieve higher speeds and greater accuracy, to provide more effective means for handling the variety of data transmission requirements, and to broaden the scope of data processing applications by reducing the cost of transmitting information.

MOBILE COMMUNICATIONS SYSTEMS

4.04 Land-mobile telephone service began in 1946 when six channels were made available for this service. Mobile customers have access to the nationwide network through the base station covering the area in which they are traveling. When the base station receives the signal, it relays it instantly to a mobile switching office where the call can be fed into the telephone network or into the dispatch office of a private fleet of vehicles.

4.05 The Telecommunications Industry is continuing its effort to meet the current mobile communications requirements and to broaden the scope of this type of service.

TSPS-REMOTE TRUNK ARRANGEMENT (RTA)

4.06 The Traffic Service Position System-Remote Trunk Arrangement (TSPS-RTA) will be a combination of hardware and software additions to TSPS which will permit the extension of TSPS service to smaller common control toll center areas where individual TSPS base units are not economically viable. The RTA will consist mainly of a scanner, signal distributor, concentrator, and trunks installed at one toll center but under the control of a distant TSPS base unit via data links. Connections to the operators will be over separate voice links via the RTA concentrator to the base unit. The toll-connecting trunks handled by an RTA will connect to its associated toll machine for distribution in the DDD network.

4.07 The primary benefits of the TSPS-RTA will be:

(1) A significant increase in the serving area of a single TSPS

(2) An enhancement of the inherent TSPS large team efficiency

(3) The continued use of the remote toll machine for switching operator-handled traffic.

NOTES ON DISTANCE DIALING

SECTION 3

SWITCHING PLAN FOR DISTANCE DIALING

CONTENTS PAGE

1. GENERAL

1.01 The telephone systems in the United States and Canada handle almost 30,000,000 long distance messages a day. These are routed over a comprehensive network of more than 700,000 intercity trunks which interconnect about 2000 long distance switching systems. This network serves, with few exceptions, all of the telephones in the two countries and provides for establishing connections to most other parts of the world as described in Section 10.

1.02 Large volumes of traffic between any two points are generally routed most economically over direct trunks. When the volume of traffic between the two points is small, however, the use of direct trunks is usually not economical. In these cases, the traffic is handled by connecting together, by means of switching systems at intermediate points, two or more trunks to build up the required connection. The places where interconnections are made are generally known as "switching centers" and the process is referred to as a "switch." "Built-up" connections may involve several switching centers if the originating and terminating points are a great distance apart. It is important that telephone plant be designed to provide adequate transmission and service for this multiswitch traffic as well as the large volumes of traffic handled by the less complex direct- and single-switch connections.

1.03 The basic routing arrangements of the Switching Plan for Distance Dialing make possible systematic and efficient handling of customer-dialed and operator-serviced long distance traffic. These arrangements are discussed in this section.

1.04 The basic principles of the Switching Plan for Distance Dialing evolved from the earlier plan for "ringdown" traffic in which the switching was performed manually by operators. The experience gained in handling large traffic volumes on a dialed basis between many separate central offices within metropolitan exchange areas also was applied to the automatic switching of intercity traffic.

1.05 The basic elements of the Network Plan for Distance Dialing are:

(1) A numbering plan. This is discussed in Section 2.

(2) A switching plan. This is discussed in parts 3, 4, and 5 of this section.

(3) Destination code routing. This is discussed in part 6 of this section.

(4) A transmission plan. This is discussed in Section 7.

(5) Standard signaling for the called telephone number and for supervisory information. This is discussed in Section 5.

1.06 The needs of distance dialing are met by switching and trunking arrangements that employ a hierarchical network configuration and the principle of Automatic Alternate Routing to provide rapid and accurate connections while making efficient use of the telephone plant. The hierarchical network configuration provides for the collection and distribution of traffic and permits complete interconnectability of all points. With the automatic alternate routing principle, a call which encounters an "all trunks busy" condition on the first route tested is automatically "route advanced" and offered in sequence to one or more alternate routes for completion. Appendix B of this section, entitled "Alternate Routing," discusses this principle.

1.07 Trends in the telephone industry are toward increasing traffic volumes with a high degree of mechanized switching and billing. Operator service locations are trending toward more centralization with service and assistance functions being provided at greater distances from the switching location. For the most economical arrangement, traffic should route as directly as possible from the point where billing details are recorded to the called destination. Concentration at various switching centers is justified only if overall network economies can be realized. Between any two points, the traffic in both directions should be combined on a 2-way trunk group where meshing of noncoincident hours and improved trunk group occupancy can achieve economies.

2. DEFINITIONS

2.01 Under the Switching Plan for Distance Dialing, each point involved in the completion of long distance calls is classified and designated according to the highest rank switching function performed, its interrelationship with other switching centers, and its transmission requirements. The hierarchical ranking (and associated class number) given to each switching center in the network determines the routing pattern. The standard classification and homing arrangements for two routing chains (sometimes called a routing ladder) are shown in Fig. 1. Possible groupings of various classes of switching centers are shown in Fig. 2. The classification of switching centers, their switching functions, and the switching areas they serve are described in the following paragraphs.

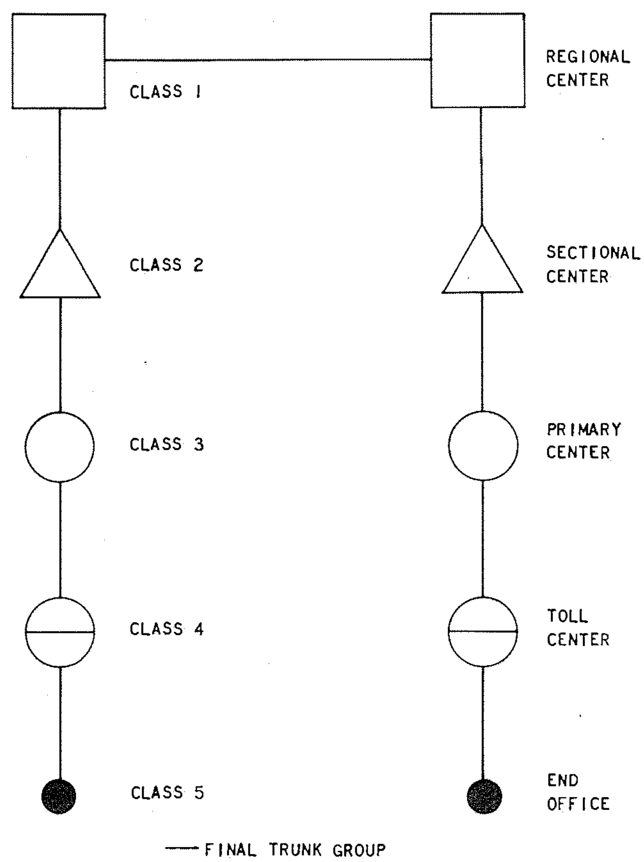


Fig. 1

2.02 The central office trunking entities where telephone loops are terminated for purposes of interconnection to each other and to the network are called "end offices" and are designated as Class 5 offices. A trunking entity is that grouping of central office equipment at which a Central Office code or a group of Central Office codes are trunked in common for network access. A trunking entity may be those step-by-step units served by the same mainframe, a No. 5 Crossbar marker group, a central processor controlled electronic central office, or any equivalent arrangement.

2.03 The switching centers which provide the first stage of concentration for network traffic originating at end offices and the final stage of distribution for traffic terminating at end offices

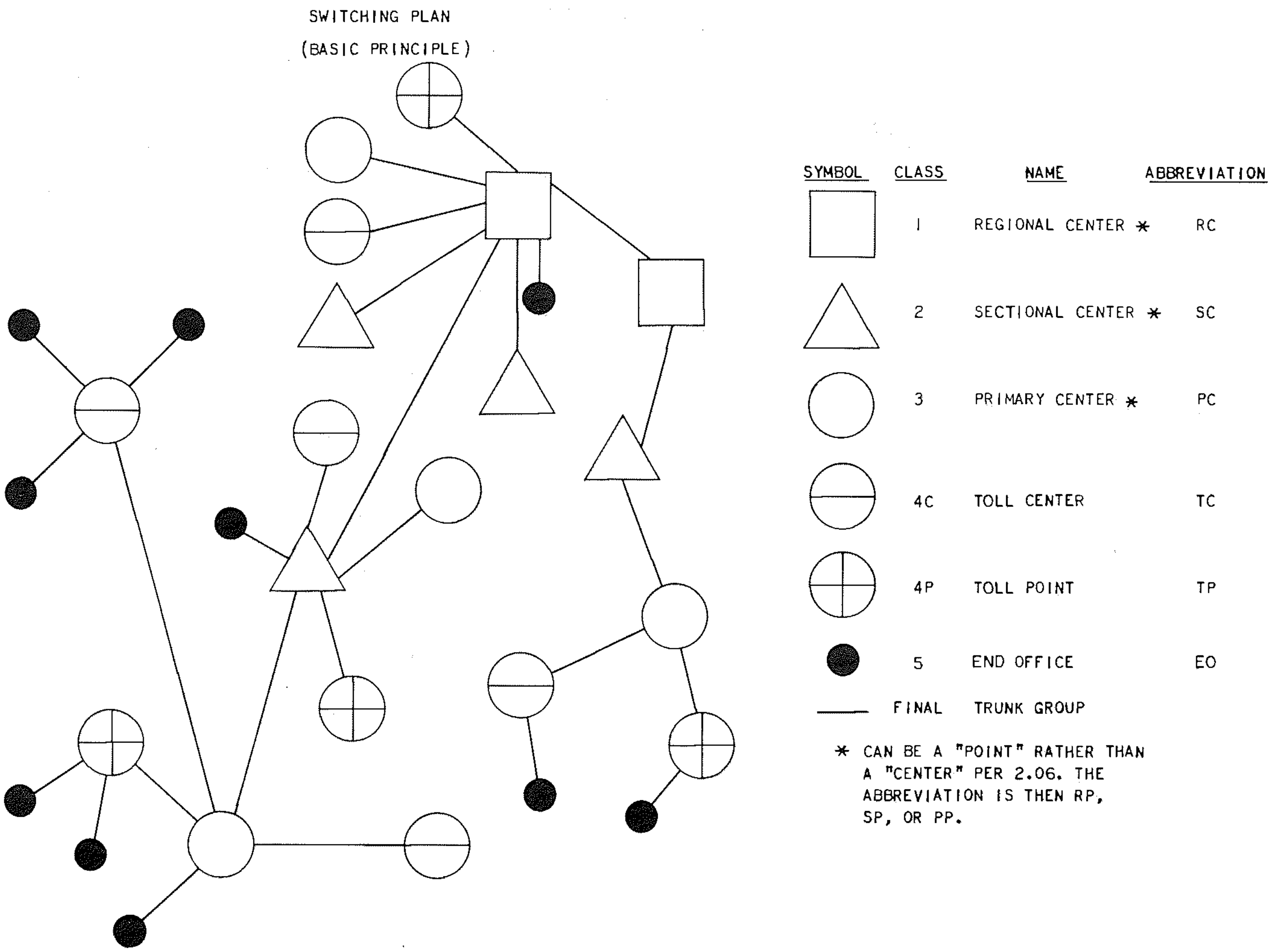


Fig. 2

are called "Toll Centers" or "Toll Points" and are designated as Class 4C or Class 4P switching systems, respectively. The Class 4 switching function connects a grouping of end offices to each other and to the network. A toll center (Class 4C) is a location at which operator assistance in completing incoming calls is provided. A toll point (Class 4P) is a location at which operators handle or service only outward calls or where switching is performed without provision for operator functions. The Class 4P designation is also assigned to such switching systems as outward and terminating toll tandems and some systems with Centralized Automatic Message Accounting (CAMA).

2.04 Operator service locations are designated as "Traffic Toll Centers" if inward assistance operator service code functions are provided. This generic designation is applicable regardless of the classification of the location in the hierarchical configuration. Those end offices which are served by operator service locations without inward assistance operator functions must be provided this service by a toll center or higher ranking switching system which has direct (nonswitched) access to the end offices. Appropriate listings in keeping with these basic considerations will appear in routing documents such as: (1) the Operating Rate and Route Guide, (2) the Traffic Routing Guide, and (3) the Distance Dialing Reference Guide.

2.05 Certain switching systems, in addition to connecting a grouping of end offices to each other and to the network, are selected to serve higher ranking switching functions on the basis of overall network economies thus providing additional hierarchical levels of concentration. These levels are: Primary Centers designated Class 3, Sectional Centers designated Class 2, and Regional Centers designated Class 1. Collectively, the Class 1, 2, and 3 switching systems constitute the Control Switching Points (CSPs) of the switching plan for distance dialing. It is important to note that higher rank switching systems can also perform lower rank switching functions. Where multiple switching functions are performed, the switching system is designated by the highest rank switching function present as tabulated in Table 1.

2.06 In some of the larger metropolitan areas which have two or more toll switching systems, the inward assistance operator function may be served from one of the lower rank switching systems instead of the highest rank system in the area. In these cases, the term "point" instead of "center" is applied to the switching system which does not directly serve the inward assistance operator function, eg, Regional Point, Sectional Point, Primary Point. There are no distinguishing symbols as yet attached to these classifications.

2.07 A Control Switching Point (CSP) is a switching system at which intertoll trunks are connected to other intertoll trunks. Basic requirements for CSPs are shown in Appendix A.

2.08 The backbone hierarchical network of "final" trunk groups, or the final route chain interconnecting the five ranks of switching systems, is shown in Fig. 1. One final trunk group is always provided from each switching system to another switching system of higher rank. That higher rank location to which a given switching system is connected over a final trunk group is called its "home." The lower rank or dependent switching system is spoken of as homing on the higher rank location. The one exception to this principle is the complete interconnection of all Regional Centers with final trunk groups, each with all of the others.

2.09 In determining classification and homing arrangements, designations are always assigned to end offices first based on the results of wire centering studies. In succession, based on overall network economies, designations are made for Classes 4, 3, 2, and 1. The network hierarchy is thus built from the bottom up, each switching system being assigned the lowest possible rank. Additional discussion of network design and switching system classification is contained in part 4 of this section.

2.10 The systematic grouping of switching centers results in a similar grouping of the areas they serve. Each Regional Center (RC) serves a large area known as a Region. (There are ten regional areas in the United States and two in Canada.) Each region is subdivided into smaller areas known as Sections; the principal switching system in the section is the Sectional Center (SC). The section is still rather large 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 centers that do not fall into these

TABLE 1

SWITCHING SYSTEM RANK	DESIGNATED CLASS NUMBER	CLASS NO. OF SWITCHING FUNCTIONS PERFORMED
Regional Center	1	Classes 1, 2, 3, and 4
Sectional Center	2	Classes 2, 3, and 4
Primary Center	3	Classes 3, 4, and sometimes Class 5
Toll Center	4	Class 4; sometimes Class 5
End Office	5	Class 5

Note: Not all toll centers perform a Class 5 switching function. Only a few primary centers perform a Class 5 switching function. Sectional centers and regional centers are of such a large size that the switching system used does not provide a Class 5 switching function.

categories are the Toll Centers (TC) and End Offices (EO).

2.11 Each separate switching system must be assigned its own classification within the hierarchical routing plan. This separate classification is applicable even when more than one system is located in a single building. The one exception is that cord switchboards in the same building with, and handling traffic exclusively for, a single toll switching system are classified as a part of that system. The cord switchboard and its trunks must also meet VNL transmission requirements as covered in Section 7. When a cord switchboard location is not in the same building as the toll switching system, the cord switchboard is treated as a separate switching system and assigned a Class 4P classification.

3. HOMING ARRANGEMENTS AND THE INTERCONNECTING NETWORK

3.01 It is not necessary that Class 5, 4, or 3 offices always home on the next higher ranking (conversely, next lower class number as shown on Fig. 1) switching system. For example, Class 5 offices may be served directly from any higher ranking location. Possible homing arrangements for each class of switching system are shown in Table 2 below and are illustrated in Fig. 2.

TABLE 2

HOMING ARRANGEMENTS

RANK	CLASS OF OFFICE	MAY HOME AT OFFICES OF THE FOLLOWING CLASSES
End Office	5	Class 4, 3, 2, or 1
Toll Center	4	Class 3, 2, or 1
Primary Center	3	Class 2 or 1
Sectional Center	2	Class 1
Regional Center	1	All regional centers mutually interconnected

3.02 Each final trunk group in the network is engineered individually to a low probability of blocking so that, on the average, no more than a small fraction of the calls offered to such a trunk group in the busy hour will encounter a "No Circuit" (NC) condition. Current Bell System service objectives for final trunk groups call for not more than one call in 100 being blocked by an NC in the average time consistent busy hour in the busy season. Final trunk groups are required to mutually interconnect all Regional Centers.

3.03 In addition to the final route network, direct high-usage trunk groups are provided between switching systems of any class wherever the volume of traffic and economics warrant and automatic alternate routing equipment features are available. High-usage trunk groups carry most but not all of the offered traffic in the busy hour. As discussed in Appendix B, overflow traffic is offered to an alternate route. The proportion of the offered traffic that is carried on a direct high-usage trunk group ordinarily is determined, in part, by the relative costs of the direct route and the alternate route (including the additional switching costs on the alternate route). High-usage trunk groups are provided when they are shown to be economically desirable. Due to service considerations, trunk groups which would normally be in the high-usage category may in some instances be engineered on a no-overflow basis with the same service objective as a final trunk group. This does not change homing arrangements and these trunk groups are called "full groups." Full groups effectively eliminate further alternate routing and truncate or limit the hierarchical final route chain for the items of traffic offered to them. Full groups can seldom be justified on the basis of economic considerations alone.

3.04 In general, trunks in both high-usage and final trunk groups between toll centers and higher rank switching systems are operated to combine traffic in both directions, ie, 2-way. Within the normal range of traffic load characteristics, 2-way trunk groups present opportunities for meshing of noncoincident traffic in either direction as well as improvement of trunk group occupancy relative to one-way trunk groups. Where there is a significant cost differential between one-way and 2-way trunk terminations on switching systems, there may be opportunities to trade off trunk termination savings against the lower occupancy of one-way trunk groups. This usually is possible with electromechanical switching systems. A large 2-way trunk group may be subgrouped into two one-way segments (for each direction) and one 2-way segment to which the one-way subgroups would overflow. (In metropolitan local networks, large trunk groups are often provided as one-way only in either direction with no 2-way subgroup.) Where DDD is not provided, the final trunk groups between a small Community Dial Office (CDO) and its toll center are sometimes consolidated on a 2-way basis called a 2-way operator office trunk group. For larger end offices and CDOs with DDD, it is common practice to provide one-way trunk groups to and from the home toll center.

3.05 Individual final groups are usually used as a service protection measure for traffic which might otherwise be routed on a final trunk group in excessive competition with alternate routed traffic. Individual final groups are engineered in a manner comparable to high-usage trunk groups and are for exclusive use of first routed traffic loads which overflow to the final trunk group. Individual final groups are engineered for high occupancy to assure adequate utilization.

3.06 The "routing pattern" for a call between any two points is established by the final route path (or final route chain) between the originating and terminating locations. Where two or more trunks must be connected to complete traffic, the intermediate switch establishing such a connection must be on the final route path. One or more intermediate switches on a final route path may be bypassed by a high-usage trunk group as long as the traffic thus routed always progresses in the direction toward its destination subject to the constraints of the one-level inhibit rule discussed in Appendix D. Referring to Fig. 1 and 2, a call originating in one final route chain and entering a second chain, say at Class 2 switching system, must progress down the second chain through Class 3 and Class 4 switching systems if necessary to the Class 5 destination. Any routing path which involves three final route chains is not permissible since standard routing involves only two chains.

3.07 Appendix C illustrates typical standard routing patterns within the switching plan. It should be noted that the maximum number of trunks connected in the final route chains from a Class 4 location to another Class 4 location cannot exceed seven. These, plus the trunk to the Class 5 office at each end, result in a maximum of nine trunks in tandem. The probability of a call traversing all of the final route links in two complete routing chains is estimated to be only a few calls out of millions. Calls between high-volume points are completed on direct trunks regardless of distance; relatively few encounter multiple switches. Multiple switching is the rule, however, between infrequently called locations.

4. SELECTION OF CONTROL SWITCHING POINTS

4.01 The use of intermediate switching (CSPs) can sometimes increase the efficiency of trunk plant. For example, Plan II, shown in Fig. 3, will effect savings in transmission facilities as compared to Plan I. However, a CSP must be provided with additional capacity for the increased switched traffic load along with features which are not ordinarily required if the switching center serves only a Class 4 switching function. This tends to offset, and in some cases will exceed, the transmission facility savings. It is necessary, therefore, to carefully evaluate these plus other related factors to determine the location, rank, and number of CSPs which will result in the most economical overall network configuration over a reasonably long time span.

4.02 CSP location studies have been made by the Bell System and Independent Operating Companies and must be reviewed from time to time as required by changing conditions. Studies currently being made often indicate the need for fewer CSPs. Such studies reflect the relative costs of transmission facilities and switching equipment suitable for the CSP functions. They recognize the changes in traffic flow occasioned by growth. They include the effect of more common control switching systems at lower levels in the hierarchy which permit additional high-usage trunking to develop with the passage of time. The combined effects of these influences reduce the need for CSP switching functions and are expected to lower the hierarchical rank of some existing switching systems.

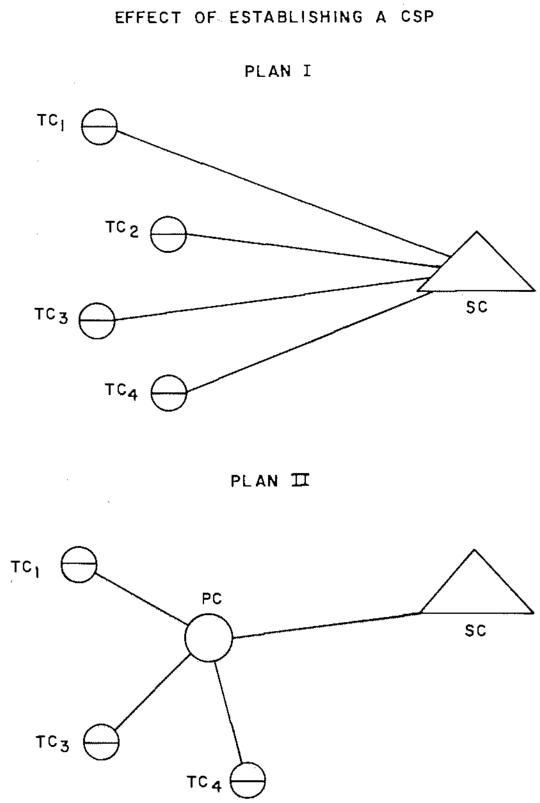


Fig. 3

5. EFFECTS OF THE SWITCHING PLAN ON PLANT LAYOUT

5.01 Alternate routing permits a more efficient (lower cost per carried CCS) network than would be obtained if the trunk groups were all engineered to objective service levels with no overflow. Most growth in an alternate routing network is accommodated by adding new high-usage trunk groups or by adding trunks to existing high-usage trunk groups. Final trunk groups thus tend to grow at a lower rate than the overall growth rate for the total area involved. Appendix B provides more detail on the principles of alternate routing.

5.02 It is essential that these concepts be considered when planning and engineering plant additions. By so doing, the most advantageous plant layout for distance dialing may be obtained and, at the same time, the needs during transition periods can be cared for adequately.

5.03 The final trunk groups between any switching system and its "home" switching system should be engineered for low probability of blocking. (See part 3 of this section.)

5.04 Switching systems of different classifications may be located in the same building. If they are physically different entities, each switching system retains its own classification according to the function(s) it performs in accordance with Table 1.

5.05 Customer-dialed station sent paid traffic must be provided with automatic recording of call billing details at the originating local office (LAMA) or at a centralized point (CAMA). With centralized operation, each end office must be connected directly to the centralized recording system which serves it. There can be ***no*** intermediate switch or concentration of transmission facilities to serve more than one local office entity. The reasons for this are:

(1) Transmission impairment will result from the addition of another switch and transmission link. Some calls could be subjected to more than the permissible nine links end to end.

(2) The traffic probability of blocking will increase from the addition of another one percent blocking link. It may cost more to obviate this impairment than the potential savings from the proposed concentration.

(3) Calling number identification signals are not readily switched intact to the recording location.

For the same reasons, customer-dialed operator serviced or handled traffic (dial 0+ or 0−) likewise must be routed over direct trunks from each end office to the Traffic Service Position System (TSPS) or cord switchboard ***without*** any intermediate switch or concentration.

6. DESTINATION CODE ROUTING

6.01 By providing flexibility and logic in switching systems and by following the numbering plan described in Section 2, whereby every telephone connected to the distance dialing network is identified by a unique 10-digit number, a call can be routed from any point on the network to any other point using the 3-digit NPA code and the 3-digit Central

Office code of the called telephone. For a specific called destination, the same address is employed regardless of where a given call may originate and enter the network. This is called "Destination Code Routing."

6.02 When a call is to be set up between two telephones in the same Numbering Plan Area, the 3-digit Central Office code plus the 4-digit station number are sufficient for completing the connection. The absence of an NPA code is the indication that the call either originates and terminates within the same NPA (home NPA) or that it has arrived from another NPA at a switching system which is capable of completing the connection within the "home" NPA of the called destination. The connection is completed over a final route to the end office which serves the called telephone number. This will require four, five, six, or seven digits as dictated by the capabilities of the central office equipment and local numbering arrangements which are discussed in Section 2.

6.03 It may be necessary to switch a call at one or more intermediate switching systems within the NPA of the called destination before the final trunk group to the desired end office is reached. This is always done within the standard hierarchical routing chain, the intermediate switching systems being of successively lower rank until the final trunk group to the terminating end office is reached. This routing chain is called the "down" chain with reference to completing calls and is represented as the right-hand segment of the routing ladder of Fig. 1. The left-hand segment in Fig. 1 is called the "up" chain with reference to originating calls. Of course, high-usage trunk groups will be used, where provided, to bypass one or more intermediate switching systems as discussed in part 3 of this section. (Also see Appendixes C and D.)

6.04 Connections between switching systems for calls between different NPAs are handled similarly using the full 10-digit destination code. Both originating and intermediate switching systems make use of the 3-digit NPA code to route each call over its particular first choice or alternate route to or toward the called Numbering Plan Area. The entire ten digits are sent forward if the next switching system in the routing ladder cannot complete the connection within the NPA of the called destination. Only seven digits are needed if the trunk route used terminates in the called NPA. Once a call reaches the called NPA, only the last seven digits are needed to advance the call to its destination as discussed above.

6.05 To complete calls to customers where the end office is served by a toll switching system across an NPA boundary, the NPA dialed must be the same as the NPA in which the end office is physically located. Similarly, where customers are served by an end office across an NPA boundary, the NPA dialed is the NPA in which the customers are located and they are assigned a theoretical office code within that NPA. Standard dialing procedures should be established at each individual end office in accordance with the procedures discussed in Section 2 for maintaining uniformity for the NPA and the entire network.

6.06 The code received by a switching system must contain sufficient information to advance the call to or toward its destination. In many instances, a 10-digit call for a distant NPA can be routed at a switching system from the translation of the NPA code alone; this is "3-digit translation." In other instances, involving calls to a distant NPA, the first three digits (NPA code) may not provide sufficient information. When this occurs, the switching system obtains the additional information it requires by also translating the 3-digit Central Office code thus using the first six digits to properly advance the call; this is "6-digit translation."

6.07 If from a particular switching system there is one first choice route to reach some end offices in a given distant NPA and a different first choice route to reach other end offices in that same distant NPA, the switching system must 6-digit translate to determine which route to select to reach the desired end office for the call destination.

6.08 For each Numbering Plan Area, there is a switching system (usually a CSP) which is designated as the "principal city" for that NPA. A CSP may be designated as the principal city for more than one NPA. A principal city is defined as that lowest ranking switching system which can complete to every end office within an NPA on a final route basis, direct or switched. The principal city accommodates those distant locations which cannot provide 6-digit translation to or toward a given NPA. A call from such a location is routed over the network on the 3-digit NPA code to the principal city. If the principal city is within the NPA, the call is completed with the 7-digit destination code. If the principal city is outside the NPA, it performs the necessary 6-digit translation for completion of the call.

6.09 The routing digits sent forward to a given switching system depend upon the requirements of the distant point to which it connects. For example, extra digits, dialed by an operator or prefixed and sent forward by a preceding switching system, may be required to switch calls through a direct control switching system. Appendix A of this section outlines digit prefixing, code conversion, and other features required at CSPs for destination code routing. The digit and translation capabilities of various types of switching systems used in the Bell System are discussed in Section 4 and are summarized in Tables 2 and 3 of that section.

7. ROUTING CHANGES

7.01 From time to time, new high-usage trunk groups and new switching systems must be added to the network to provide for growth. These additions usually require routing changes to be put into effect in many existing switching systems. In order to minimize the frequency of reproducing switchboard bulletins and first reference lists, routing changes are combined for implementation on specified dates. The scheduled time and dates for network switching system cutovers and routing changes are 2 PM Eastern Time, generally on the first and third Saturdays of each month. Exceptions occur when the tentative "cutover" weekend includes Easter, Mother's Day, or Father's Day. To avoid these heavy traffic days, the scheduled date is either advanced or deferred one week. The "after midnight hours" are not precluded when the changes involve rearrangements such as local office replacement or wire center boundary changes and can be controlled between the end office and the switching system on which it homes.

APPENDIX A—BASIC REQUIREMENTS FOR CONTROL SWITCHING POINTS (CSPs) (ALL CLASS 1, 2, AND 3 OFFICES)

1. HOMING ARRANGEMENT REQUIREMENTS

1.01 There must be at least one switching system of the next lower rank homing on a CSP, ie, a Class 2 switching system must have at least one Class 3 switching system homing on it.

2. TRANSMISSION REQUIREMENTS FOR A CSP (Also see Section 7.)

ANALOG TRANSMISSION

(1) VNL operation of intertoll trunks.

(2) VNL plus 2.5-dB operation of toll-connecting trunks.

(3) Terminal balance objectives must be met by actual measurement on all toll-connecting trunks.

(4) Through balance requirements must be met at 2-wire switches between intertoll trunks for through switched traffic. Any CSP which does not meet through balance requirements is classified as deficient.

DIGITAL TRANSMISSION

2.01 Network objectives for digital transmission are covered in Section 7.

3. SWITCHING SYSTEM REQUIREMENTS

(1) Storing of digits

(2) Variable spilling—deletion of certain digits when not required for outpulsing

(3) Prefixing of digits when required

(4) Code conversion—a combination of digit deletion and prefixing (also termed substitution)

(5) Translation of three or six digits (also translation of four or five digits for WH calls, ie, calls to operators coded 11XX or 11XXX)

(6) Automatic alternate routing.

3.01 Where step-by-step switching equipment is employed at a Class 3 location, requirements of parts 1 and 2 can be met. The switching requirements delineated in part 3 can be provided only with common control equipment. Any Class 3 step-by-step installation not provided with common control features is, therefore, deficient in these equipment capabilities. It follows that only equipment with the common control capabilities listed can be permitted to route traffic items through a noncommon control step-by-step switching system providing a Class 3 switching function.

APPENDIX B—ALTERNATE ROUTING

1. GENERAL

1.01 The successful completion of long distance traffic dialed by operators and customers depends upon a high-speed trunking network so that "No Circuit" (NC) conditions are rarely encountered under engineered conditions. Alternate routing is one of the techniques that makes this possible with reasonable trunk efficiency. It is the purpose of this appendix to explain alternate routing and why it is employed.

1.02 Definitions:

(1) Alternate Routing—The feature of a switching system by which a call, after encountering "NC" in the first choice route, is offered another route to or toward its destination.

(2) Multialternate Routing—Alternate routing with provision for advancing a call to more than one alternate route tested in sequence within the hierarchical routing discipline.

(3) High-Usage Trunk Group—A group of trunks for which an engineered alternate route is provided.

(4) Final Trunk Group—A group of trunks to the next office on the final route and in which the number of trunks is engineered to result in a low probability of blocking. A final trunk group provides the last choice route for all traffic using it, including traffic from high-usage groups overflowing to it.

(5) Full Trunk Group—A group of trunks which ordinarily would be a high-usage group but is engineered like a final trunk group with low probability of blocking for the traffic offered to it. The normal alternate routing capability is not employed for this traffic. A full trunk group may receive overflow traffic but is not permitted to overflow to an alternate route.

2. THEORY OF ALTERNATE ROUTING

2.01 The principle of alternate routing is applied to telephone traffic by providing a first choice (high usage) route for a given item of traffic and a second choice (alternate) route when the call fails to find an idle trunk on the first choice route. Additional alternate routes may be provided subject to certain routing restrictions discussed later.

FUNDAMENTALS

2.02 Alternate routing is advantageous for two reasons: (1) it creates the potential for meshing traffic streams which have differing peak periods (busy hours) and (2) it provides the opportunity to minimize the cost per CCS for carried traffic.

MINIMIZING THE COST PER CARRIED CCS (HUNDRED CALL SECONDS)

2.03 Figure B1 depicts an alternate routing arrangement.

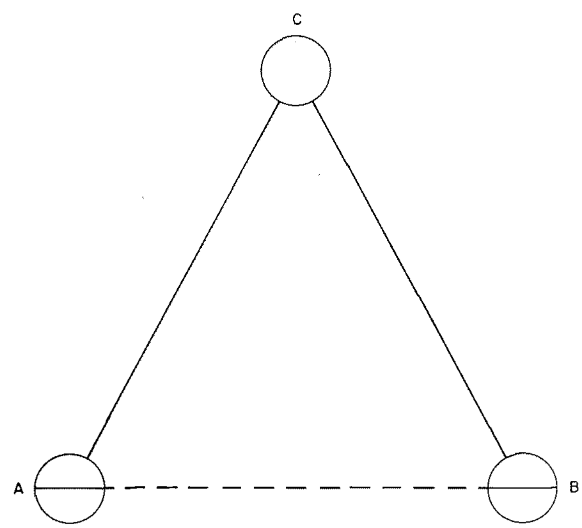


Fig. B1

2.04 This figure illustrates a high-usage (HU) trunk group connecting Toll Centers A and B with an alternate (final) route via a Primary Center C. In general, the direct or high-usage route is shorter and cheaper than the alternate route path. However, because each leg of the alternate route is used by other calls, a number of traffic items can be combined for improved efficiency on that route.

2.05 The basic engineering problem is to minimize the cost of carrying the offered load. (How much of the offered load should be carried on the direct route and how much on the alternate route?)

2.06 The graph in Fig. B2 shows the relationships involved. The graph shows, as a function of the number of trunks in the HU trunk group, the cost of the direct route, the cost of the alternate route, and total cost for serving the given offered load. HU trunk group cost, of course, increases in direct proportion to the number of HU trunks.

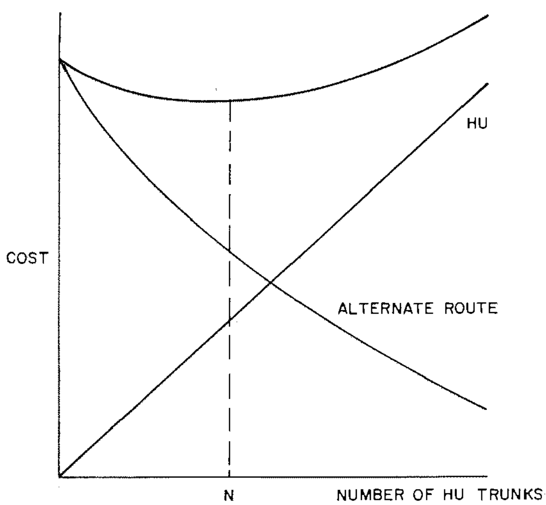


Fig. B2

If there are no HU trunks, then all of the offered traffic must be carried on the alternate route so that alternate route cost is high. As trunks are added to the HU trunk group, less of the offered traffic is overflowed to the alternate route so that the alternate route cost decreases. This cost decreases very rapidly as the first trunks are added to the HU trunk group since each of these trunks is very efficient,* thereby relieving the alternate route of a substantial amount of load. As more HU trunks are added, each successive HU trunk carries less traffic while each alternate route trunk continues to carry a significant amount of traffic and eventually it becomes undesirable to add any more HU trunks. The point at which this threshold occurs is where the total cost (the sum of the two curves) is minimized. This point is designated as N in Fig. B2.

*This principle may be illustrated by assuming the case of a step-by-step switching system offering a call to a group of ten one-way outgoing 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; and trunk No. 3 will be used less than No. 2 and so on to the tenth trunk which is called into use only when all prior trunks are busy.

2.07 A method commonly used to determine N is called Economic CCS (ECCS) engineering. This method determines the maximum number of HU trunks for which the cost per CCS carried on the "last" trunk of the HU trunk group is less than or equal to the cost per CCS on an additional alternate route trunk.

2.08 This relationship can be expressed in equation B1:

$$\frac{\text{CALT}}{\text{CHU}} = \frac{28}{\text{ECCS}} \qquad \text{(B1)}$$

This equation is the basis of ECCS engineering. The equation is solved for the ECCS which is the load to be carried by the "last" or least efficient trunk in the high-usage trunk group. Given the ECCS and the offered load, standard trunking tables can be entered to determine the number of trunks required so that the load carried on the last trunk is equal to the ECCS. (In actual practice, the cost ratio may be such that an integer number of trunks will not result in the last trunk CCS equaling the ECCS. In this case, the usual procedure is to select the number of trunks such that the load carried on the last trunk is as close as possible to but not greater than the ECCS.)

2.09 Since equation B1 is solved for the ECCS, the other elements of the equation must be known. The left part of the equation $\left[\frac{\text{CALT}}{\text{CHU}}\right]$ is the cost ratio or the relationship of the cost of a path on the alternate route to the cost of a trunk on the direct route. Cost ratios used for alternate route engineering are always greater than unity (1).

2.10 The "28" shown in the equation is the incremental capacity of the alternate route (that capacity which would be added to the alternate route by the addition of one path). This value is usually assumed to be a constant of 28 CCS, thereby permitting calculation of the ECCS as a function of a single variable, the cost ratio.

2.11 It can be seen, thus, that with low cost ratios, the ECCS will be high and fewer high-usage trunks will be provided. Conversely, a low ECCS would result from a high cost ratio and a greater number of HU trunks will be provided. Simply, the more expensive the alternate route relative to the high-usage trunk group, the less traffic will be overflowed to it.

2.12 It will be noted on Fig. B2 that the total cost curve has a rather broad minima. As a result, errors in ECCS which might result from inaccurate cost ratios or incremental CCS values will not have a significant impact on network costs.

EFFECT OF LOAD VARIABILITY

2.13 The number of high-usage trunks to be provided in a group depends not only on the ECCS and offered load but on the variability of the offered load as well. This variability can be either within the hour, usually peakedness, or day to day. Such variability can be the result of traffic patterns as in the case of day-to-day variations or it may be system induced as is usually the case with peakedness. In either event, the effect of such variability is a reduction of the capacity of a group of trunks below that predicted by standard Erlang or Poisson trunking tables. Where such variability is present, equivalent random engineering techniques are required and special capacity tables are used to size probability engineered trunk groups.

NONCOINCIDENT BUSY HOURS

2.14 Traffic volumes reach peaks during certain hours. Transmission facilities are usually provided to care for average time consistent busy hour loads in the busy season of the year.

2.15 Where only one outlet (trunk group) is available, facilities must be provided for the group busy hour load. If two routes (a direct and an alternate route) are available, however, the busy hours on each of the two routes frequently will be different. Where this is the case, facilities need only be provided in the direct route to care for that portion of its busy hour offered load which cannot be carried on idle trunks in the alternate route which is sized for a different busy hour and, thus, is not fully loaded in the busy hour of the direct route.

ALTERNATE ROUTE SELECTION

2.16 Often there are two or more potential alternate routes for a high-usage trunk group. The selection of alternate routes may be based on a routing discipline if overall cost differences are not significant or the choice may be based on the economics of each individual case, ie, selection of the least expensive alternate route. In general, overall network economics are not highly sensitive to variation in alternate routes.

MINIMUM TRUNK GROUP SIZE CONSIDERATIONS

2.17 New high-usage trunk groups are ordinarily established when offered loads are large enough to justify them. Cost ratio techniques alone will prove in groups with as few as one trunk. Other factors, however, such as the administrative costs associated with data collection, trunk forecasting, and trunk servicing, usually preclude establishing these groups until at least three trunks can be efficiently loaded. With the longer intertoll groups, the administrative costs are higher and larger minimum group sizes may be necessary. There can also be cases where the cost of certain central office equipment should be considered.

3. APPLICATION OF ALTERNATE ROUTING

LOCAL DIALING (COMMON CONTROL OFFICES ONLY)

3.01 In large multioffice cities, direct trunks are provided from each local office to every other local office where there is sufficient traffic to economically justify such trunks. Also, each local office has trunks to and from one or more common tandem points. Calls between offices not directly connected are completed through a tandem center. Since every local office is connected to a tandem, the tandem network may be used to provide an alternate route for each of the direct groups. Therefore, fewer direct trunks are needed. Furthermore, with the ability to alternate route through a tandem, it generally becomes economical to accommodate growth by establishing new direct groups of small size between offices not previously served by direct groups and thus reduce requirements for tandem switching.

3.02 Because alternate routing can be done automatically, it is used extensively to provide economies and service advantages. Calls may be offered in succession to a series of alternate routes via one or more tandem centers.

3.03 In an emergency situation of limited impact and extent such as a cable failure, the ability to use an alternate route provides a measure of protection to service. However, if there is a heavy surge of traffic over an entire area (as in a major disaster such as a hurricane), there is little margin to absorb surges in load and the service may not be as good as it would be with a nonalternate route network.

DISTANCE DIALING—AUTOMATIC SELECTION OF ALTERNATE ROUTE

3.04 The principle of alternate routing is basic in the design of the distance dialing network. Switching equipment automatically seeks out the alternate routes. The field of application in distance dialing is more extensive than in the case of local dialing since a call may be subject to routing through more switching systems in the 5-level hierarchy.

3.05 At each switching system, all of the trunk groups to which a call may be offered, except the last, are kept very busy (high usage) with a portion of the traffic overflowing to other routes. The final trunk groups are fewer in number and are low blocking groups so that the engineered level of service is good. The overall chance of completing a call is improved by the fact that it can be offered to more than one trunk group. The switching equipment operates rapidly and there is no significant change in speed of service between the selection of direct and alternate routes.

3.06 In addition to the final trunk groups which connect switching systems to their home switching centers, direct high-usage trunk groups to other switching systems are provided wherever it is economical to do so. However, there are no direct routes for calls to many low-volume points. The first route for such calls is a switched route over two or more trunk groups of the network using the cheapest routing combination possible in the standard routing pattern.

3.07 Since the 50 states, Canada, and the Caribbean area are integrated into the switching plan, the employment of an alternate routing network on such a large scale requires an orderly and prearranged routing plan. The routing plan is described under "Homing Arrangement and the Interconnecting Network" in this section. Appendix C of this section, entitled "Routing Patterns Under the Switching Plan," describes how alternate routing is used.

APPENDIX C—ROUTING PATTERNS UNDER THE SWITCHING PLAN

1. GENERAL

1.01 This appendix discusses routing patterns that are permissible within the framework of the switching plan for distance dialing. Economic and other considerations determine various individual patterns. Examples are included.

1.02 Figure C1 illustrates many (although not all) permissible high-usage trunking patterns within the framework of the standard routing plan. It should be understood that the traffic items permitted to traverse high-usage trunk groups between switching systems which are not the same rank or which have more than one rank order of difference are limited by the one-level inhibit rule discussed in Appendix D.

2. TYPICAL ROUTING PATTERNS

2.01 Figure C2 and the following discussion illustrate a particular routing pattern that might be involved in completing a call that appears at End Office A served from Toll Center B destined for End Office P served from Toll Center Q. In this example, B has trunks to C only; hence, the call must be routed to that Primary Center.

2.02 At C, the call would be offered first to the high-usage trunk group to R. Finding a trunk in this group idle, the call would be routed to R where the switching system would look for an idle trunk in the final trunk group to Q. At this toll center, the call would be completed to the called customer served from P over an idle trunk in the final trunk group to P.

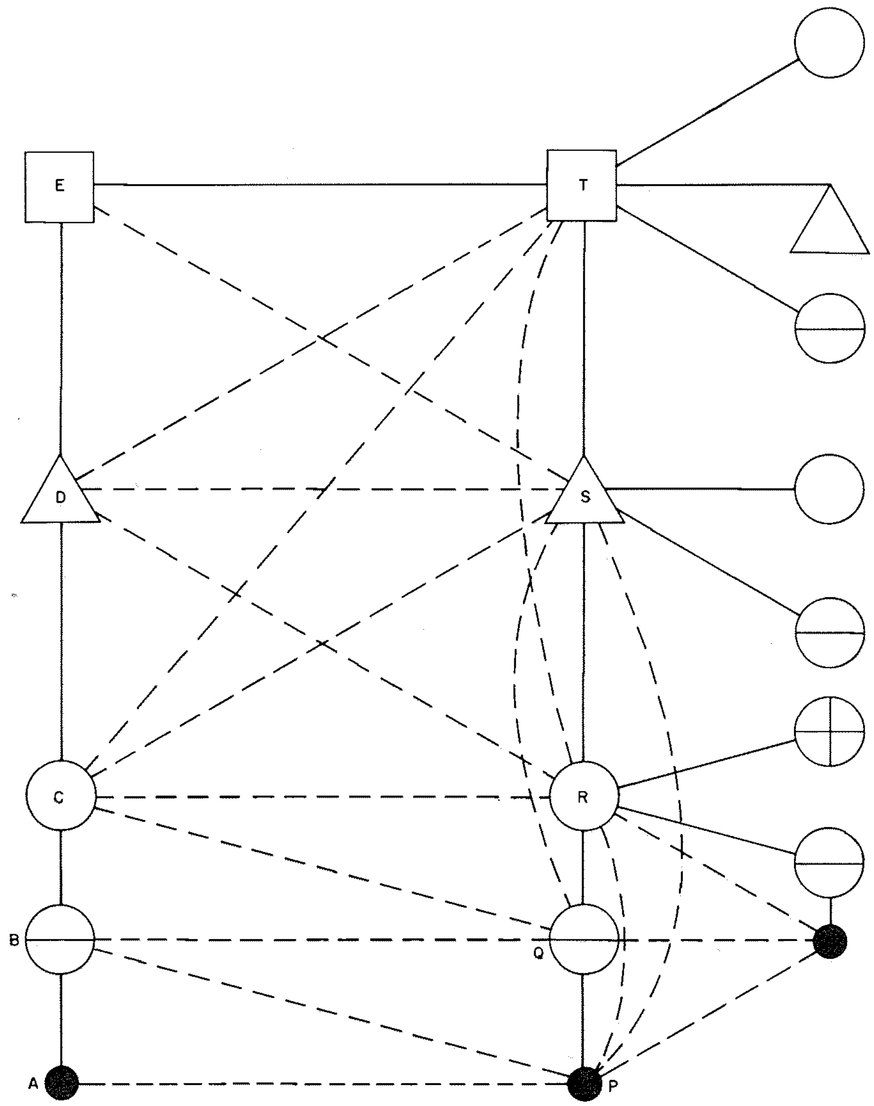
2.03 If, however, all of the trunks in the first choice high-usage trunk group (between C and R) were busy, the call would next be offered to the high-usage trunk group between C and S assuming C - S - R is the alternate route. At S, the call would have a choice of two routings: (1) via the direct high-usage trunk group to Q or, if all trunks in this group were busy (2) over the final route chain S - R - Q.

> ***Note:*** The routing S - Q is an apparent violation of the one-level inhibit rule covered in Appendix D. It must be remembered however, that if no trunk groups can be justified other than those shown in Fig. C2, such routing is desirable and necessary to bypass a switch at R for all but alternate routed traffic to Q.

2.04 In the event that all trunks in the group between C and S are busy, the call should next be offered to the final trunk group to D. The other high-usage trunk groups at C are not permissible routes for this illustrative call under the one-level inhibit rule. At D, all high-usage trunk groups shown are permissible routes.

2.05 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 offer different configurations of high-usage trunk groups.

SWITCHING PLAN
(ROUTING PATTERN)

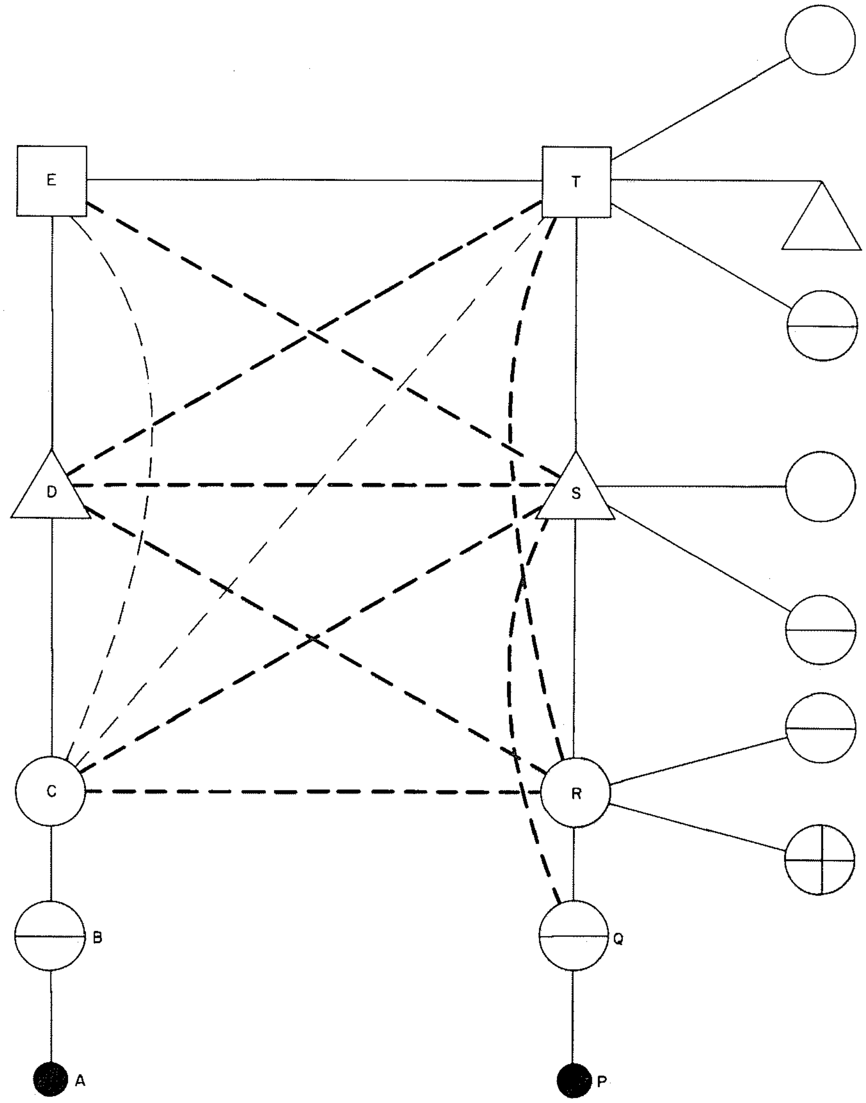


NOTE:
AN HU TRUNK GROUP MAY BE ESTABLISHED BETWEEN ANY TWO OFFICES REGARDLESS OF LOCATION OR RANK, WHENEVER THE TRAFFIC VOLUME JUSTIFIES, SUBJECT TO THE ONE-LEVEL INHIBIT RULE.

——— FINAL GROUP
— — — POSSIBLE HIGH-USAGE GROUP

Fig. C1

SWITCHING PLAN
(ROUTING PATTERNS)



NOTE:
OF THE VARIOUS ALTERNATE ROUTES AVAILABLE, ONLY THOSE HIGH-USAGE GROUPS SHOWN HEAVY — — — — ARE EMPLOYED FOR ROUTING FROM TOLL CENTER B TO TOLL CENTER Q.

——— FINAL GROUP
— — — HIGH-USAGE GROUP

Fig. C2

APPENDIX D—ONE-LEVEL INHIBIT RULE

1. GENERAL

1.01 In general, a high-usage trunk group may be established between any two offices if the volume of traffic and economics justify it. High-usage trunking should be developed to the maximum economical extent to reduce the requirements of intermediate switching and thereby route traffic at as low a level in the hierarchy as possible. To accomplish the objective of keeping the traffic as low as possible in the hierarchy on an equitable basis, the "one-level inhibit rule" has been established.

2. DEFINITION

2.01 The basic purpose of the one-level inhibit rule is to avoid the use of a high ranking switching system in a distant final route chain as a concentrating point for traffic to locations below it in its final route chain. Such use has the disadvantage of forcing more switching at a higher level in the switching hierarchy than is really necessary. Under the one-level inhibit rule, the switching ***function*** performed for the ***first routed*** traffic by the switching system at either end of the high-usage trunk group ***may be of the same class number of switching function or may differ by only one class number of switching function.*** This rule is based on the assumption that a route will be available along a path with switching systems whose ranks differ by no more than one class number. Illustrations of proper application are discussed below.

3. SPECIFIC APPLICATIONS

3.01 The following are specific applications of the one-level inhibit rule. In Fig. D1, Toll Center B (Class 4 switching function) may have high-usage trunk groups for first routed traffic to:

(1) Toll Center Q (Class 4 switching function ***same*** as B)

(2) End Office P (Class 5 switching function—one ***class number*** of switching function greater than B)

(3) Primary Center R (Class 3 switching function—one ***class number*** of switching less than B).

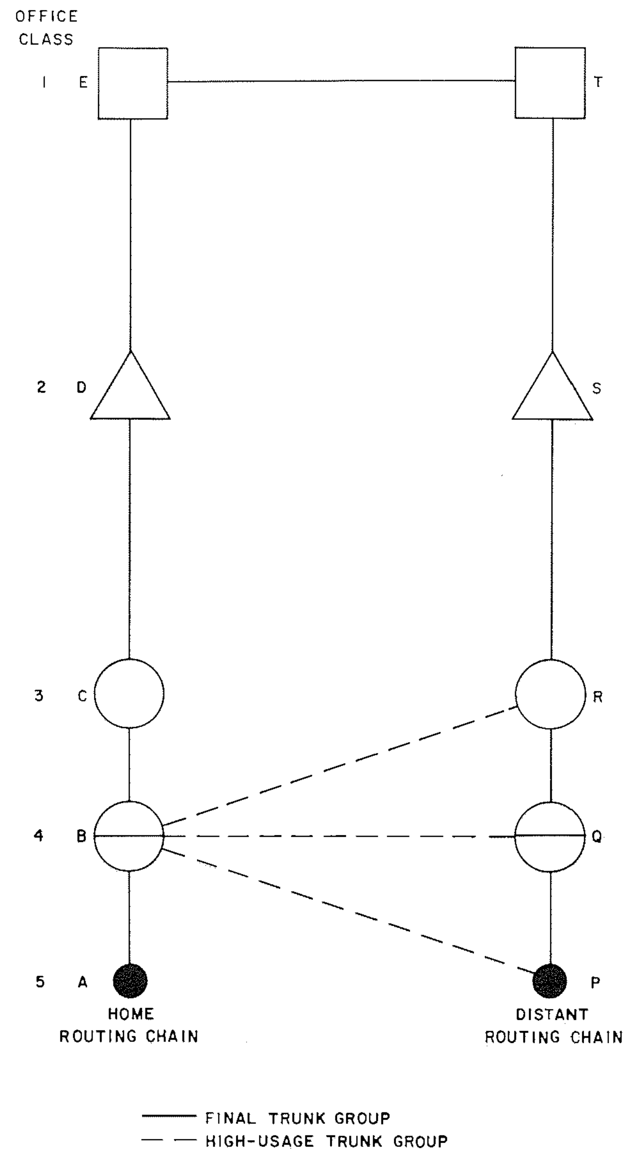


Fig. D1

3.02 If trunk groups from Toll Center B to P, Q, or R cannot be justified because of insufficient traffic loads, these traffic items are routed to the home Primary Center C. Since this Primary Center more than likely serves as a concentrating point for other Class 4 offices in addition to B, trunk groups can probably be justified between C and Q or R. Should this not be the case, a C - S trunk group may be established utilizing the Class 2 switching function at S. In no case does the one-level inhibit rule permit a high-usage trunk group between B and S to be established for the Class 2 switching function of Sectional Center S.

3.03 Another application of the one-level inhibit rule is shown in Fig. D2. In this case, the B - S trunk group is justified by the traffic load utilizing the Class 3 and Class 4 switching functions of the Sectional Center S. In this illustration, there is insufficient traffic to justify high-usage trunk groups from either B or C to Q or R. Therefore, B and C traffic to the sectional area served at S must switch at S. Under these conditions, it is permissible and desirable to route traffic between B and P, Q, and R over the B - S trunk group. In like manner, calls arriving at S for completion within its final route chain will use the most direct route available to the call destination. It is most important to note, however, that this "skip-level" routing imposes an obligation to establish the "missing" direct high-usage trunk groups at lower hierarchical levels just as soon as traffic volumes and costs can justify them.

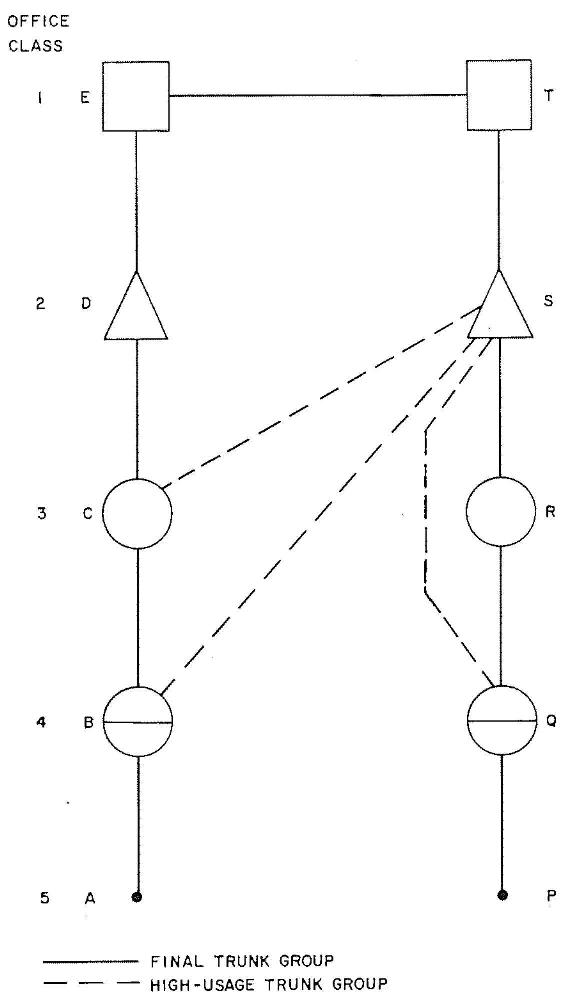
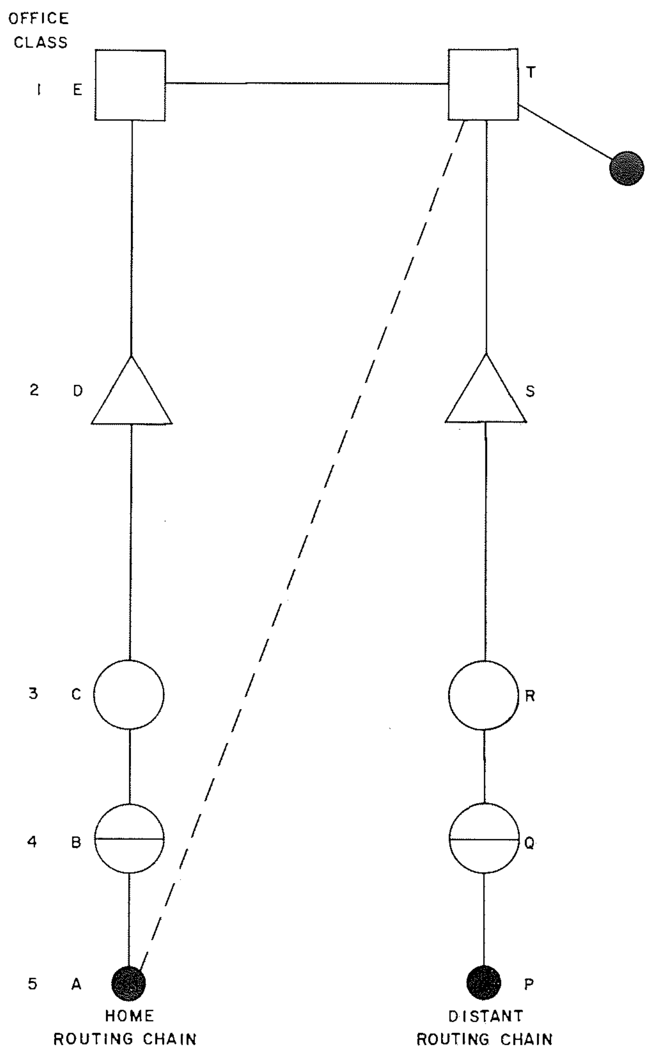


Fig. D2

3.04 As an illustration of an unusual case, a trunk group may be established between an end office (Class 5 switching function) and a distant Regional Center, but only for the Class 4 switching function performed by that Regional Center switching system (Fig. D3), that is, the switching function by which end offices are connected to each other and to the network via an intermediate switch. A Regional Center acts as an ordinary toll center for the end offices homed on it. It should be noted that, if the trunk group A-T is arranged for 2-way traffic, items of traffic from anywhere in T's routing chain destined for A will use this trunk group. This follows the principle of utilizing the most direct high-usage trunk group when no trunk group can be justified at lower levels in the routing chain to the terminating location.

3.05 The one-level inhibit rule applies also to the home routing chain in a manner similar to that for a distant routing chain. In Fig. D4, for example, a high-usage trunk group may be established between End Office A and Sectional Center D, but only for the end offices homed on D for which it performs a Class 4 switching function. Similar high-usage routes can be established for the various ranks of switching systems and classes of switching functions within the home routing chain. Traffic from End Office A to distant routing chains may use the A - D high-usage trunk group to bypass intermediate hierarchical levels in the home routing chain to the extent that trunk groups cannot be justified to any distant routing chain at these lower levels.



FINAL TRUNK GROUP
HIGH-USAGE TRUNK GROUP

Fig. D3

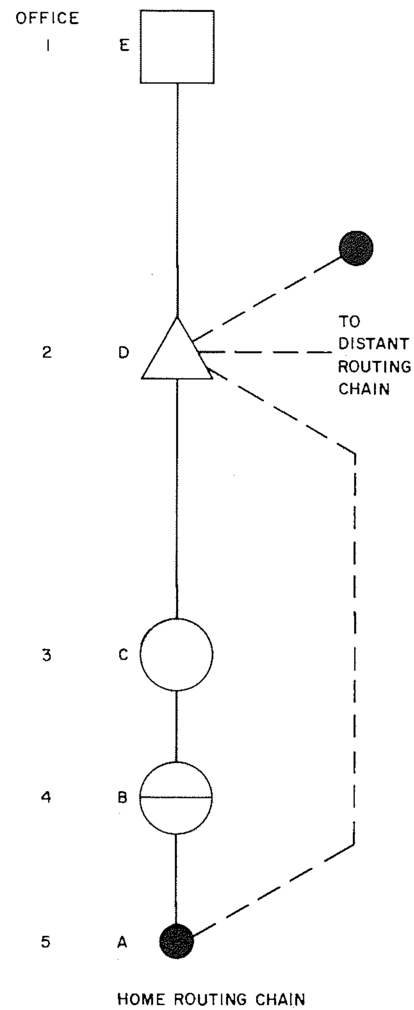


Fig. D4

NOTES ON DISTANCE DIALING

SECTION 4

EQUIPMENT REQUIREMENTS

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CONTENTS PAGE

1. GENERAL

1.01 The equipment arrangements and features described herein for originating and completing calls through the distance dialing network are based primarily on equipment of Bell System manufacture; however, other equipment may be used if it provides the necessary operational features. All arrangements described here are designed to operate within the bounds stated in the previous sections.

2. CUSTOMER PREMISES EQUIPMENT

GENERAL

2.01 Customer premises equipment consists of that apparatus provided on the customer's premises to permit the telephone user to originate and receive communications over the exchange and toll networks. This equipment provides incoming and outgoing signaling, local switching, concentrating, and 2-way communication.

2.02 Incoming signaling consists of ringing a bell or operating some other device which will make the telephone user aware that there is an incoming call on the line. When Centrex-CU service is provided, the dial switcher on the customer's premises receives the dialing information which is passed forward from the central office and establishes the connection through the switches to the called station.

2.03 Outgoing signaling consists of an off-hook condition and dialing (dc pulses or tone signals) on a line to operate central office or customer premises switching equipment to route a call to its destination.

2.04 Local switching and concentration, using key equipment, private branch exchanges (PBXs), or Automatic Call Distributing (ACD) systems, provide flexibility, versatility, and efficient use of telephone lines at customer locations.

2.05 An increasing number of devices for transmitting other forms of information over the telephone network are coming into existence. However, this section will not be concerned with equipments other than those used for voice communications.

2.06 Direct current for signaling the central office and for energizing the station transmitter is supplied over telephone lines from a common battery located in the serving central office.

LINES

2.07 Individual lines are central office lines which serve only one customer. There may be several telephone sets bridged across this line but all are for use by one customer.

2.08 Multiparty lines are central office lines which serve more than one customer. Since the line has only one set of equipment at the central office, only one customer can use the line at any time for separate calls. Each customer may be selectively signaled (up to four parties) using superimposed ringing systems. Selectivity is obtained by ringing to ground from either side of the telephone line and by using cold cathode tubes and polarization. Other systems employed include various types of multifrequency ringing such as harmonic ringing systems.

EQUIPMENT

2.09 Station equipment may generate either dc pulses or tones which enable the central office or PBX equipment to initiate the routing of the call through the switched network to its destination.

2.10 Rotary dials are used to dc pulse (alternately open and close) on a central office or PBX line. These are discussed in Section 5. A typical rotary dial set is shown on Fig. 1.

2.11 TOUCH-TONE® dials are used to generate tones needed to operate central office or PBX equipment. The dial is arranged to generate two frequencies whenever one of the buttons is depressed. A typical TOUCH-TONE dial set is shown on Fig. 1.

2.12 Customer premises equipment can be divided into three broad categories: (1) telephone sets, (2) key telephone systems, and (3) private branch exchanges. There are other categories but these three are the most numerous and will be the only ones discussed here.

2.13 A telephone set or its equivalent must be used by anyone communicating by voice over the exchange and toll network. A telephone set consists of a transmitter, a receiver, an induction coil (hybrid), a switchhook, a dial, and a ringer. Direct current and ringing current for operating a telephone set are usually supplied from the central office. Two typical telephone sets are shown in Fig. 1. There are many other types, too numerous to be covered here, which operate under the same principles as the two shown.

2.14 Key telephone systems are station switching systems, and associated relay equipment located on customer premises, consisting of one or more multibutton telephone sets similar to those shown on Fig. 2. This system permits access to and control of a number of central office lines. A number of telephone sets can be used in key systems. They range from single line pickup through multibutton sets of two, three, four, six, etc, buttons to a variety of turrets, key boxes, and consoles permitting upwards of 30 lines to be picked up. Systems of this type are assembled for reasons of flexibility and versatility. Key systems permit one or more persons to select any one of a number of lines available to them by depressing a button on the telephone set. Calls can be originated, received, or held and a number of other functions performed by using key systems of various sizes and types.

2.15 Private branch exchanges (PBXs) are manual or dial systems which basically perform concentration and intercommunication. The concentrating feature permits a large number of telephone stations to share the use of a number of central office lines (PBX-central office trunks) on a one-at-a-time basis. The intercommunicating feature permits stations on the same PBX to talk to each other without using central office equipment. There are a number of other functions performed by PBXs but this discussion will be limited to central office and intercommunicating calls.

2.16 Manual PBX switchboards connect central office trunks to stations by the use of jacks, cords, and cord circuits. Cord circuits contain signaling, transmission, dialing, and supervisory equipment. An attendant manually completes all calls (including station-to-station) through a switchboard. Rotary or TOUCH-TONE dials are used on central office lines terminated at a switchboard.

2.17 Dial PBX equipment can be step-by-step, crossbar, or electronic. The dial equipment usually has an associated manual switchboard or console whose primary purpose is to connect incoming central office calls to stations. With "Centrex-CU" service, a central office call can be completed to the PBX station without operator assistance since the dial equipment interprets digits forwarded from the central office equipment and routes the call directly to the station. Outgoing calls to a central office can be made by dialing through the switching equipment or by placing it through an attendant position.

2.18 The manual switchboard (attendant position) associated with the dial PBX equipment is similar in appearance and operation to the manual PBX switchboard discussed. One difference is that station jack appearances have no associated lamps because the jacks are used for call completion only. The station reaches the attendant position by dialing "0" which routes the call to a separate set of lamp-equipped jacks at the attendant position rather than to the station jack.

2.19 Consoles serve the same purpose as attendant switchboards. They are used rather than manual switchboards for reasons of appearance and efficiency. They occupy less space and reduce attendant motion.

2.20 Step-by-step dial PBXs use switches (line finders, selectors, and connectors) to complete calls mechanically. These switches follow dial pulses, climbing vertically to select levels and then moving horizontally on a level, either automatically (selector) or again following dial pulses (connector). The number of switches in a dial PBX is determined by such factors as the number of stations, holding time per call, number of trunks, etc. The equipment for a step system can vary from one frame for 100 lines (2-digit system) to a large number of frames requiring a separate switchroom for systems consisting of several thousand lines.

2.21 A crossbar dial PBX is one that uses common control equipment to establish all connections. A typical system contains the following main parts:

(1) A crossbar switch field through which a path is established by the operation of a specific select magnet followed by the operation of two hold magnets. This interconnects two verticals over a selected horizontal path called a link.

(2) Originating registers are needed to originate calls. They function as a dial pulse receiver and counter for digit, class, and group information storage. In addition, the register provides dial tone to calling stations or trunks.

(3) A marker, which is the logic element of the system, establishes calls through a switch field in response to signals received from station lines, trunks, registers, etc. A marker processes one call at a time. Simultaneous bids for service by the marker are sequenced by a gating arrangement. The marker serves each originating register, one trunk bid in each trunk group, one station bid in each horizontal group sequentially. When all originating registers are in use, the marker stops until a register becomes available.

(4) A junctor circuit is required to establish station-to-station calls within the PBX. It provides ringing current to the called station and talking battery and supervision for the calling and called stations.

(5) Various types of lines and trunks can be used to make this system compatible with other systems and equipments.

2.22 The newer PBX systems apply the advantages of electronic switching techniques to station switching.

(1) Use of a centralized stored program common control and solid-state devices permits a considerable reduction in the amount of equipment installed on customer premises. The stored program directs all the processing and diagnostic maintenance routines as well as traffic data collection on switch units.

(2) One such system is organized in two units: (1) a switch unit located on the customer's premises and (2) a control unit located in the central office. Exchange of information between the control unit and the switch unit is achieved via data links. One control unit can serve several switch units. A single switch unit generally serves a single customer; however, a large business customer may be served by several switch units as in a main-satellite arrangement. Calls to this system are handled one at a time under control of the stored program instructions.

(3) Time division switching, an application of the principle of speech sampling, is used. This permits a number of conversations to use the same transmission path and drastically reduces the need for a large number of transmission paths. Printed wiring boards are the basic hardware element of the system on which are mounted transistors, diodes, resistors, networks, etc. Diagnostic maintenance printouts which result in infrequent replacement of circuit packs are part of the basic maintenance routine.

2.23 The electronic PBX has been designed to be compatible with present station equipment and electromechanical central offices. Both TOUCH-TONE and rotary dial station sets may be used on this system.

3. DIAL SWITCHING EQUIPMENT

3.01 Distance dialing places no restriction on the type of dial switching system (step-by-step, crossbar, ESS, etc) provided at Class 4 or 5 offices. (Section 3 describes office classes.) However, the facilities should send, receive, and be actuated by the signals discussed in Section 5. Common control equipment such as registers, senders, directors, etc, are used in many instances to effect economies in switching traffic and to provide uniform dialing procedures. Class 1 and 2 offices are equipped with common control and Class 3 offices with either common or direct control switching facilities having the Control Switching Point (CSP) features described in Section 3.

3.02 Destination code routing is used in the distance dialing network and requires a 10-digit address to identify the called station. However, the number of digits actually passed between offices may vary. Table 1 shows the minimum number of digits that all classes of offices must be arranged to receive over incoming trunks. It may be desirable for an office to receive more than this minimum number and such situations should be studied jointly by the companies involved. In general, the 7-digit number is sent to the toll center on which the distant end Class 5 office "homes" so that the toll center can route the call properly.

CLASS 5 OFFICES

3.03 Local central offices are arranged to process both originating and terminating traffic. The office may be categorized as direct control or common control equipment.

3.04 ***Originating Traffic***—The central office receives dial pulse or multifrequency signals from customer equipment and routes the call. This may be locally to another station, to the distance dialing network, to an operator, or to a recorded announcement.

3.05 ***Terminating Traffic***—The central office receives signals from other offices (local, tandem, or toll) and uses the received information to complete calls to local stations. When connecting to the station line, it applies ringing voltage to ring the called station. If the called line is busy, busy tone is returned to the calling customer. If the called station is a station on a PBX equipped for in dialing (Centrex-CU), the local central office is arranged to transmit the dial pulses required to reach the PBX station. Ringing current is then furnished by the PBX.

Direct Control Equipment (Class 5 Offices)

3.06 Direct control equipment is actuated directly under the control of dial pulses received from local stations or from other central offices. The type of equipment which operates in this manner is step-by-step.

3.07 On local calls within the office, or calls completing from distant offices, dial pulses actuate switches or relays in proper sequence to connect the calling customer to the called station.

3.08 On local calls to other offices, the central office code dial pulses actuate switches or relays to select a trunk to the distant office. The remainder of the digits are transmitted to the distant office which completes the call using the received digits. Some typical trunking plans for completing inward calls in small and medium-sized step-by-step 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 traffic are applicable in all types of offices.

3.09 On outward toll calls, destination code routing requires that the Class 5 office send the complete 7- or 10-digit called number to the toll center. This requirement is met by having the customer prefix the called number with an access code which connects the calling line to a toll-connecting trunk circuit. The customer-dialed seven or ten digits are then sent to and registered in the Centralized Automatic Message Accounting (CAMA) office. Where CAMA arrangements are used, Automatic Number Identification (ANI) equipment at the local office may be used to identify the calling station and transmit its identity to the CAMA equipment by sending multifrequency pulses over the same trunk after the dial pulsing has ended. The CAMA equipment then records information pertinent to billing the call. When ANI equipment is not provided, Operator Number Identification (ONI) is used to obtain the calling station number. This is keyed into the CAMA equipment by the operator.

3.10 At local offices not equipped for CAMA operation, toll traffic has to be routed to an operator who places the call on the network and records the information necesary for billing. The operator has direct trunks to the toll or tandem switching office and uses multifrequency pulsing (to common control toll offices) or dial pulses (to direct control toll offices) to advance the call.

3.11 Incoming trunks from common control offices to direct control offices must be arranged for stop-go dial pulsing and usually have a signaling integrity check feature.

Common Control Equipment (Class 5 Offices)

3.12 Common control equipment receives dial pulses or multifrequency signals from calling stations or dial pulses, multifrequency signals, or revertive pulses from other offices. It stores the digits, determines the proper disposition of each call, and routes it accordingly. Types of equipment which are included in this category are crossbar, panel, common control step-by-step, and electronic switching systems.

3.13 On local calls within the office or calls completing from other offices, the incoming pulses are used to identify the line associated with the called number. The line is tested. If it is not busy, a connection is established and the ringing signal is applied to the station line. If the called station is busy, the office returns busy tone to the calling customer. If the called number is not a working number, the call is routed to an intercept operator or to a recorded announcement.

3.14 On calls to other offices, the central office stores the digits received from the calling station, translates and routes the call, and outpulses digits as required to the next office. The use of multifrequency pulsing is increasing for calls to common control offices although revertive pulsing still handles a high percentage of traffic. Dial pulsing is used to complete calls in direct control offices.

3.15 Some common control offices have the ability to delete or convert digits, as required, to facilitate routing of calls at succeeding offices. An alternate route may be selected (except from panel) when the direct or most direct trunk group cannot be used.

3.16 Certain types of common control central offices can be arranged with Local Automatic Message Accounting (LAMA) equipment. Other common control equipment types can be equipped with ANI to work with CAMA equipment for recording toll calls.

3.17 Certain types of local common control offices are equipped with message registers which record a cumulative total of the number of message units generated by a calling station. This arrangement may be used for local or Extended Area Service (EAS) calls, in conjunction with CAMA recording for toll calls, where the customers are billed for the number of message units originated by their telephone stations.

Local Offices—Miscellaneous Arrangements

3.18 Inward calls may be either operator or customer originated. These calls usually are completed by fully automatic means, but certain calls, such as collect to coin stations, requests for busy line verification, etc, require the services of an inward operator. (Calls dialed by either customer or distant operators should not have access to verification and coin control equipment.)

3.19 Neither called operators nor called stations should be signaled until the full complement of digits has been received. If calls to "operator codes" (Section 2) or plant test codes (Section 8) reach an outgoing trunk circuit before the complete code has been dialed, provision should be made to wait for any remaining digits before the connection is cut through. Otherwise, off-hook supervision upon fast answers may block sender outpulsing and interfere with the operation of the automatic switching equipment.

3.20 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. Level hunting connectors used on distance dialed calls to reach PBX terminals should be arranged not to trunk hunt until all digits have been received.

3.21 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 while hunting for the outgoing trunk. This requirement is explained in more detail in Fig. 3.

TOLL SWITCHING EQUIPMENT (CLASS 4, 3, 2, OR 1 OFFICES)

3.22 Toll switching offices are generally equipped with common control equipment. However, Class 4 and Class 3 offices have been established using direct control equipment. (Class 3 offices can use direct control equipment only where connecting offices are equipped with common control equipment capable of adding, deleting, or converting digits to facilitate switching through the toll office.) Toll switching offices serve to provide access between local offices and the distance dialing network and to provide economical traffic routing arrangements including alternate routing for some trunk groups. Generally, crossbar, step-by-step, and electronic switching equipment are used.

4-Wire Common Control (Class 4, 3, 2, and 1 Offices)

3.23 No. 4 Crossbar is the type of equipment presently used for these offices. New No. 4 Crossbar offices are being equipped with an Electronic Translator System (ETS) and many of the existing card translator offices are being converted to ETS operation. In addition, 4-wire electronic systems will become available. The features described for the 2-wire common control arrangements are all used in the 4-wire toll offices. However, these 4-wire offices do not require through (office) balancing. Pad switching arrangements [high-loss operation (Section 7, 3.21)] are used. Where required, CAMA equipment is incorporated in the office. Alternate routing and extensive translation and digit manipulation features are also available. Trunk classmarks are used for traffic separation.

2-Wire Common Control (Class 2, 3, and 4 Offices)

3.24 Crossbar tandem and the tandem portion of No. 5 Crossbar offices are often used for tandem switching offices. The No. 1 ESS will be used for new offices in small- and medium-size toll centers. This type of office can be arranged to provide CAMA service for its tributaries and each must be balanced to meet transmission objectives.

3.25 These offices have the ability to manipulate digits (delete, prefix, and substitute) as required to maintain uniform numbering arrangements. They may work in connection with the Traffic Service Position System (TSPS).

3.26 Traffic alternate routing arrangements are used to provide the most economical trunking arrangements. (See Section 3, Appendix B.) Traffic separations are accomplished through the use of trunk classmarks as discussed later in this section.

Direct Control (Class 3 and 4 Offices)

3.27 These are 2-wire offices which must be balanced to meet transmission objectives described in Section 7. Also, they can be equipped with CAMA equipment to provide Automatic Message Accounting for their tributaries.

3.28 The switching trains must be carefully engineered for compatibility with the numbering plan. Digit-absorbing techniques are frequently used to minimize equipment quantities.

3.29 Limited traffic alternate routing and digit manipulation (deletion, prefixing, and substitution) are feasible when step offices are equipped with CAMA.

SWITCHBOARDS AND TRAFFIC SERVICE POSITIONS

3.30 In central offices, equipment and trunking facilities are arranged so that customers gain access to an operator by dialing "Operator" (zero). The operator handles assistance calls, operator-handled long distance calls, etc. (Different numbers are generally used to reach Information, Repair Service, and the Telephone Company Business Office.) Arrangements are also provided with TSP/TSPS to allow customers to dial special toll calls such as person-to-person, credit card, and collect calls by dialing 0 (zero) followed by the called number.

3.31 Positions should be arranged:

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

(2) To pulse by means of dials (switchboards only) or keysets. Positions should be arranged for pulsing toward called and calling customers and for operation with a "start dial" lamp. (Switchboards with MF pulsing should not send MF tones back to the calling customers.)

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

TRUNK CIRCUITS

3.32 Trunk circuits should be arranged to transmit and receive on-hook and off-hook signals as required. The signals are described in part 2 of Section 5. They are:

(1) Connect and disconnect

(2) Called station answer (off-hook) and hang-up (on-hook)

(3) Ring forward (by operator)

(4) Ring back (by operator).

3.33 Intertoll trunk circuits should meet the following requirements for satisfactory operation with signaling systems:

(1) The ring forward signal should result in an on-hook pulse, on the M lead from the trunk circuit, with a duration of 100 $\pm$30 milliseconds. (See Section 5.)

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

(a) Have the tip and ring of the voice path opened.

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

(3) Trunk circuits should not disconnect on an E lead open of less than 140 milliseconds duration. (See Section 5.)

(4) Dial pulsing switchboard trunks using 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 to avoid singing during the pulsing intervals.

3.34 In the crossbar tandem office, the incoming trunk circuit recognizes a nominal 100-millisecond on-hook as a ring forward signal. To be recognized as a ring forward signal, the on-hook must be: (1) longer than the recognition time of the trunk circuit (about 55 milliseconds) and (2) shorter than the disconnect time of the trunk circuit (140 to 300 milliseconds). After recognition, the incoming trunk circuit returns to the off-hook state and converts the ring forward to a simplex signal which is +130 volts through 2000 ohms applied for 100 milliseconds minimum to both the tip and ring leads. This signal passes through the office to the incoming loop trunk circuit at the terminating office. If the incoming trunk circuit does not have a supervisory relay with balanced windings, the +130 volts may cause a false disconnect. If E&M lead trunk facilities are used between the crossbar tandem and the terminating office, the simplex signal may be blocked at the crossbar tandem office or passed forward if required. This option is provided in the outgoing trunk circuit at the crossbar tandem office.

3.35 Toll-completing trunks incoming to Class 5 offices preferably should not be terminated on line circuits or links. However, if this type of termination is used, "stop-go" signals must 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 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) Only delay dialing

(3) Only one stop-go

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

3.36 Some crossbar tandem senders presently in operation, on a particular dial outpulsing 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.

More recent crossbar tandem 11-digit senders permit operation with the following signals:

(1) No delay dialing and one stop-go

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

3.37 Dial back operator office trunks provide facilities over which a calling customer having a party line in a Community Dial Office (CDO) may reach the operator who, in turn, may dial back over the same trunk to connect the calling customer to a called customer served from the same party line. Calling customers having a party line in common control offices should dial a code and hang up to reach the other party. The operator should not be involved. 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 5 and conform to design loss objectives as discussed in Section 7. If these trunks have other signaling characteristics, inward traffic to the CDOs should be handled through the inward operator or separate toll-connecting trunk groups should be established to each CDO. Dial back type trunks cannot be used for customers to gain access to Bell System CAMA equipment for DDD calls.

3.38 It is desirable that all operator trunks, except dial automatic or multifrequency automatic, be arranged to return audible ringing signal to the calling end. In addition, trunks to 121 (inward) operators and leave-word operators (11XX) should be arranged to ring back and to receive ring forward.

3.39 ***Joint Control Trunks***—Although the distance dialing network operates on the basis of "calling customer control," it may sometimes be necessary to complete calls to Class 5 offices over trunks which are arranged for control by either end (joint control). This is permissible if the joint control trunks are arranged to:

(1) Have the toll center office end of the trunk release its switching equipment upon calling customer disconnect and then

(2) Make the trunk appear busy until the called customer disconnects.

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

3.40 ***Two-Way Trunks***—Should have the following operating characteristics:

(1) The calling end of a 2-way trunk should be held busy 750 to 1250 milliseconds for terrestrial facility operation and 1050 to 1250

milliseconds for satellite facility operation 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) After the called end recognizes the disconnect signal (150 milliseconds on-hook), it should time for an additional interval of not less than 610 milliseconds to permit the switches to release before giving an idle indication for calls in the opposite direction.

3.41 *Glare*—Two-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. This is called "glare." (See Section 5.)

3.42 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. To disengage from the blocking condition, some types of common control equipment are arranged to flash forward at the reorder rate when the blocked condition is recognized. The flash is sent after the expiration of the intervals shown in Chart 9 of Section 5 on MF pulsing trunks; it is sent immediately on dial pulsing trunks which do not require delay dialing.

3.43 The trunk circuits are so arranged that the flash brings about the release of the connection at the distant end. The near end is also arranged to release and route to reorder or alternatively to complete the call over the same trunk after a 2-second pause (if the start pulsing signal is received from the distant end).

3.44 *Tone Appliers*—In preparation for the introduction of International Direct Distance Dialing (IDDD) in 1970, directives were issued to purge busy flash from the North American DDD network to prevent false charging on foreign billing systems which did not provide a "charge guard" interval upon receipt of off-hook supervision. At that time, tone appliers were no longer required since they were activated by busy flash. In fact, tone appliers in the DDD switching network should be removed or permanently disabled since there may occur, in some types of calls, supervisory conditions unrelated to busy flash which will inadvertently activate the tone applier causing a single burst of tone.

SPECIAL REQUIREMENTS

3.45 The distance dialing network imposes special requirements on signals and features sometimes found in local central offices. Dial tone should not be applied to any incoming toll-completing or intertoll trunk. If for circuit reasons dial tone cannot be removed from incoming trunks, provision should be made for blocking the tone at the connecting office. Second dial tone is not desirable. Equipment arrangements precluding its use are preferred.

3.46 Control of the connection:

(1) On customer-dialed calls, the connection should be under the immediate control of the calling customer and under delayed control (timed disconnect) of the called customer. The timed disconnect period ranges from 13 to 32 seconds in most Bell System designed equipment.

(2) On operator-dialed calls, the connection between the operator and the calling customer should be under joint control except for TSP/TSPS. The equipment from the operator to the called station should be under control of the operator.

3.47 Timed cutoff arrangements in local offices (to limit conversation time on local calls) are undesirable. Where they are used, provision should be made to disable the feature on both inward and outward DDD calls.

DIGIT CAPABILITIES AND TRANSLATION

3.48 *Digit Capacities*—Table 2 is a summary of both dial pulsing and multifrequency digit and translation capacities for various switching systems. Any particular installation may not be equipped for the full capacity shown.

3.49 Direct distance dialing is currently based on the use of a 10-digit called station number and the more recently designed equipment is not arranged to handle more than ten digits. If operator dialing is used to complete calls to some locations which have 8-digit local numbers, a minimum capacity of 11 digits is required in the intermediate equipment.

3.50 *Six-Digit Translation*—When a foreign area (FNPA) can be reached by more than one route, the first six digits of the 10-digit number (area and office codes) of each call to that area are examined (translated) to select the preferred route. (See Section 3.)

3.51 *Digit Deletion*—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. Some of the more important uses of the digit deletion features are:

(1) Send forward all digits received when they are required in the next office. (Delete nothing.)

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

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

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

(5) Drop an area and/or office code when other digits are to be substituted for them. (Delete three or six.) This is called code conversion. (See 3.53.)

(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 one or two.)

3.52 *Prefixing*—One, two, or three digits may be prefixed to the routing digits (Table 3). An example is the prefixing of the extra digits required for switching through a step Primary Center. Another example is the prefixing of the Home Area code (HNPA) to the office code and numbers received. This latter is necessary to bring the call back to the Home Area when it is routed via an office in an adjacent NPA.

3.53 *Code Conversion*—Digits may be substituted in some system for some or all of the routing digits received. This feature, which is called code conversion, provides flexibility for meeting numbering plan requirements by furnishing routing digits for certain systems in the network. For example, an established step-by-step train may require routing digits which differ from those provided by the 7-digit numbering plan. The last preceding CSP can delete some of the seven digits and furnish instead digits which fit the switching train.

3.54 The outpulsing capabilities are listed on Table 3 for various switching systems. The permissible combinations of digit deletion and prefixing are indicated for each system. For each combination, the digits outpulsed are shown in order from left to right. 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 system's literature and no inferences should be made from these data to the mechanics of performing these functions.

4. MISCELLANEOUS CENTRAL OFFICE AND TRAFFIC ADMINISTRATION FACILITIES

INTERCEPTING FACILITIES

4.01 Adequate facilities should be provided to intercept calls which cannot be completed due to the following conditions:

(1) Unassigned numbers including those on a terminal-per-line arrangement

(2) Changed numbers

(3) Vacant levels in step-by-step offices

(4) Unassigned Numbering Plan Area codes or Central Office codes (Vacant codes).

4.02 Intercepted calls should be routed to an operator in a manual intercept bureau or to a recorded announcement as in Automatic Intercept System (AIS). The use of busy, reorder, audible ringback, "no such number tone," or no tone at all is considered unsatisfactory.

4.03 Recorded announcements are adequate to intercept disconnected numbers, unassigned numbers, vacant codes, and vacant levels but it is most desirable that arrangements be provided for cut-through to an operator. Calls to changed numbers should be handled by operators or by an Automatic Intercept System which should be arranged for cut-through to an operator.

4.04 With large scale number change projects, such as Area code boundary shifts where the change is uniform and easily explainable, recorded announcements may be used. In many cases, this may be the only practical method of handling the large volume of traffic. At step-by-step offices, previously working selector levels can be supplied with this announcement to provide better service during and immediately following the number change.

4.05 Blocked thousand levels on step-by-step incoming toll trains should be minimized by building out the incoming train as much as practicable in order that calls to these levels may be properly intercepted.

4.06 To avoid false charging on distance dialed traffic, intercepting equipment needs to be arranged so that it will:

(1) Return neither answer supervision nor flash

(2) Not differentiate between local and toll calls

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

Directory Assistance Service

4.07 The incoming trunks to dial switching equipment at each toll center (Class 4C or higher rank office) should have access to the directory assistance bureau serving that location. An up-to-date listing should be maintained for each Class 5 or 4P dial office homed on that location. Customers in areas equipped for direct distance dialing can dial directly to distant points for directory assistance service by dialing 555-1212 for home NPA points and the appropriate NPA plus 555-1212 for foreign NPA locations. Under this arrangement, the customer will be connected directly to a centralized directory assistance bureau in the called NPA containing number information for the entire Numbering Plan Area or to an inward operator in the called NPA who will connect the customer with the proper bureau.

4.08 The ultimate objective is to establish centralized directory assistance bureaus for each NPA. (See Section 2 for further information on dialing procedures.) Any 131 operator information trunk associated with this arrangement should return off-hook supervision if used alternatively by operators and customers. On 131 trunks used exclusively by operators, the return of off-hook supervision upon operator answer is not required.

VERIFICATION FACILITIES

4.09 ***Verification***—For security, customers must not be permitted access to verification facilities. In addition, operator access should be limited to the regular verification positions unless the cost to do so is prohibitive.

4.10 ***Busy Line Cut-In***—If verification arrangements are not provided, it may be desirable to employ busy line cut-in equipment on those few important lines, ie, police and fire department lines, that should have means for being apprised of an emergency call while busy with an existing call.

SERVICE OBSERVING FACILITIES

4.11 It is desirable that suitable service observing facilities be installed with equipment for distance 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 forces and telephone plant, serves as a measurement of the effectiveness of training programs for operators and of instructional material furnished the customer.

4.12 Service observing facilities, if they are to be effective, should produce an adequate sample over a 24-hour 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 the telephone connection such as:

(a) Speed of answer to trunk signals

(b) Speed of attention to cord signals

(c) Speed of service

(d) Speed of completion.

(2) Quality of Service—Measured in terms of errors, irregularities, and other significant

qualities of performance of equipment, operators, and customers except 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.

Operator Training Equipment

4.13 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 are available for the scheduling of an efficient training program, in-board units may be used. Either type of equipment should provide adequate facilities for giving operators controlled practice on each type of call taught in the initial and subsequent training courses.

TRAFFIC SEPARATION FACILITIES

4.14 ***Registers***—Traffic separation registers are used to give an indication of the number of intrastate and interstate connections through No. 4-type and crossbar tandem 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.

4.15 ***Classmarks***—The diversified sources of traffic having access to certain switching locations and the variation in characteristics among these sources make it necessary 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 classmarks. These classmarks are scored in different combinations in the traffic separation registers to indicate the volume of separate classes of traffic. The 4A and 4M systems are provided with four incoming and seven outgoing classmarks for a total of 28 separate classes. When No. 4 Crossbar is equipped with an Electronic Translator System (ETS), eight incoming and eight outgoing classmarks are available for a total of 64 separate classes. The crossbar tandem system has four incoming and four outgoing marks with a maximum capability of scoring ten separate classes. The classmarks and illustrative traffic separation assignments for these systems are shown in Table 4.

AUTOMATIC RECORDING OF MESSAGE BILLING DATA

4.16 ***General***—Direct dialing of station-to-station calls 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 and 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.

4.17 ***Data Requirements***—Automatic equipment for recording message billing data may be arranged to care for both bulk billed and detailed billed calls. The data listed in Table 5 shows the items needed to render a detailed bill under direct distance dialing and also what is needed for bulk billing.

4.18 ***Automatic Message Accounting***—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.

(1) Local Automatic Message Accounting (LAMA) data recording systems have the recording equipment located at the Class 5 office where the extra-charge calls are originated.

(2) Centralized Automatic Message Accounting (CAMA) 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 depending on specific local considerations.

4.19 ***CAMA at Class 4 and Higher Ranking Offices***—Centralized recording equipment may be provided only at Class 4 or higher ranking offices. Extra-charge traffic from Class 5 offices not equipped with local recording facilities and extra-charge traffic that cannot be served by local recording equipment, when provided, are trunked to the centralized location where the required billing data is recorded.

4.20 ***Data Processing Equipment***—In addition to the central office equipment mentioned above, suitable data processing equipment is required to process the message billing data into the form needed for billing the customer.

4.21 ***Common Control Features***—Several types of equipment for the automatic recording of billing information are currently being manufactured by the Bell System and by independent suppliers to work with both common control and 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.

4.22 ANI Timing:

(1) 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 outpulsing of digits over the trunk nor should it result in an extended interdigital time interval. Such delays could result in time-outs in the common control office and consequent failure to complete calls.

(2) When identification of the calling number is made after the calling customer 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.

FIG. A—TYPICAL ROTARY DIAL TELEPHONE SET

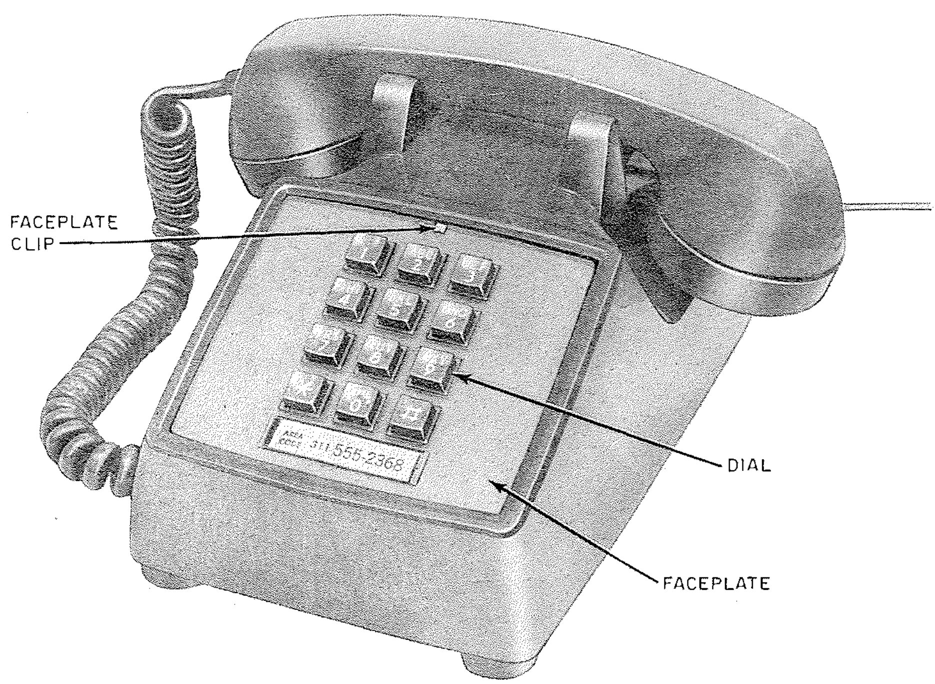


Fig. 1—Typical Rotary and TOUCH-TONE® Dial Telephone Sets

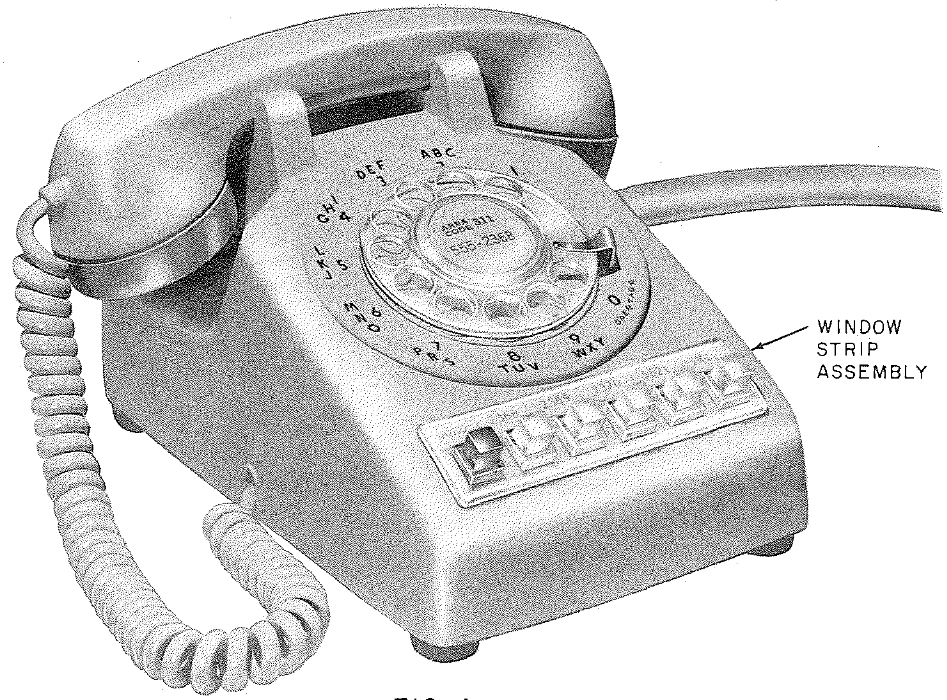


FIG. A

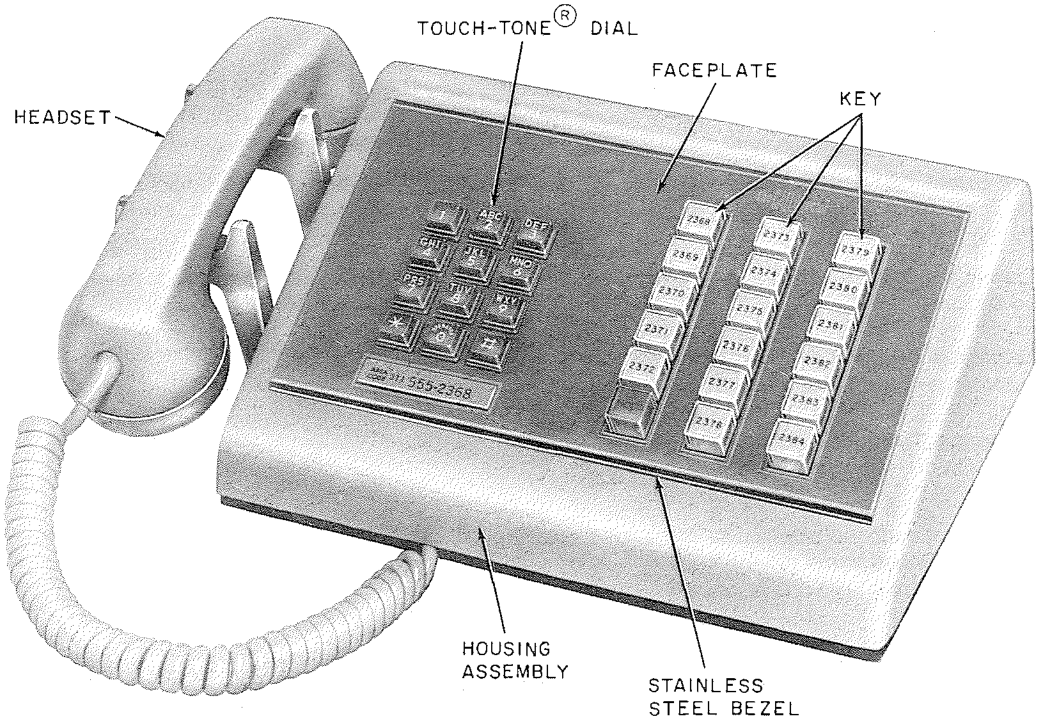
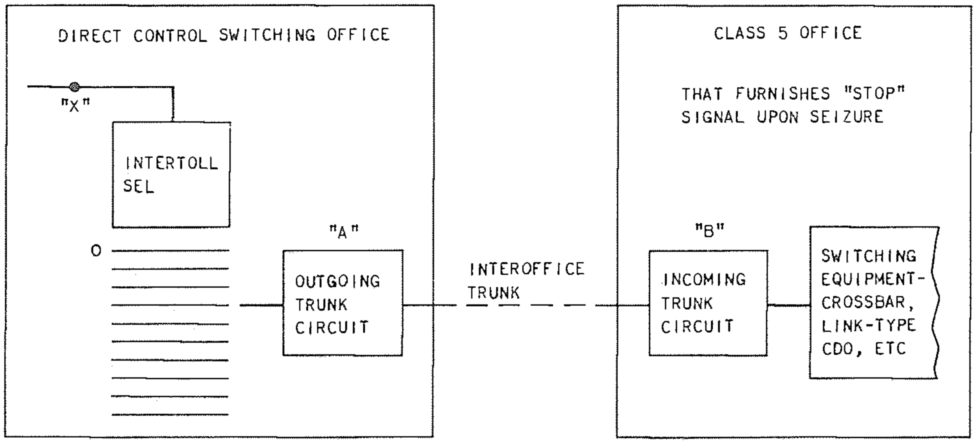


FIG. B

Fig. 2—Typical Multibutton Telephone Sets



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:	"off-hook"	"Off-hook" condition is maintained by intertoll selector.
	a. Originates a request for a sender, incoming register, link, etc		
	b. Returns a "stop dial" signal (off-hook condition) toward trunk circuit "A".		
6.	"Off-hook" condition received at trunk circuit "A" causes trunk circuit "A" to present "off-hook" condition toward intertoll selector.	"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 control 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.

Fig. 3—Stop Dial Signals—A Typical Application

TABLE 1

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

CLASS OF OFFICE	MINIMUM DIGITS INCOMING	EXAMPLE*
5	4	(625) 1234
4P	5 (See Note 1.)	(62) 51234
4C	5 (See Note 2.)	625 1234
3 (or higher)	7	See Note 3.

*Numbers in parentheses ordinarily need not be received.

Notes:

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 seven digits.

2. Most 4C offices will be arranged to receive seven digits. An exception to this requirement may be made where the cost of arranging the equipment at the 4C office for full 7-digit dialing appears excessive in comparison with the advantages offered by uniform operating procedures. Such exception should be limited to the deletion of the AB or ABX digits on groups (intracompany or intercompany intrastate) which will not be reached from the nationwide network. This is a matter for local decision.

3. If the Class 3 office is of the common control type, seven 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 seven digits are needed at the home switching point on calls to Class 5 offices that home directly at the switching office.

TABLE 2

DIGIT CAPACITIES OF VARIOUS SWITCHING SYSTEMS

	4A AND 4M	4A AND 4M CAMA	CROSSBAR TANDEM (INCL CAMA) (NOTE 8)	NO. 5 CROSSBAR	NO. 5 CROSSBAR CAMA	SXS CAMA	NO. 1 ESS	NO. 1 ESS CAMA	NO. 4 ESS
Max. No. of Digits Received (Required Capacity)	11	10	11	12	10	10	12	10	11
Max. No. of Digits Outpulsed (Required Capacity)	11 (Note 1)	10 (Note 1)	11 (Note 1)	11 (Note 1)	10 (Note 1)	12 (Note 1)	12	Note 1	11 (Note 1)
No. of Digits Translated for Routing	3, 4, 5, 6 (Note 4)	3, 6	3, 6 (Note 3)	3, 6 (Note 2)	3, 6	3, 6	3, 4, 5, 6, 7, 8	3, 6	3, 4, 5, 6, 7, 8, 9 (Note 4)
No. of Digits Received Which Can be Deleted	0, 3, 6 (Note 5)	0, 3, 6	0, 1, 2, 3, 4, 5, 6	0, 1, 2, 3, 4, 5, 6	0, 1, 2, 3, 4, 5, 6	0, 3, 6	0, 1, 2, 3, 4, 5, 6, 7	0, 1, 2, 3, 4, 5, 6, 7	0, 1, 2, 3, 4, 5, 6, 7, 8, 9 (Note 5)
No. of Digits Which Can be Prefixed or Substituted for Routing Digits Received	0, 1, 2, 3	0, 1, 2, 3	0, 1, 2, 3	0, 1, 2, 3 (Note 6)	0, 1, 2, 3	0, 1, 2, 3, 4, 5 (Note 7)	0, 1, 2, 3, 4, 5, 6, 7	0, 1, 2, 3, 4, 5, 6, 7	0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Notes:

1. Technically, these systems can outpulse a maximum of 13, 14, or 15 digits. However, there is usually no need for outpulsing more than 10, 11, or 12 digits.
2. Also translates three and four digits for TX calls.
3. Also translates four and five digits for TX calls.
4. Four- and five-digit translation, although fully flexible in these systems, is used at present principally for TX codes.
5. Equivalents for the deletion of one, two, four, and five digits are shown in Table 3.
6. See Note 3 in Table 3.
7. Includes one or two exit digits.
8. Early XB tandem designs do not include all items listed in table.

TABLE 3

OUTPULSING CAPABILITIES OF SWITCHING SYSTEM SENDERS

ITEM NO.	NUMBER OF DIGITS DELETED	NUMBER OF DIGITS PRE-FIXED OR SUB-STITUTED	DIGITS OUTPULSED		SYSTEMS				NO. 1 ESS	NO. 1 ESS CAMA
			DIGITS PREFIXED OR SUB-STITUTED (NOTE 1)	DIGITS A-L REGISTERED (NOTE 2) ("I" DESIG NOT USED) A B C D E F G H J K L	4A AND 4M (INCL CAMA) (NOTE 4)	XB TDM (INCL CAMA)	NO. 5 XB (INCL CAMA) (NOTE 3)	SXS (CAMA) (NOTE 4)		
1	0	0		x x x x x x x x x x x	#	#	#	#	#	#
2	1	0		0 x x x x x x x x x x	(Note 5)	#	#	(Note 5)	#	#
3	2	0		0 0 x x x x x x x x x	(Note 5)	#	#	(Note 5)	#	#
4	3	0		0 0 0 x x x x x x x x	#	#	#	#	#	#
5	4	0		0 0 0 0 x x x x x x x	(Note 5)	#	#	(Note 5)	#	#
6	5	0		0 0 0 0 0 x x x x x x	(Note 5)	#	#	(Note 5)	#	#
7	6	0		0 0 0 0 0 0 x x x x x	#	#	#	#	#	#
8	0	1	+	x x x x x x x x x x x	#	#	#	#	#	#
9	1	1	+	0 x x x x x x x x x x	#	(Note 6)	#	(Note 6)	#	#
10	2	1	+	0 0 x x x x x x x x x	#	(Note 6)	#	(Note 6)	#	#
11	3	1	+	0 0 0 x x x x x x x x	#	#	#	#	#	#
12	4	1	+	0 0 0 0 x x x x x x x	#	(Note 6)	#	(Note 6)	#	#
13	5	1	+	0 0 0 0 0 x x x x x x	#	(Note 6)	#	(Note 6)	#	#
14	6	1	+	0 0 0 0 0 0 x x x x x	#	#	#	#	#	#
15	0	2	++	x x x x x x x x x x x	#	#	#	#	#	#
16	1	2	++	0 x x x x x x x x x x			#		#	#
17	2	2	++	0 0 x x x x x x x x x	#	(Note 6)	#	(Note 6)	#	#
18	3	2	++	0 0 0 x x x x x x x x	#	#	#	#	#	#
19	4	2	++	0 0 0 0 x x x x x x x			#		#	#
20	5	2	++	0 0 0 0 0 x x x x x x	#	(Note 6)	#	(Note 6)	#	#
21	6	2	++	0 0 0 0 0 0 x x x x x	#	#	#	#	#	#
22	0	3	+++	x x x x x x x x x x x	#	#	#	#	#	#
23	1	3	+++	0 x x x x x x x x x x			#		#	#
24	2	3	+++	0 0 x x x x x x x x x			#		#	#
25	3	3	+++	0 0 0 x x x x x x x x	#	#	#	#	#	#
26	4	3	+++	0 0 0 0 x x x x x x x			#		#	#
27	5	3	+++	0 0 0 0 0 x x x x x x			#		#	#
28	6	3	+++	0 0 0 0 0 0 x x x x x	#	#	#	#	#	#
29	0	4	++++	x x x x x x x x x x x				*	#	#
30	3	4	++++	0 0 0 x x x x x x x x				*	#	#
31	6	4	++++	0 0 0 0 0 0 x x x x x				*	#	#
32	0	5	+++++	x x x x x x x x x x x				*	#	#
33	3	5	+++++	0 0 0 x x x x x x x x				*	#	#
34	6	5	+++++	0 0 0 0 0 0 x x x x x				*	#	#

Legend

000 Digits deleted (registered but not outpulsed).
xxx Digits registered and outpulsed.
+++ Digits prefixed or substituted in accordance with instructions previously gives to the machine.
(Each digit may be any digit 0 through 9.)
\# System has capability for this item.
* Only three prefixed digits if MF and four if DP may be transmitted. At least one and possibly two prefixed digits must be dial pulsed exit digits.

Notes:

1. Substituted digits may be identical to those that are deleted.
2. These digits are outpulsed only if registered.
3. All No. 5 Crossbar 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.
4. SXS CAMA and the 4A and 4M CAMA systems will accept only seven or ten digits
5. Items 2, 3, 5, and 6 are provided by the means used to obtain items 18, 11, 21, and 14, respectively.
6. 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.

TABLE 4

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

4A AND 4M SYSTEMS (CARD TRANSLATOR)

INCOMING TRUNK CLASSMARKS	OUTGOING TRUNK CLASSMARKS 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

4A AND 4M SYSTEMS (ELECTRONIC TRANSLATOR SYSTEM)

DATA BLOCK E – DIVISION OF REVENUE

	N	A	B	C	D	E	F	G
N								
1								
2								
3								
4								
5								
6								
7								

Note: Incoming ITSP class combines with OTSP class and will increment one register in Data Block E on a first trial basis only. If either the incoming or outgoing trunk group has not been assigned a traffic separation class on a particular call, no traffic separation will be scored. Separation is always based on initial trunk group intended, not on the route finally selected.

CROSSBAR TANDEM SYSTEMS

INCOMING TRUNK CLASSMARKS	OUTGOING TRUNK CLASSMARKS 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.

TABLE 5

DATA REQUIRED FOR RECORDING
BILLED MESSAGES

DETAIL-BILLED CALLS

1. Called customer's telephone number. This may be either a 10-digit or a 7-digit number, ie, NXX + seven digits if the call terminates in a foreign area or seven digits if the call terminates in the home area. In the recording process, a single digit is often substituted for the NPA code of each of ten of the most frequently called areas.

2. Calling customer's telephone number, seven digits.

3. Date.

4. Time of Day.

5. Duration of Conversation.

BULK-BILLED CALLS

1. Calling customer's telephone number, seven digits.

2. Message units chargeable to calling telephone. This quantity is determined from the following data that needs to be available to the recording equipment:

   a. Office code of called telephone
   b. 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 a. It may also be desirable to record the date and time of day.)

APPENDIX A—TYPICAL TRUNKING DIAGRAMS FOR STEP-BY-STEP OFFICES

1. GENERAL

1.01 Every office has individual requirements that must be met when establishing trunking arrangements for distance dialing. The sketches shown in Fig. A1, A2, and A3 and the following discussion are intended to illustrate some of the fundamental principles of automatic switching. Specific trunking, signaling, and pulsing arrangements should be worked out jointly by the companies whose offices are involved.

1.02 Figure A1 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 out. Figure A2 shows how toll and local trains may be integrated in an end office.

1.03 Figure A3 shows the use of one switching train in Class 5 offices having prepay coin and free service (official) lines.

2. OFFICE NUMBERING—TRUNKING PLAN CONSIDERATIONS

2.01 Substantial savings in switching equipment and uniform operating procedures at distant offices can frequently be had by the use of digit-absorbing facilities in direct control offices. The capabilities and limitations of available digit-absorbing equipment need to be kept in mind, however, when developing office trunking and numbering plans. The attached Fig. A1 and A2 show some applications of the digit-absorbing principle. The left-hand portion of Fig. A1 shows, in simplified form, a step-by-step 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 office shown on the right-hand side of the figure. In addition to its through switching functions, the Primary Center also serves as the "toll center" for the following end offices:

(1) "625," "626," "627," and "628" Class 5 offices located in the same building

(2) "232," "233," ... "239" Class 5 offices in the same exchange but in a different building

(3) "445" and "437" Class 5 offices, each of which requires only four effective digits for switching purposes

(4) "33" building which houses several Class 5 offices "332," "333," etc, and, therefore, requires five effective switching digits.

2.02 By arranging the intertoll first selectors to absorb "4" repeatedly (AR4) and to absorb "6" 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 office, 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 Since inward and delayed operation is cared for at Class 3 offices, the auxiliary train is also provided.

2.05 Figure A2, Fig. A, shows a local office (about 3000 numbers) with office code "437." The local customers may make local calls by dialing either the listed 7-digit number or the abbreviated 5- or 4-digit number as desired. It will be noted that the incoming toll-connecting trunks are terminated on 3-wire local switches arranged to return tone only busy signals. (See 3.04 of this Appendix.)

2.06 Figure A2, Fig. B, shows a somewhat larger installation, the four units of the "79X" offices. For this installation, a regular toll train using toll transmission selectors is provided for inward distance dialed traffic.

3. SINGLE SWITCHING TRAINS IN CLASS 5 OFFICES

3.01 The Bell System now combines local and incoming distance dialed traffic on one switching train in new step-by-step offices. Separate toll trains are no longer provided for Class 5 offices. Toll trains were originally provided for transmission reasons and such features as flashing signals, controlled ringing, and coin control were added later. With present-day engineering and operating practices, it is felt that all requirements may be satisfied on a single local-type train as outlined in the following.

TRANSMISSION CONSIDERATIONS

3.02 With the introduction of improved station instruments, toll grade battery as provided by toll trains is no longer required to meet transmission objectives.

3.03 Other transmission requirements such as proper impedance matching, suitable return loss, and minimizing noise resulting from inductive interference can generally be met on a single-train arrangement by the provision of incoming trunk circuits which include appropriate repeating coils.

FLASHING SIGNALS

3.04 Flashing signals have been eliminated and tone only signals, such as are available on a local train, are used. The operator should stay on a connection until audible tone is received.

CONTROLLED RINGING

3.05 Elimination of the toll train results in the loss of controlled start of ringing and the ability to rering. Although this imposes some operating penalties, Traffic Operating Practices have been revised to cover the handling of delayed calls over facilities with immediate ringing.

COIN CONTROL ARRANGEMENTS

3.06 For prepaid coin service, the line number method of coin control may be used in some offices, particularly the smaller ones.

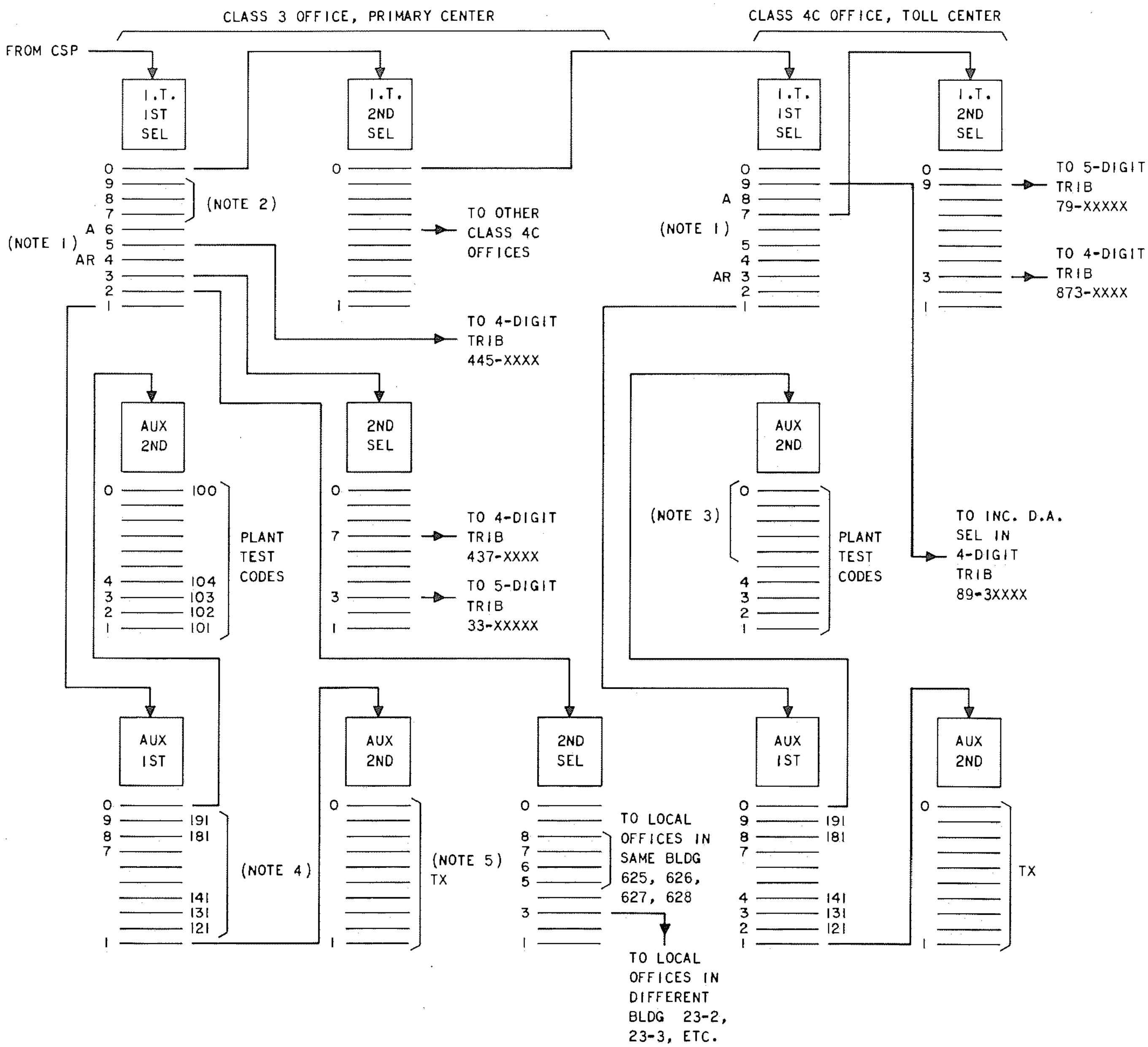
3.07 For prepaid coin service in offices associated with switchboards requiring positional coin control operation, a partial toll train with access to coin lines only may be used. Equipment arrangements are shown in Fig. A3.

(1) Only incoming collect to and delayed outward traffic from coin lines would be routed over this train, thereby permitting the train to be relatively small. All other incoming traffic would be routed over the local-type train. For example, in an office requiring 4-digit in-dialing and having less than 1000 coin lines, the arrangements described in (2) would be used.

(2) Terminate incoming trunks on toll transmission selectors and provide combination connectors in the group or groups serving the coin lines. Mark all the levels of the transmission selector for blocking except the level which represents the thousand digit assigned to coin and have this level marked for once-only digit absorption. Assign as many of these levels as required (equivalent to the number of coin connector groups) and connect other levels to intercept or recorded announcement. With this arrangement, the hundreds series of numbers of the coin thousand not required for coin may still be assigned to noncoin lines but access to the noncoin lines will be over the local train only.

CHARGE SUPERVISION ON DISTANCE DIALED CALLS TO FREE NUMBERS

3.08 The provision of a 4-wire incoming local train is suggested where requirements exist for charging on distance dialed calls to official numbers which are free service within the local dialing area. Connector groups or connector levels serving free lines would return an off-hook supervisory signal via the fourth wire, through the selectors, to the incoming trunk from the switching office.



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 PREVIOUSLY ON A LEVEL DESIGNATED "A."
2. BY PROVISION OF ADDITIONAL GROUPS OF SECOND SELECTORS FROM OTHER LEVELS OF THE FIRST 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 SECOND 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".

Fig. A1—Simplified Hypothetical Trunking Plan

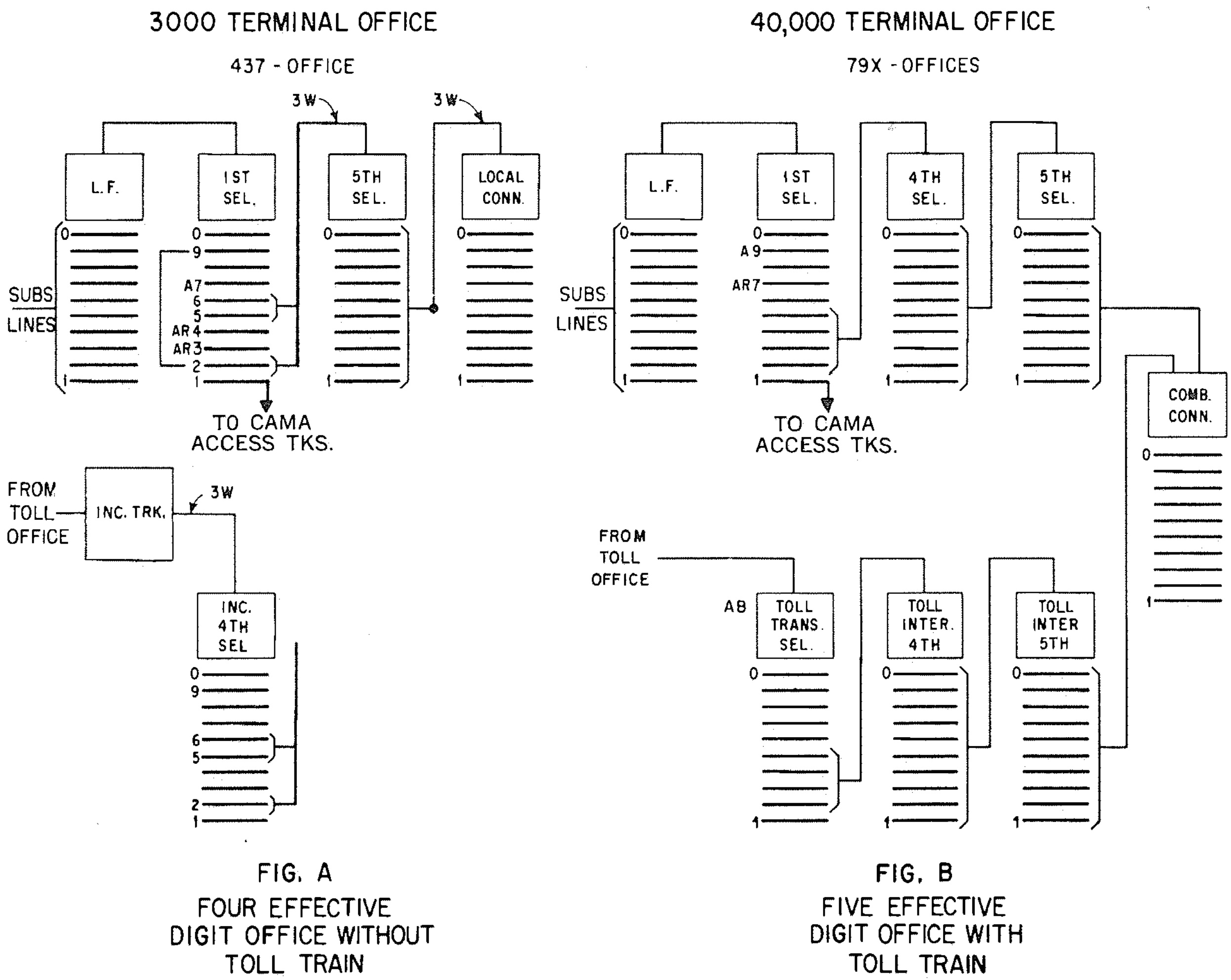


Fig. A2—Diagram Showing Relation Between Local and Toll Trains

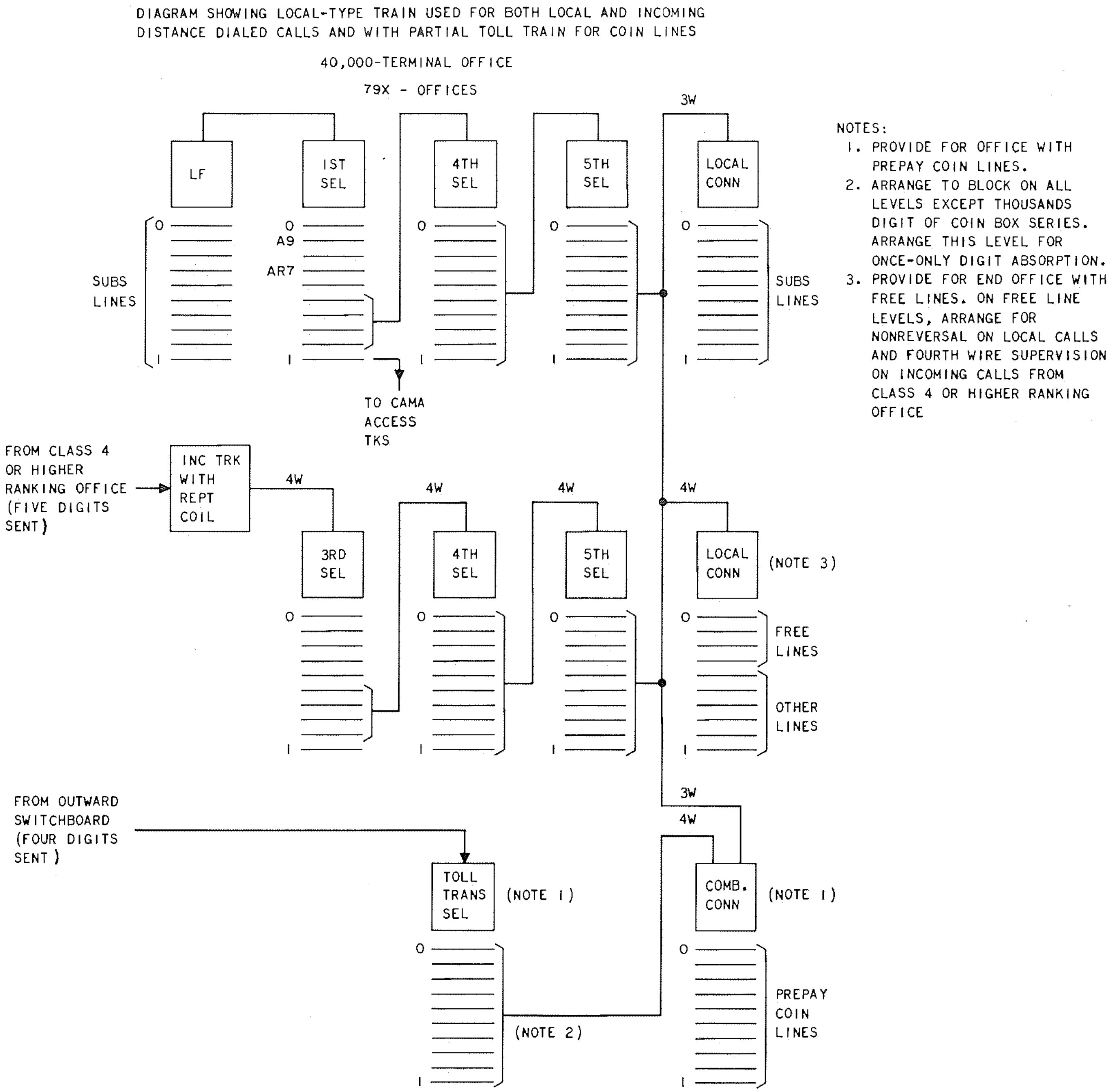


Fig. A3—Single Switching Train in Class 5 Office

NOTES ON DISTANCE DIALING

SECTION 5

SIGNALING

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1. GENERAL

1.01 Interoffice signaling for operator and direct distance dialing is described in this section. Full dial operation is assumed; therefore, ringdown and straightforward methods are not discussed. Such signaling as revertive pulsing, PCI (Panel Call Indicator) pulsing, and call announcer are discussed briefly because their use in the distance dialing network at this time is limited.

1.02 The names given for the different signals are those which are well established by general use. A few alternative terms having considerable usage are shown in parentheses on Chart 1. The direction of each signal, the indication given to the customer or operator, and the on-hook or off-hook classification of the signal are shown where applicable.

1.03 Applications of several of these signals are listed in Chart 2 for a direct distance dialed connection switched through three intermediate offices in addition to the originating and terminating end offices. Calls can, of course, be switched through more or fewer offices. The number of offices shown should suffice to illustrate the use of signals.

1.04 This section will describe on-hook and off-hook signaling from the technical viewpoint as well as how they are combined to form signaling systems. The requirements for sender and register timing intervals are also included in this section.

1.05 A significant number of electronic switching systems are now in use. For the most part, signaling to and from these offices is presently handled much as it is between electromechanical offices. In the future, special signaling arrangements between electronic offices are anticipated.

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 direct distance dialing applications, they should be compatible with the equipment herein described.

1.07 A new kind of signaling system, known as Common Channel Interoffice Signaling (CCIS), is now under development for Bell System use. In this system, the signaling information for a number of interoffice trunks is encoded and transmitted over a separate voice grade channel by digital techniques. Between ESS and crossbar offices with Stored Program Control (SPC), the CCIS system permits eliminating all per-trunk signaling equipment. CCIS is covered in Section 6.

1.08 Signaling on international circuits to points outside the integrated North American network use systems different from those in domestic service. At present, most such circuits terminating in the United States use the CCITT (International Telegraph and Telephone Consultative Committee) number 5 system. A new system is known as CCITT number 6 and is similar in many respects to the CCIS system mentioned above. Reference should be made to Section 10 for more details on the signaling systems used in international dialing.

1.09 Use of the Traffic Service Position System (TSPS) is growing rapidly. Signaling to and from this system is different in some ways from the signaling associated with cordboard operation. This has been taken into account at appropriate locations in this section.

1.10 The Pulse Code Modulation (PCM) carrier system (eg, T1) has an integral signaling system which makes use of one of the code bits associated with each channel for conveying the signaling state of the channel. Further discussion of this method of signaling is beyond the scope of this document. PCM systems can use conventional systems discussed in this section.

2. ON-HOOK AND OFF-HOOK SIGNALS

2.01 A number of interoffice signals are classified as on-hook, off-hook, or a sequential combination of the two. The terms were derived from the position of the receiver of an old fashioned telephone set in relation to the mounting (hook) provided for it. If the station is on-hook, the conductor loop between the station and central office is open and no current flowing. For off-hook conditions, there is a dc shunt across the line and current is flowing.

2.02 These terms have also been found convenient to designate the two signaling conditions of a trunk. Usually, if a trunk is not in use, it is signaling on-hook toward both ends. Seizure of the trunk at the calling end initiates an off-hook signal transmitted toward 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 an off-hook signal back toward the calling end. However, it should be noted that trunks using delay-dial operation with loop reverse-battery signaling can use off-hook toward the originating office when idle.

2.03 Both off-hook and on-hook signals, when not used to convey numerical information, are often referred to as supervisory signals or simply as "supervision."

2.04 The signals which are on-hook or off-hook or a combination of both are included in Chart 1. The direction of transmission of each signal is also shown. One or more of the following factors help in determining the significance of a signal in addition to the information given in Chart 1:

(1) Duration—The on-hook interval of a dial pulse is relatively short and is distinguishable from an on-hook disconnect signal which is transmitted in the same direction but for a longer duration.

(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 transmitted in the same direction and both are off-hook, they are distinguished by the relative time of their occurrence.

(3) Frequency of Repetition—Such as 60 IPM (Interruptions Per Minute) and 120 IPM.

2.05 The remainder of part 2 discusses types of on-hook and off-hook signals. Some of the other signals included in Chart 1 are covered in other parts of this section.

CONNECT (SEIZURE) AND DISCONNECT

2.06 A connect signal is a sustained off-hook signal transmitted toward the called end of a trunk following its seizure. This signal is the means by which the calling end indicates a request for service. It continues as long as the connection is held. Momentary interruptions in the connect signal caused by dial pulses or the ring forward signal are ignored as far as the connect and disconnect functions are concerned. To avoid double seizures, a connect signal must be sent immediately upon seizure of a 2-way trunk in order to make it busy at the other end. The simultaneous seizure of a 2-way trunk at both ends is called "glare." (See 2.14.)

2.07 A disconnect signal is an on-hook signal which is transmitted toward the called end and which exceeds a minimum on-hook interval of 300 to 800 milliseconds for step-by-step trunk circuits and about 150 to 500 milliseconds for other types of trunk circuits. This signal is the means by which the calling end notifies the called end that the established connection is no longer needed and should be released. To insure that ring forward signals do not cause false disconnections, incoming trunk equipments to inward and/or through operators must not release during a minimum on-hook interval of 140 milliseconds (a maximum 130-millisecond ring forward pulse plus a 10-millisecond safety margin). In general, any trunk circuit connected to inband signaling equipment must also be arranged so that it will not release during an on-hook interval of less than 140 milliseconds.

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

ANSWER (OFF-HOOK) AND HANG-UP (ON-HOOK)

2.09 When the called customer answers, an off-hook signal is transmitted toward the calling end (usually repeated by relays) to the outward operator's supervisory lamp 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 by the requirement that it must be continuous for a minimum interval which ranges from 0.6 to 5 seconds. With the elimination of flashing signals, the lower limit (0.6 seconds) is sufficient to guard against false charging resulting from spurious off-hook signals up to 500 milliseconds.

2.10 Direct dialed information calls to 555-1212 and NPA+555-1212 trunks originally did not return answer supervision. This prevented the use of AMA-CAMA tape analysis for network completion studies on calls to information. Consequently, to improve the effectiveness of the network completion studies, it has been recommended that answer supervision should be returned on all 555-1212 and NPA+555-1212 calls.

2.11 Where 131 trunks are used jointly to complete customer-dialed 555 calls and operator placed 131 calls, these trunks should also be arranged to return answer supervision. Where the 131 trunks handle only operator-dialed traffic, the return of answer supervision is optional; it is not required but may be provided.

2.12 The condition of most trunks when idle and all trunks when awaiting the customer's answer is that an on-hook signal is being transmitted from the called end to the calling end. Most trunks are on-hook again when the called station hangs up. However, some one-way loop signaling trunks are arranged to signal off-hook toward the calling end when idle.

GUARD TIME

2.13 The timed interval used to insure trunk release before reseizure is called "guard time." The disconnect time averages 360 milliseconds for calls to a common control office and about 500 milliseconds for calls to a step-by-step office. Therefore, typical guard times are 700 milliseconds for common control offices and 1000 milliseconds for step-by-step offices. Minimum guard times for common control senders are chosen to be longer than the average disconnect times for the incoming office but generally not as long as the maximum possible disconnect interval. A guard time less than the maximum possible disconnect interval is used to save sender holding time. This can be done without an appreciable effect on service because trunks do not usually take the maximum time to release, a new call is not usually connected in the minimum time, and signaling distortion is not normally at its most adverse limit.

GLARE

2.14 Two-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. This is called "glare." These simultaneous seizures cause each end of the trunk to receive an immediate and sustained off-hook signal. When delay-dialing signals are used, the blocking condition is assumed to exist if the off-hook condition persists longer than the intervals shown in Chart 9 of this section. When delay-dialing signals are not used, the blocking condition can be detected immediately upon trunk seizure.

2.15 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. To disengage from the blocking condition, some types of common control equipment are arranged to flash forward at the reorder rate when the blocked condition is recognized. The flash is sent after the expiration of the intervals shown in Chart 9 of this section on MF pulsing trunks; it is sent immediately on dial pulsing trunks which do not require delay dialing.

2.16 The trunk circuits are so arranged that the flash brings about the release of the connection at the distant end. The near end is also arranged to release and route to reorder or, alternatively, to complete the call over the same trunk after a 2-second pause (if the start pulsing signal is received from the distant end).

IMMEDIATE DIALING

2.17 Trunk groups employing common receiving equipment (such as senders or registers) may be equipped at the called end with fast links (or bylinks) with both the links and the common receiving equipment liberally engineered to minimize delays. Such groups are normally ready to receive pulsing in about 120 milliseconds after receipt of connect signal. Immediate dialing is used with these trunks and is required for direct-dialed CAMA traffic from nonsenderized SXS offices to avoid the use of second dial tone. In addition, dial pulsing trunks from common control offices to direct control switching systems which are ready to accept digits immediately after seizure need not employ delay dialing. Some advantage is realized, however, if delay dialing is employed for signaling integrity check purposes.

2.18 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 70 milliseconds after trunk closure to allow time for operating the A relay and soaking the B relay of the distant selector or equivalent circuit. Senders are informed by classmarks whether they are operating with this type of trunk or with trunks requiring either a delay-dialing or a wink-start signal prior to the start-dialing indication.

CONTROLLED OUTPULSING

2.19 A method called controlled outpulsing is used between common control offices and between operators and common control offices because less common equipment is needed than if immediate dial operation is used. Controlled outpulsing permits the use of slower links and results in higher register usage. Originally, the only method of controlled outpulsing was delay dialing. Switchboards and No. 4 Crossbar have used this method of controlled outpulsing since the start of DDD. The vast majority of intertoll trunks employ the delay-dialing method of controlled outpulsing. No. 4 Crossbar will continue to require a delay-dialing response on intertoll trunks and the crossbar tandem will require the delay-dialing method of controlled outpulsing on trunks with the retrial feature.

2.20 Wink start is used in more applications today than formerly and its use is expected to grow. Wink start is the preferred method of controlled outpulsing for No. 1 ESS, TSPS, and No. 4 ESS including 2-way trunks for No. 1 ESS and No. 4 ESS. The No. 1 and No. 4 ESSs can return a delay-dial signal; however, TSPS cannot. All three systems will accept delay-dial signal from other offices. Glare on 2-way trunks in No. 1 ESS and No. 4 ESS is detected more quickly with wink start than with delay-dial operation.

2.21 Until recently, all 2-way trunk circuits used the delay-dialing method of controlled outpulsing. CAMA one-way incoming trunks utilize the wink-start signaling method. No. 4 Crossbar toll-completing (one-way outgoing) trunks normally employ delay dial. The changes made in these trunks for the inclusion of the integrity check permit either delay-dial or wink-start operation.

DELAY DIALING

2.22 In the delay-dialing method of controlled outpulsing, the originating office seizes the trunk toward the called office. The distant office returns a delay-dialing signal until a register (or sender) is attached and ready to receive pulses. At that time, the called office sends the calling office a start-dialing signal. After receiving the start-dialing signal, the calling office starts the outpulsing procedure.

2.23 The delay dialing is an off-hook signal and is maintained for a minimum of 140 milliseconds. It is desirable to minimize the delay by sending the off-hook to on-hook transition (start dialing) as soon as possible after the register (or sender) is ready to accept pulsing. The signaling system used with the transmission facility will distort the off-hook (delay dial) signal as it is transmitted between offices. As a result, the originating office must recognize an off-hook as short as 100 milliseconds as a delay-dialing signal.

2.24 The speed with which the called office returns the delay-dialing signal is especially important in the delay-dialing method of operation. Where signaling integrity check is not used, the failure to receive a delay-dialing signal may permit the sender to outpulse before the register or sender is attached at the called end. The call will be routed to reorder or left high and dry depending on the exact conditions involved. With signaling integrity check but not retrial, failure to receive delay-dialing signal at the proper time will route the call to reorder and cause false trouble indications. With signaling integrity check and retrial features, a slow return of the delay-dialing signal will cause false trouble indications and false retrial attempt.

2.25 The trunk circuits that use E&M leads for signaling in the delay-dialing method of operation are on-hook when idle. The called end goes off-hook when seized. This transition from on-hook to off-hook is controlled within the trunk circuit. The called end goes on-hook when the register (or sender) is ready to receive pulses. This transition from off-hook to on-hook is controlled by the sender (or register) and is recognized as a start-dialing signal at the originating office. E&M lead signaling trunks should receive the delay-dialing signal less than 300 milliseconds after seizure.

2.26 Some loop signaling trunks using the delay-dialing method of controlled outpulsing must receive the delay-dial signal within 75 milliseconds of trunk seizure. With this method of operation, the incoming trunk is in the off-hook state when idle to meet the timing requirements. Other loop signaling trunks using the delay-dialing method must receive the signal in less than 300 milliseconds after seizure. With this operation, the incoming trunks can be either off-hook or on-hook when idle.

WINK OPERATION

2.27 With wink operation, the trunk equipments signal on-hook toward each end when in the idle condition. On receipt of a connect signal, the called office initiates a request for register (or sender) but the called office does not immediately return an off-hook (delay dialing) signal to the calling office. The idle condition on-hook signal to the calling office is maintained until the register (or sender) is attached at the called office, at which time the idle on-hook signal is changed to off-hook. The register (or sender) maintains the off-hook signal for a time interval (a minimum of 140 and a maximum of 290 milliseconds). It is desirable to minimize post-dialing delay by maintaining the duration of the off-hook close to 140 milliseconds. The nominal wink signal is about 200 milliseconds for electromechanical offices and 150 milliseconds for electronic offices. The transitions from on-hook to off-hook to on-hook, with the duration of off-hook constrained as indicated, constitute the wink.

2.28 The signal transmission system will generally distort the wink as it is transmitted between offices. As a result, the receiving office must recognize an off-hook in the range of 100 to 350 milliseconds as a wink signal. Off-hooks over 350 milliseconds should be treated as glare on 2-way wink-start trunks. All wink-start trunks operate in the same manner, whether E&M lead or loop reverse-battery signaling.

START DIALING (START PULSING)

2.29 Start dialing is an on-hook signal transmitted from the called office to the calling office occurring when the receiving office is ready to accept digits. However, a momentary delay of a minimum of 70 milliseconds should be introduced before dial pulsing is started. 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 false reflected pulse. In No. 4A Crossbar, a nominal 200-millisecond delay is introduced after receipt of the start-dialing signal and before MF outpulsing. This delay was introduced to prevent false stop-dial signals when the older type single-frequency signaling was used. It also facilitates proper sender retrial operation (when such features are provided) during simultaneous seizures of 2-way intertoll trunks.

STOP-GO

2.30 The stop-go method of operation is used where a step-by-step intertoll office is a tandem between two common control offices or a common control office and a link type CDO not equipped for immediate dial. The originating common control office dial pulses the address information. An off-hook returned to the originating office within the interdigital interval stops outpulsing until the supervisory condition returns to on-hook. The off-hook sent toward the originating end to stop outpulsing is known as a stop signal. The on-hook that signals to resume pulsing is the go signal.

2.31 In stop-go operation, the step-by-step intertoll office uses digit one, two, or three to route the call to the proper outgoing trunk. After the last pulse is registered and as the selector begins to rotate, a stop signal is sent by the step-by-step selector circuit toward the originating end of the connection. The stop signal is a timed off-hook signal about 330 milliseconds long. The terminating office uses delay-dialing method of operation on stop-go trunks.

2.32 The delay-dialing signal from the terminating office overlaps the stop signal at the step-by-step outgoing trunk circuit preventing outpulsing until the terminating office is ready to receive pulses. A start-dialing, on-hook signal from the terminating office is the go signal to resume pulsing. After receipt of the go signal, the originating office should delay outpulsing a minimum of 70 milliseconds. Stop-go operation cannot be used with local step-by-step tandems because local step-by-step circuits are not equipped to return a stop signal.

SIGNALING INTEGRITY CHECK

2.33 Signaling integrity check is a per-call test made by a common control office during the initial call setup to another switching system. It is used as an indication of the ability of the trunk to transmit signals. It is associated with detection, identification, and recording of trunk/facility troubles as well as with a second attempt at call completion if the switching system has this capability. The ability to detect trunk/facility troubles lessens the probability that customers will be left high and dry and it improves the call completion rate when the switching system has second attempt capability. The ability to identify and record trunk/facility troubles greatly assists the maintenance force. Therefore, the integrity check feature is recommended on intertoll and toll-connecting trunks whenever possible.

2.34 The exact nature of the check varies from switching system to switching system. However, there are two general types of signaling integrity check. The first and the most complete check requires a signaling response from the incoming office in the form of a delay-dial or wink signal. The second requires circuit continuity and the correct polarity on the tip and ring of the trunk.

2.35 No. 4 Crossbar, No. 5 Crossbar, Crossbar Tandem, step-by-step CAMA, No. 4 ESS, and No. 1 ESS all provide signaling integrity check using the continuity and polarity test method on immediate-dial calls to progressive control offices over physical facilities using loop reverse battery supervision. No change in the progressive control office is necessary for this operation. However, it does not provide as complete a check as would be possible if E&M lead supervision were used and the trunk circuits in the progressive (ie, direct) control office were equipped to return a stop-dial/start-dial signal. The signal sent by the progressive control office as an integrity check signal is a timed off-hook that meets the requirements for both delay-dial or wink-start operation. As a result, the originating office can use either delay-dial or wink-start operation. The signal is called wink start by some and delay dial by others.

2.36 Trunks using immediate dial (not equipped for integrity check) over carrier do not have any form of signaling integrity check. Under these circumstances, the common control switching machine outpulses blindly on the trunk. If there is a trunk trouble, it generally goes undetected by the equipment (no trouble record) and the customer usually ends up high and dry.

2.37 No. 4 Crossbar, Crossbar Tandem, No. 5 Crossbar, step-by-step CAMA, No. 4 ESS, and No. 1 ESS can provide signaling integrity check on all outgoing calls using the delay-dial or wink-start method of operation with MF pulsing and loop reverse battery or E&M lead supervision to common control offices. This method can also be employed with dial pulsing and E&M supervision to common control or progressive control offices, provided the progressive (direct) control office uses an incoming trunk circuit that will return a stop-dial/start-dial signal.

DIAL PULSING

2.38 Dial pulsing is a means of transmitting digital information from a subscriber's dial to the central office equipment. Pulses from a customer's dial are momentary openings of the loop which are followed at the switching equipment by operation of a relay. In nonsenderized step-by-step systems, the pulses from the customer's dial are used to actuate the switching equipment directly in the local office. On trunked step-by-step calls, the dial pulses for the distant selectors are relayed forward by an outgoing dial pulse repeater. At the terminating office, the relayed pulses may either operate the switching equipment directly or may again be relayed by an incoming dial pulse repeater. Senders which accept dial pulses from trunks are available as well as senders which will dial pulse outward.

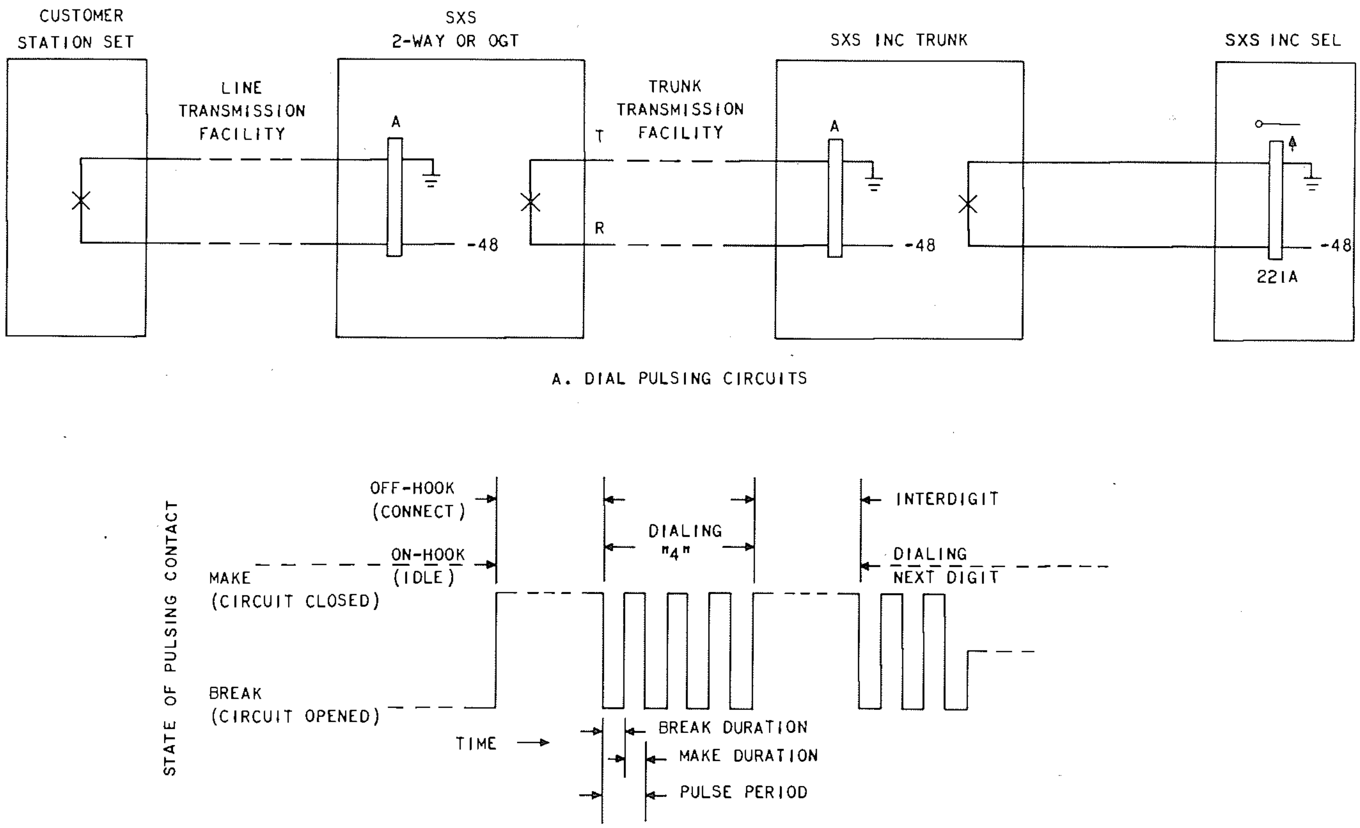
2.39 Dial pulsing represents the numerical value of each digit by the number of on-hook intervals in a train of pulses. The on-hook intervals of each digit are separated by short off-hook intervals while the digits themselves are separated by relatively long off-hook intervals. The on-hook signals do not interfere with the function of the disconnect signal since they fall much below the minimum disconnect times given previously. The off-hook interval between digits is distinguished from the off-hook between pulses by the timing of a slow release relay or by other means. In step-by-step systems, the end of a digit is recognized when the off-hook signal exceeds 90 to 295 milliseconds. In common control systems, the range is in the order of 75 to 210 milliseconds. When the end of a digit is recognized, additional operations must be performed before the next digit can be received.

2.40 Dial pulse signaling in the Bell System is originated at a "pulsing speed" of approximately ten pulses per second (PPS) at approximately 61 percent break (BK). Pulsing speed is maintained as close to the nominal 10 PPS as economic considerations warrant. The break ratio is deliberately changed away from 50 percent BK in order to compensate for the characteristics of relays, switches, and signal transmission systems, which differ substantially, and in order to make the most advantageous use of circuit conditions occurring during the break and make time intervals.

2.41 Figure 1 illustrates dial pulsing. Figure 1A shows typical pulsing contacts (which may be the cam-operated contact in a rotary dial or the "make" contact of a pulse-repeating relay in a signaling circuit as shown) which open and close a dc circuit a number of times equal to the digit being dialed together with relays which are intended to respond accordingly. Figure 1B illustrates some of the terms employed in describing dial pulse signaling circuits.

LOOP AND LEAK

2.42 Series resistance in the circuit connecting the pulsing contact with the relay winding reduces the maximum current that can flow and the rate at which the current increases from zero to maximum. The net effect is to increase the break ratio measured at the relay contact. Shunt capacitance and shunt resistance have the opposite effect. Instead of ceasing to flow abruptly when the pulsing contact is opened, relay winding current continues flowing at a steady rate through the shunt resistance and then at an exponentially decreasing rate until the capacitance is charged to



PULSING PERIOD = BREAK DURATION + MAKE DURATION (MILLISECONDS)
PULSING SPEED = PULSES PER SECOND = 1000 ÷ PULSING PERIOD (MS)
PERCENT BREAK = 100 X BREAK RATIO
= 100 X BREAK DURATION ÷ PULSING PERIOD

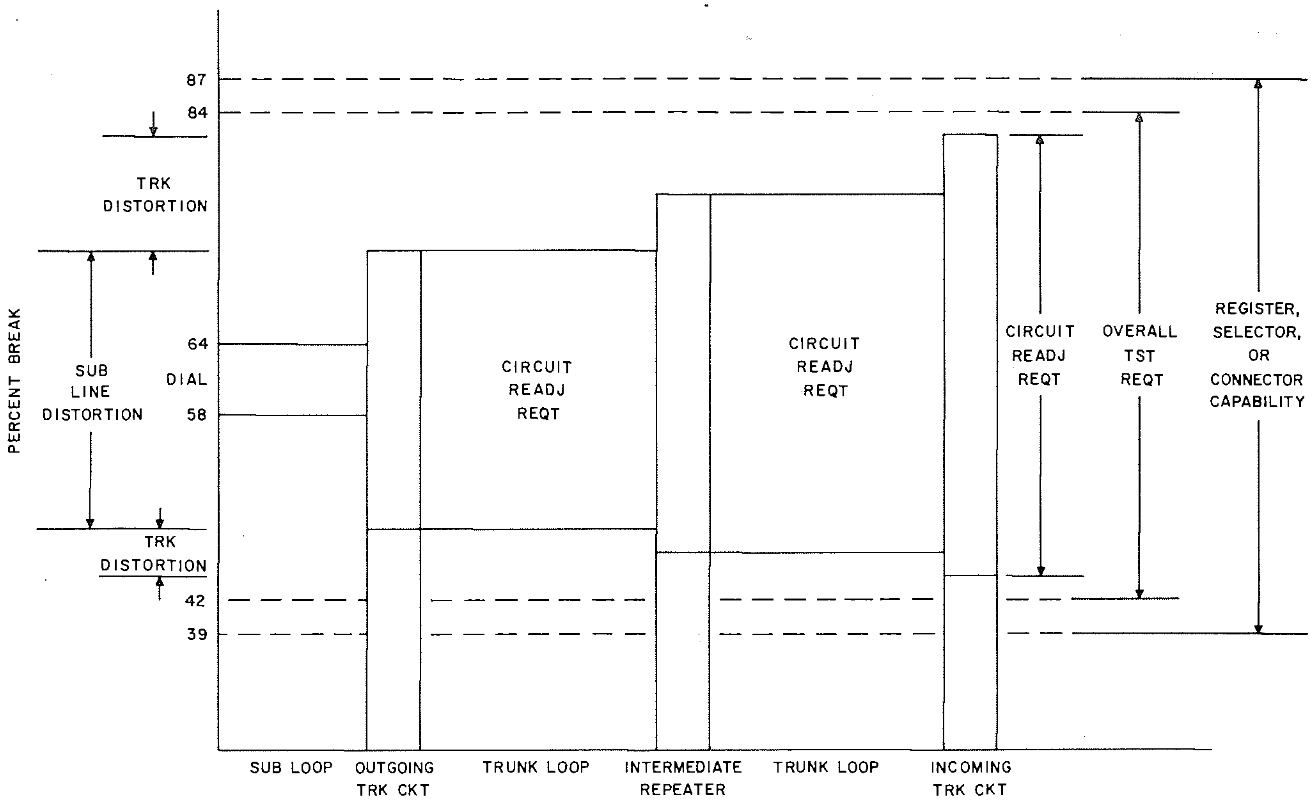
B. DIAL PULSING DEFINITIONS

Fig. 1—Dial Pulse Signaling

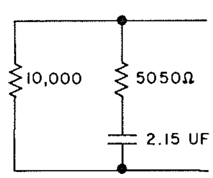
the signaling voltage. The effect is to decrease the break ratio measured at the relay contact.

2.43 In certain pulsing tests, series resistance is added to simulate, roughly, the effect of a long loop in increasing the break ratio. The test condition is then known as the LOOP condition and the amount of resistance is usually stated. Various standardized combinations of resistance and capacitance are often shunted across the test circuit to simulate the tendency of ringers, ringing bridges, and other apparatus and equipments to reduce the break ratio. The conditions are known as "LEAK" conditions and the combinations are designated LEAK A, LEAK B, LEAK SF, etc. Figure 2B shows the circuit of the LEAK A condition.

2.44 In a purely nonreactive dc circuit, the flow of current would correspond exactly to the changing state of the pulsing contact. In practice, however, circuits do have considerable inductance and capacitance, so that the flow of current in the relay winding does not correspond exactly to the instantaneous state of the pulsing contact. Furthermore, practical relays cannot exactly translate change of current in their windings into changes of state of their own contacts. The important thing, however, is the state of the contact upon which all subsequent activity in the circuit depends. This is why the terms and definitions in Fig. 1 are referred to states of the pulsing contact and not to current flow or any other feature of the circuit. In fact, the terms "break ratio" and "percent break" always imply the presence of a switch or relay contact at the point where the break ratio is specified. They have no meaning apart from such a contact.



A. DIAL-PULSE PERCENT-BREAK DISTORTION



B. LEAK A

Fig. 2—Circuit Requirements for LOOP Conditions

2.45 In most cases, the contact of the signaling circuit at which a break ratio is specified is accessible for the connection of a signaling test set. Where it is not accessible, a relay furnished as part of the test set is substituted in place of the regular relay just for the purpose of providing an accessible contact for testing. The relay is a specific type representative of relays generally used to terminate dial pulse signaling circuits. Pulsing test measurements and requirements are then identified with the test relay and not with the one in the signaling circuit for which it is substituted.

2.46 Modern customer dials are designed to a break ratio of 58 to 64 percent and operate under normal service conditions between 8 and 11 pulses per second during any portion of the rundown. Older dials were manufactured to somewhat wider tolerances and may be expected to vary in service from 7.5 to 12 PPS and from 59.5 to 67.5 percent BK. The difference between new and old dials is partly reflected in changes over the years in average loop lengths and estimated central office range capabilities.

2.47 Modern 10-PPS switchboard dials are held to a requirement of 10 ±0.3 PPS, 62 to 66 percent BK. Older 10-PPS switchboard dials, still in service, can vary over the range 10 ±0.5 PPS, 59.5 to 67.5 percent BK. Twenty PPS dials are provided on some switchboards for use over certain metallic trunks. The limit for modern dials is 17 to 21 PPS, 62 to 66 percent BK.

The objective output for modern senders is:

E&M Pulsing	10 ±0.5 PPS	58.0 ±2 percent BK
LOOP Pulsing	10 ±0.5 PPS	63.5 ±2 percent BK
Battery and Ground	10 ±1.0 PPS	58.0 ±4 percent BK

The majority of senders in service will outpulse within the following limits:

E&M	10 ±1 PPS	57.0 to 64.0 percent BK
LOOP	10 ±1 PPS	59.5 to 67.5 percent BK
Battery and Ground	10 ±1 PPS	48.5 to 66.0 percent BK

2.48 The nominal dial pulsing speed in the various signaling, trunk, and pulse repeater circuits used in direct distance dialing is 10 pulses per second. Percent break requirements for these circuits differ since the percent break may be shifted in passing through various circuits.

2.49 Signaling circuits are usually designed to shift the break ratio of received dial pulses, if necessary, to a value better suited to the requirements of the circuit to which they deliver those pulses. For example: a switchboard dial operates at 64 percent BK because the connected trunk circuit works best with this break ratio on its input loop; however, the CX interoffice signal transmission system (to which the trunk circuit is assumed to be connected) functions best with 58 percent BK on its M lead; therefore, the trunk circuit is designed to convert the loop pulsing it gets from the dial to M-lead pulsing for interoffice transmission and also to change 64 percent BK incoming to 58 percent BK outgoing. With 58 percent incoming on its M lead, the CX system operates best when it delivers 59 percent BK on its E lead at the other end.

2.50 At the receiving end of the CX system, the E lead is connected to a trunk circuit which, in turn, may be connected to an AB toll transmission selector. In this case, the A relay of the trunk circuit and its associated circuitry change the 59 percent BK received on the E lead to 62 percent BK which is optimum for the A relay in the selector for driving the vertical stepping mechanism. Further examples of the percent break of a signal and typical shifts in percent break are given in Table 1. These examples are illustrative only and are not meant to be all inclusive. For types not listed, other literature should be consulted.

2.51 In general, the various dial pulse receivers, such as step-by-step selectors and the senders or registers of other switching systems, must have capabilities broader than the requirements of the dial pulse generators and the transmitting and repeating devices to provide a margin for normal variations in break ratio and pulsing speed.

2.52 Figure 2 shows the limiting conditions on loop pulsing. The circuit diagram for this arrangement is shown in Fig. 1. The percent break limits for a dial are shown on the left. The distortion these pulses experience from the subscriber's line, the originating office, the intermediate office, and the terminating office are shown from left to right. The capability of selector or connector is shown on the far right. The diagram shows loop pulsing through three repetitions to drive a register, selector, or connector. However, when pulse distortion exceeds the capability of the registers, selector, or connector, pulse correction must be provided, usually at the terminating office.

The percent break ranges shown in Fig. 2 are for pulsing over a customer's loop of 1200 ohms and no LEAK in one test and pulsing with LEAK A and no LOOP in the other.

2.53 The 1200-ohm loop test is made with the highest dial percent break of 64 percent. This test will give the highest percent break because the current in the pulsing relay is at the lowest possible value during the make interval and zero during the break interval. The LEAK test is with zero loop and is made with the lowest dial break of 58 percent. This test will give the lowest percent break because the current through the pulsing relay is highest during the make interval and continues to flow at a decreasing rate during the break interval. The current in the break interval is

TABLE 1

TYPE OF TRUNK (BELL SYSTEM)	AVERAGE PERCENT 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 circuit to toll intermediate selector or intertoll transmission selector	59	59	0
Trunk circuit to AB train	59	62	+3
Trunk circuit to loop toll train	59	64	+5
Operator office trunk circuit — 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.

made up of two components. The first is the current that flows until the capacitance in the LEAK circuit is charged to the signaling voltage; the second is the current that flows through the dc leakage.

2.54 The LEAK test represents a test on a subscriber's line with zero loop resistance, maximum number of ringers, and maximum permissible leakage. The percent breaks shown in Fig. 2 are measured at the repeater or incoming trunk circuit on the contacts of the pulsing relay. If this relay is not accessible, another pulsing relay should be substituted for it. A 221A relay is used for this purpose in the Bell System. The tests are made at the highest dial pulsing speed encountered in practice because the higher the pulsing speed, the higher the distortion. (Refer to 2.45.)

INTERDIGITAL TIME

2.55 The interdigital time is the interval from the end of the last on-hook pulse of one digit train of dial pulses to the beginning of the first on-hook pulse of the next digit train. A slow release relay, which ignores the digit pulses but releases between pulse trains, is used to advance or condition the receiving equipment for the next digit. For customer dialing and operator keying or dialing, the interdigital time is under human control. See Fig. 1.

2.56 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. The requirements for the minimum interval are:

(1) Three hundred milliseconds when pulsing into senders or registers of crossbar or No. 1 ESS.

(2) Six hundred milliseconds was the recommended interdigital interval in the past for pulsing into step-by-step selectors or equivalent. The nominal time for all actions necessary, including a 10-step hunt of the selector, is 534 milliseconds. This is well within the 600 milliseconds. However, the maximum time for selector action is 695 milliseconds. Field evidence is available that shows the 600-millisecond interdigital time is causing occasional call failures. As a result, 700 milliseconds is the new recommended interdigital

interval. Six hundred milliseconds should only be used where no higher interdigital time is available.

Although senders and registers are capable of recognizing interdigital intervals as short as 300 milliseconds, Bell System senders do not in practice use interdigital intervals of less than 500 milliseconds when outpulsing. An accuracy of 5 percent is considered satisfactory for timing this interval.

2.57 In step-by-step offices, three functions must be completed during the interdigital interval as follows:

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

(2) Trunk hunt over as many as ten terminals.

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

2.58 A sender must receive a stop-dial signal 65 milliseconds before the termination of the interdigital interval to allow time for the sender to recognize the signal and stop outpulsing. Thus, to return a useful stop signal when the interdigital time is 600 milliseconds, the total time requirements itemized below, measured from the end of the last pulse of a digit pulse train, must not exceed 535 milliseconds:

(1) The delay due to transit time before an off-hook is seen at the source of the stop

(2) The reaction time required to generate a stop

(3) The delay due to transit time before the stop is seen at the originating end.

Improper adjustment of the digit pulse train detecting slow release relay in a step-by-step selector can, of course, reduce the time available for other interdigital functions.

FLASHING

2.59 Flashing signals were once transmitted between offices in the DDD network to flash supervisory lamps in the operator's cord circuit. Sixty flashes per minute indicated line busy and 120 flashes per minute indicated no circuit or reorder. With the advent of customer dialing of DDD calls, tone was added to the flash to provide both customer and operator with identifiable signals. However, where single-frequency signaling was used, the flash often removed all or part of the tone. In turn, the tone could distort or eliminate the flash in other cases. As a result, flash was eliminated from all but the maintenance uses for this signal. The 103 test line (Section 8) is one of the few remaining uses for flash signals. Every effort should be made to eliminate flashing signals between offices where they still exist. (See Section 4.)

REVERSE MAKE BUSY

2.60 Reverse make busy is a method of making an outgoing trunk busy from the terminating end. Outgoing trunks using E&M lead signaling and trunks using loop signaling are available with the reverse make-busy feature. In both signaling systems, an off-hook signal applied at the terminating end of the trunk makes the outgoing trunk circuit busy.

3. LOOP SIGNALING

3.01 The basic loop signaling circuit is a series circuit such as illustrated in Fig. 1A. It provides one signaling state when it is opened and a second when it is closed. The loop signaling apparatus is usually combined with other apparatus in a trunk circuit. A third signaling state is obtained by reversing the direction or changing the magnitude of the current in the circuit. Combinations of (1) open/close, (2) polarity reversal, and (3) high/low current are used for distinguishing signals intended for one direction of signaling (eg, dial pulse signals) from those intended for the opposite direction (eg, answering signals). The principal loop methods are described in the following paragraphs.

REVERSE BATTERY SIGNALING

3.02 Reverse battery signaling employs basic methods (1) and (2) above and 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. Figure 3 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 looped 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. The calling end receives signals transmitted by the called end by operation of the CS polar relay. 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 the wink-start dialing signal are in the on-hook condition when idle.

3.03 Figure 4 illustrates repeated reverse battery signaling at a tandem office. The slow release D relay is used to hold the connection through the tandem switches.

BATTERY AND GROUND SIGNALING

3.04 The range of loop signaling can be increased by employing battery and ground signaling. This is accomplished by having battery and ground at both ends of the loop but with opposite polarities at each end. This doubles the current available for signaling. 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 bridge supervisory relay may be substituted for the pulsing battery and ground to detect the backward signals. This widely used arrangement is sometimes called "battery and ground pulsing—loop supervision." When maximum range is required without the use of an incoming repeater, "battery and ground pulsing, battery and ground supervision" may be employed. Caution should be observed in using battery and ground signaling since, in some cases, it may result in impulse noise which can cause adverse effects on data service. Figure 5 shows a circuit using battery and ground pulsing with loop holding.

HIGH-LOW SIGNALING

3.05 At the calling end, a connect signal is provided by connecting battery and ground to the trunk through a marginal supervisory relay. At the called end, the on-hook (high resistance) signal is changed to low resistance for off-hook. A disconnect is indicated by an open trunk at the calling end. The basic high-low scheme, long used in straightforward local manual trunks from "A" to "B" boards, is shown in Fig. 6. The marginal cord circuit supervisory relay (C) has a noninductive winding, in addition to the operating winding, to reduce the unbalanced impedance in the voice path. This relay is adjusted to operate when the

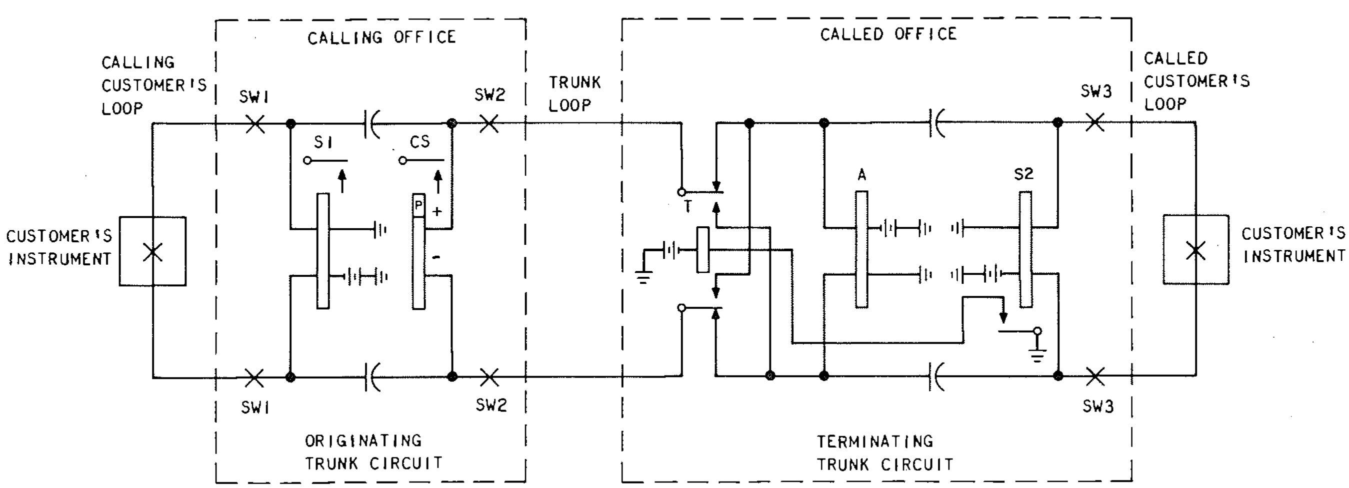


Fig. 3—Reverse Battery Signaling

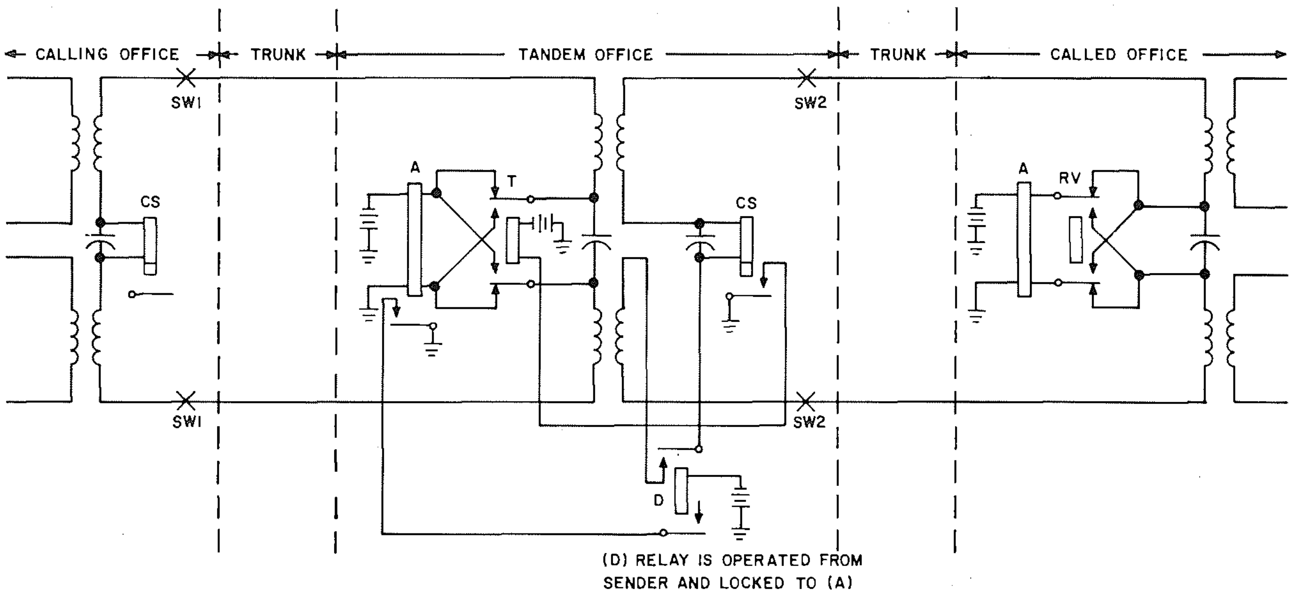


Fig. 4—Repeated Reverse Battery Signaling

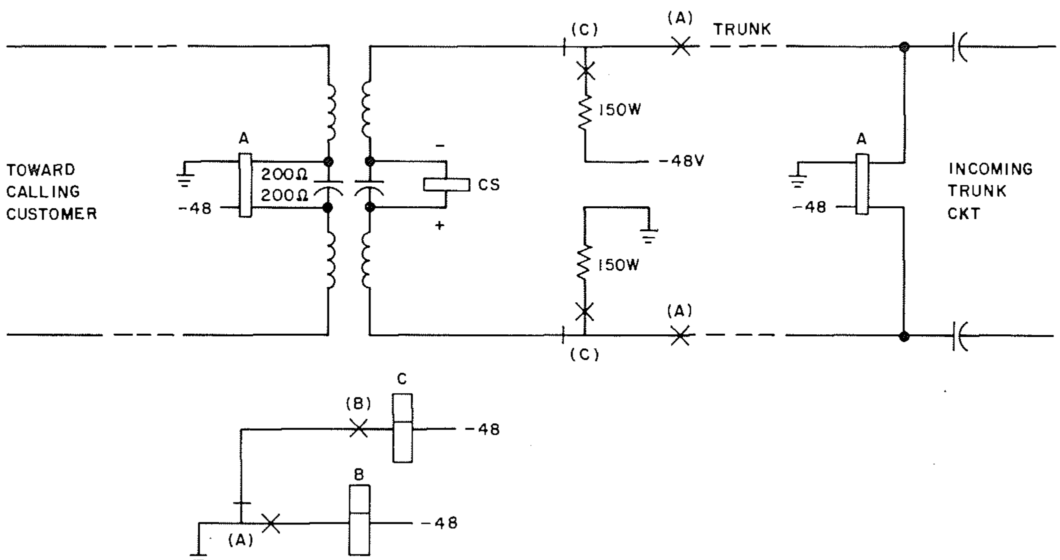


Fig. 5—Battery and Ground Pulsing With Loop Supervision

high-resistance winding of the (L) relay is shorted out by the (S) relay, even on a maximum resistance trunk. It is also adjusted not to operate and to release, if operated, on the current which results when the high-resistance winding of the (L) relay is not shorted, even on a minimum length trunk. Numerous auxiliary circuits and variations in relay types have been used to extend the range of conductor resistance over which signaling may be secured with adequate reliability.

3.06 By prior usage, high-low signaling means that high- and low-signaling states are applied at the terminating end as a signal to the originating end. In other arrangements, the high-low signaling states may be applied at the originating end with

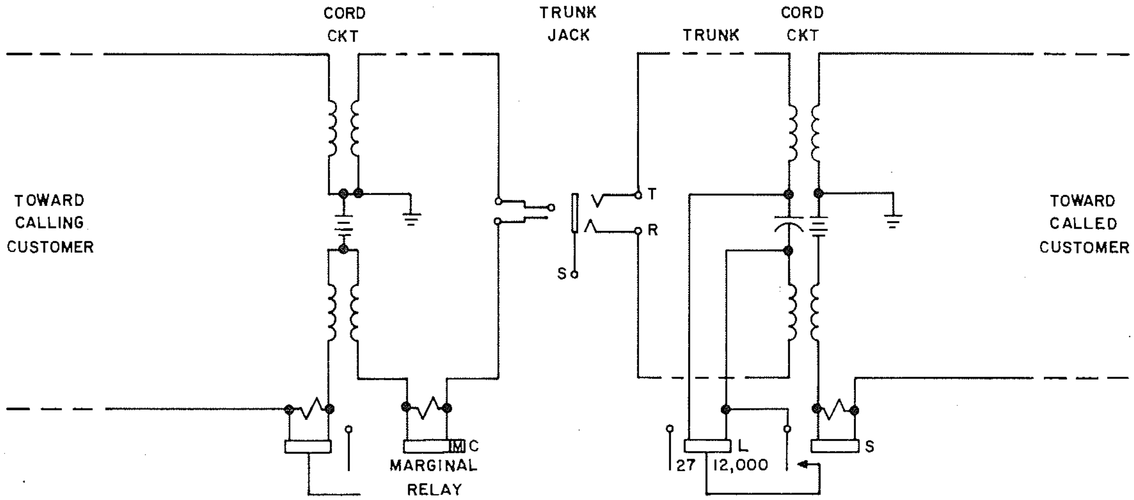


Fig. 6—High-Low Signaling

other signaling schemes such as reverse battery applied at the terminating end.

High-Low, Reverse-Battery

3.07 CAMA and TSPS trunks have the capability for being made busy from the terminating end. Figure 7 shows such a trunk originating in a SXS local office. These trunks are reverse-battery trunks as described in 3.02 but the outgoing trunk circuit uses a polar supervisory relay with low- and high-resistance windings (usually 200 and 30,000 ohms) to provide the on-hook, off-hook supervisory (but not the pulsing) conditions. When the trunk is idle, reversing the battery at the terminating end operates the polar supervisory relay via its 30,000-ohm winding to make the outgoing trunk busy. This feature is used for maintenance purposes. It is also used at the end of a charge call to make the outgoing trunk momentarily busy while the CAMA or TSPS office completes charging functions.

Reverse-Battery, High-Low

3.08 This signaling arrangement is used between a local office and an operator at a switchboard. As shown in Fig. 8, the operator office responds to reversed battery and the local office to high-low supervision. When the customer is connected, the (A) relay operates, reversing the battery; but the reversed battery is not applied to the trunk conductors until the (B) relay operates a fraction of a second later. At the switchboard end, the operator responds with an off-hook condition which operates the (S) relay reducing the trunk resistance and operating the marginal (TK) relay. The (TK) relay holds the (B) relay operated. The trunk is now held by "joint control" and both the operator and customer must go on-hook to release the trunk. In some documents, the reverse battery, high-low scheme is simply referred to as "reverse high-low."

3.09 The joint control feature allows the customer to recall the operator by flashing the switchhook without fear of a premature disconnect and, on a coin trunk, it allows the operator to ring back the customer at a coin telephone after he has hung up. (See 8.07.)

4. ADDITIONAL DC SIGNALING SYSTEMS

WET-DRY

4.01 A trunk is "wet" when battery and ground are connected to it. It is "dry" when battery and ground are removed. In the wet-dry signaling arrangement shown in Fig. 9, the trunk is wet during on-hook (idle) and dry during off-hook (busy). At the calling end, a connect signal is indicated by applying the (CS) relay to the trunk operating the (L) relay. Upon answer, the (S) relay operates applying the dry bridge to the trunk and releasing the (CS) relay. A disconnect is indicated by an open trunk.

4.02 By prior usage, wet-dry signaling means that the wet and dry states are applied at the terminating end as a signal to the originating

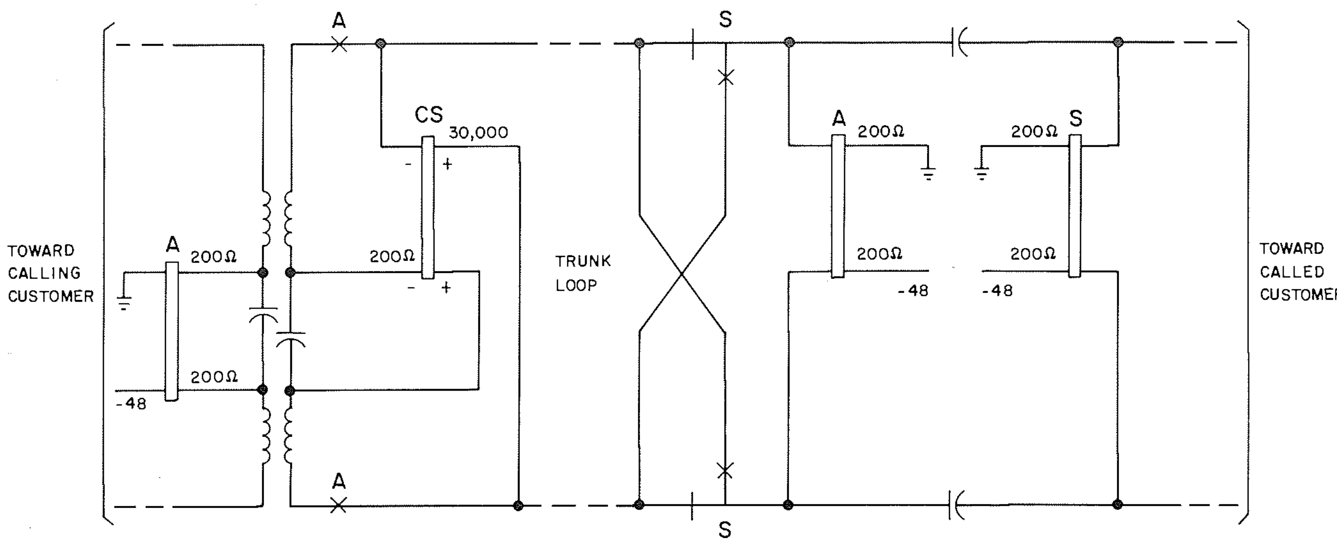


Fig. 7—High-Low, Reverse Battery Signaling

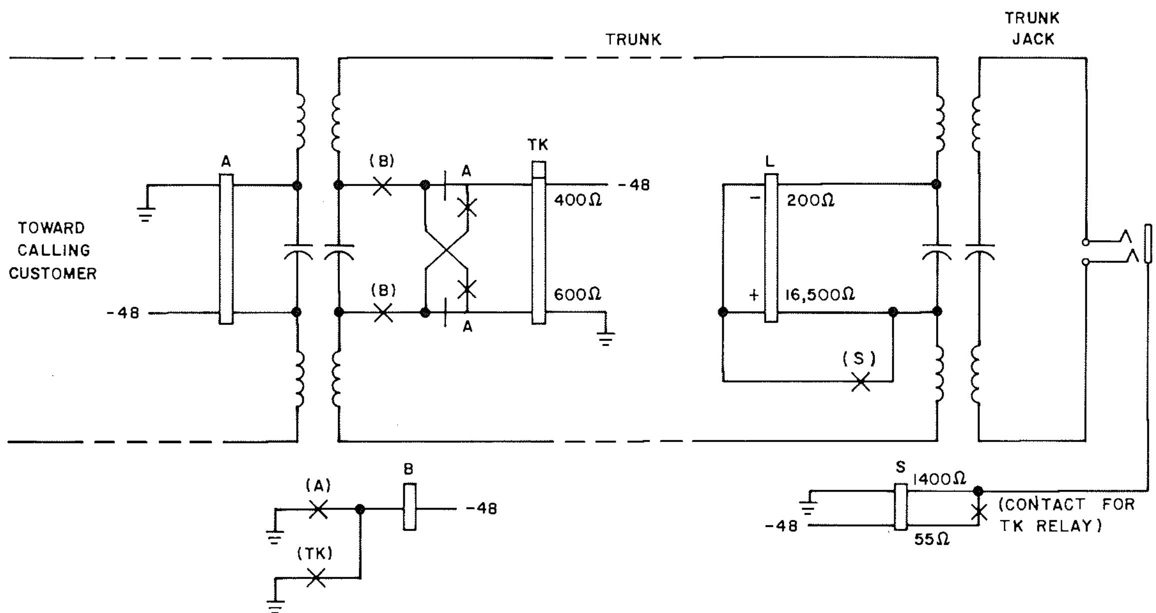


Fig. 8—Reverse Battery, High-Low Signaling

end. In many switchboard arrangements presently in use, the wet-dry signaling states are applied at the originating end and additional signaling states are achieved by adding other schemes such as high-low or reverse battery. (See Chart 3.)

E&M LEAD CONTROL

4.03 Most signaling systems, other than loop signaling, are separate from the trunk equipment and functionally are normally located

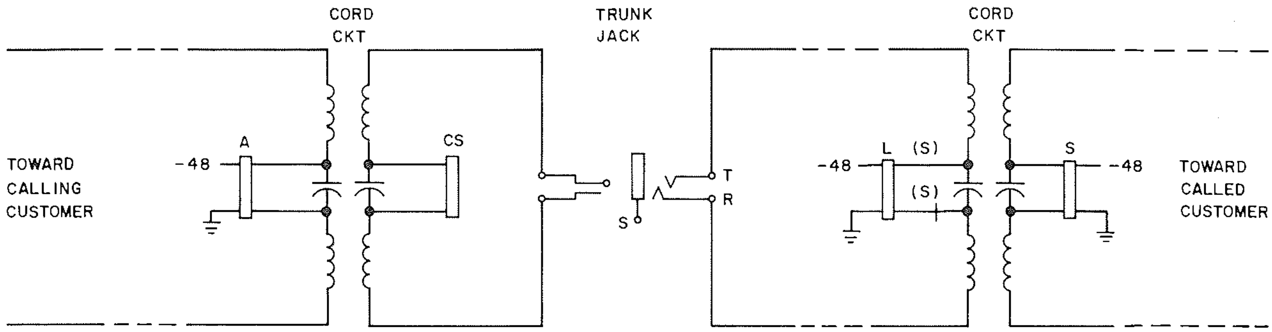


Fig. 9—Wet-Dry Signaling

between the trunk equipment and the line. The E&M lead signaling systems derive their name from certain historical designations of the signaling leads on the circuit drawings covering these systems. Historically, the E&M lead signaling interface consisted of two leads between the switching equipment and the signaling equipment for a trunk. One lead is called the M lead. This lead carries signals from the switching equipment. The second lead is called the E lead. This lead carries signals from signaling equipment to the switching equipment. As a result, signals from office A to office B leave on the M lead of the trunk circuit in office A and arrive on the E lead in office B. In the same manner, signals from office B leave on the M lead and arrive on the E lead of office A. The flow of signals between two offices using E&M lead signaling is shown in Fig. 10.

4.04 The historic E&M lead signaling circuit uses only one lead for each direction of transmission. This means the current that flows between switching and signaling equipment must return over a common ground path. It also means that the signaling leads have a greater noise influence than if the leads were balanced (two wire) as are transmission circuits. While the historic E&M lead signaling circuits operated satisfactorily in electromechanical systems, they were not satisfactory for electronic systems. As a result, two new E&M lead interfaces were designed for electronic switching systems. To differentiate between the three E&M interfaces, they are named Type I, Type II, and Type III. The Type I interface is the historic interface used in electromechanical systems. The Type II interface is a new interface designed for No. 4 ESS but may be used by other systems. The Type III interface was originally designed for No. 1 ESS. It is also used in No. 2 ESS and TSPS. It is expected that Type II interface would be used in preference to Type III interface where possible. As a memory aid to identify the interface type, it will help to remember that Type I interface has one lead, Type II interface has two leads, and Type III interface has three leads for the M lead function.

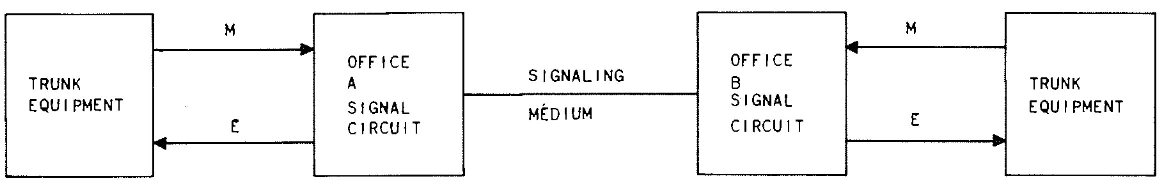


Fig. 10—E&M Lead Control Status

Type I Interface

4.05 The historic 2-wire E&M lead Type I interface is shown in Fig. 11. This is the preferred interface for electromechanical systems. Signaling from trunk circuit to signaling circuit is by means of battery and ground signals over the M lead. The off-hook signal is battery on the M lead while the on-hook signal is ground on the M lead. The battery shall be −48 volts and should be protected by a resistance lamp or fixed resistance.

4.06 Tradition requires the trunk circuit to supply the surge suppression which is usually 1000 ohms from M lead to ground. Signaling from the signaling circuit to the trunk circuit is by open and ground signals over the E lead. The off-hook signal is ground on the E lead and the on-hook signal is an open E lead. If the trunk circuit uses an inductive sensor on the E lead, the trunk circuit must provide appropriate surge suppression circuitry.

Type II Interface

4.07 The Type II E&M lead interface is shown in Fig. 12. It is the preferred arrangement of trunk circuits in electronic switching environments. However, not all No. 1 ESS, No. 2 ESS, or TSPS trunks can use this arrangement. It is a 4-wire, fully looped arrangement in which open and closure signals are used in each direction. Signaling from trunk circuit to signaling circuit is over the pair designated MA, MB (or M, SB). The signaling circuit must supply −48 volt resistance protected battery on the MB (or SB) lead and sense for the open and closure signals on the MA (or M) lead. If the sensor is an inductive device, it must be equipped with appropriate surge suppression circuitry.

4.08 Signaling from the signaling circuit to the trunk circuit is by means of open and closures on the EA, EB (or E, SB) pair of leads. Ground

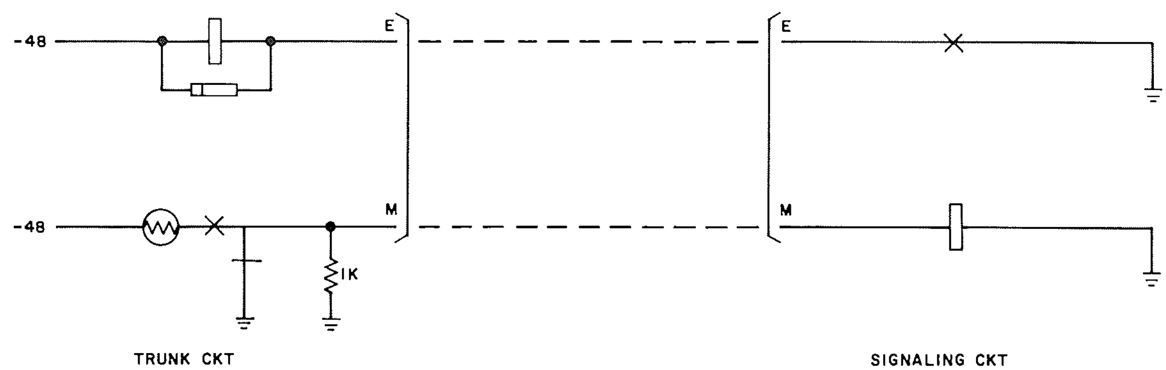


Fig. 11—Type I Interface

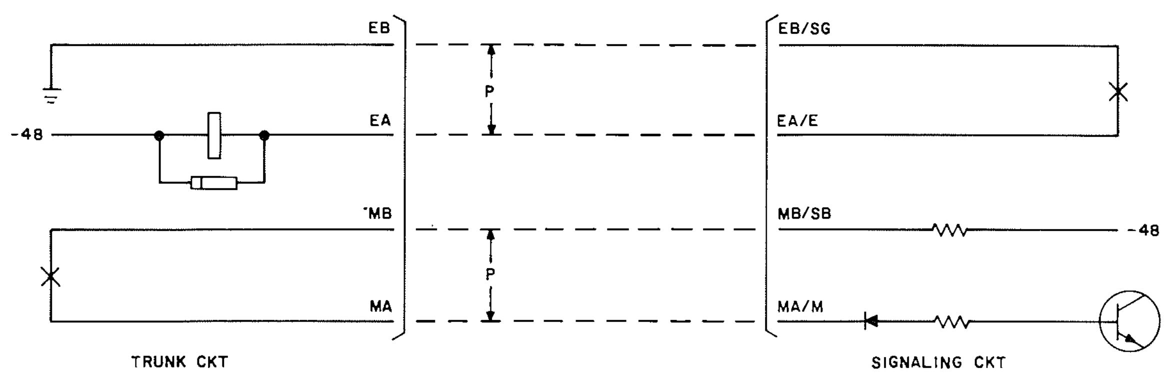


Fig. 12—Type II Interface

must be supplied to the EB (or SG) lead and a sensing device applied to the EA (or E) lead. If the sensor is an inductive device, it must be equipped with appropriate surge suppression circuitry. On-hook signals are opens in either direction and off-hook signals are closures in either direction.

4.09 The Type II interface has the advantage that trunk circuits can be directly connected together without interposing converter circuits or signaling circuits as shown in Fig. 13 and Fig. 14. Neither the Type I nor Type III interface offers this advantage.

Type III Interface

4.10 The Type III E&M lead interface is shown in Fig. 15. It is a compromise partially looped 4-wire interface for use in electronic switching environments when the fully looped Type II interface cannot be provided. The loop portion, using three leads designated SB, M, and SG, is for signaling from the trunk circuit to the signaling circuit. The signaling is over the M lead in exactly the same manner as described for Type I interface except that the trunk circuit obtains the signaling battery and ground from the signaling circuit over leads SB and SG, respectively. The trunk circuit must supply surge suppression which is usually 1000 ohms connected between the M lead and the SB lead. If the trunk circuit uses an inductive sensor on the E lead, the trunk circuit must provide appropriate surge suppression circuitry.

4.11 The signaling equipment determines the M lead range while the trunk circuit determines the E lead range. The objective range for E&M leads in new Type I or Type III interfaces is 100 ohms. The older circuits have ranges as low as 25 ohms. The objective range for E&M leads in

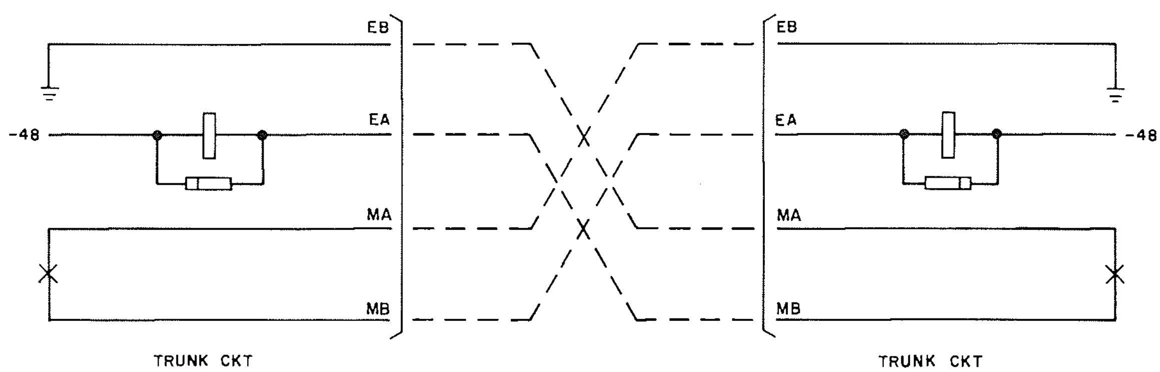


Fig. 13—Back-to-Back Trunk Circuit Connection

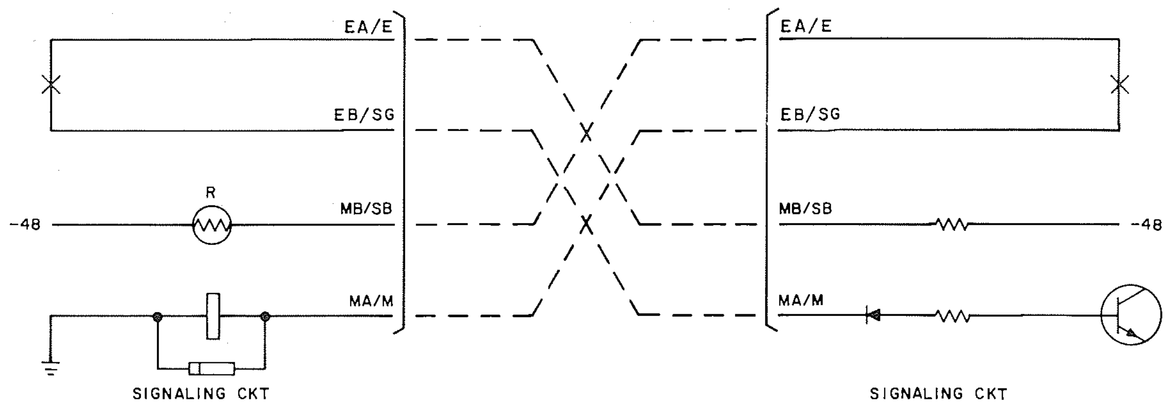


Fig. 14—Back-to-Back Signaling Circuit Connection

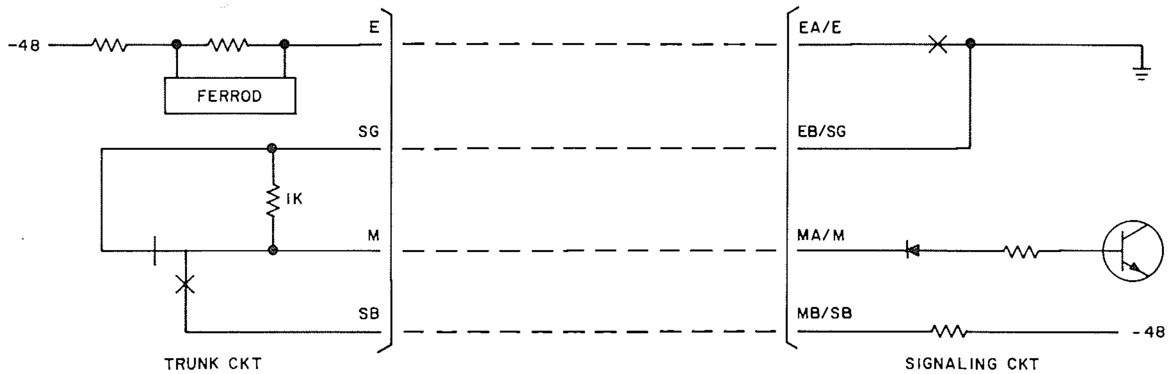


Fig. 15—Type III Interface

Type III interfaces is 300 ohms loop (150 ohms one way).

4.12 Note that the operation of these systems is "full duplex"; that is, signals can be sent simultaneously in both directions without mutual interference. ("Half duplex" means that signals can be sent equally well in both directions but in only one direction at a time.) Compatible signaling circuits must be used at both ends of a signaling section. There are dc types of systems which employ E&M lead signaling, such as duplex (DX) and composite (CX), as described in this part. Part 5 describes the ac signaling systems which use E&M lead control.

PULSE LINKS AND CONVERTERS

4.13 A trunk may be made up of two or more signaling sections connected in tandem using the same or different types of signaling systems. If two adjacent sections have E&M signaling arrangements, an auxiliary pulse link is usually provided to repeat the signals. If the signaling arrangements of the two sections are different, converters are provided. For example, if a trunk circuit employing loop signaling is connected to a trunk facility using signaling with E&M lead control, a converter is used to convert loop signaling to E&M signaling and vice versa.

4.14 Because of the time delay inherent in single-frequency (SF) signaling, two signaling sections of SF signaling should not be used in applications where delay is important such as delay-dialing or stop-go operation. See 2.22 and 2.32 and the following.

COMPOSITE (CX) AND DUPLEX (DX) SIGNALING

4.15 Composite as well as duplex signaling arrangements were developed to provide means for direct current signaling and dial pulsing beyond the range of loop signaling methods. Duplex (DX) and CX signaling arrangements are duplex in operation; that is, they provide simultaneous 2-way signaling paths. The circuit techniques of DX and CX are fundamentally those used in full duplex telegraph and teletypewriter operation. A sensitive polar relay at each end of the line receives signals from the distant end. Balancing networks are provided and must be adjusted for each circuit according to the impedance of the line conductors.

4.16 Composite (CX) signaling employs a single line conductor with ground return for each signaling channel. A balanced polar relay is used at each end of the signaling section as shown in Fig. 16 in a symmetrical arrangement which permits full duplex operation. Higher frequency voice currents are separated from the low-frequency signaling currents by a filter arrangement called a CX or "composite" set. The crossover frequency is about 100 Hz. Two CX signaling legs can be derived from a pair of wires and four from a phantom group. These four legs can be used to signal independently with a ground return but, in most cases, one leg is used as an ac and dc earth potential compensation path. The signaling channels can be assigned independently of the voice channels with which they are physically associated because of the isolation provided by the CX sets.

4.17 Three types of CX sets are used in the Bell System and they are coded as follows:

(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 it cannot be used for intertoll trunks. 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.

4.18 A number of CX signaling equipment units are available and are usually classified as either short haul or long haul with the following broad applications:

(1) Short Haul—Maximum of 4800 ohms loop resistance on cable circuits or 90 to 100 miles of open wire.

(2) Long Haul—Maximum of 12,000 ohms loop resistance. Such circuits usually include one intervening voice repeater around which the signals are bypassed.

4.19 Earth potential compensation is essential to proper performance where earth potential conditions indicate its use. On all intertoll trunks, ac and dc earth potential compensation should be used. On toll-connecting trunks, its use is optional. Depending on the signaling equipment design, 1-1/2 to 4-1/2 volts difference in earth potential usually requires compensation. Under some conditions, filters may be required to overcome the effect of induced longitudinal alternating current voltages.

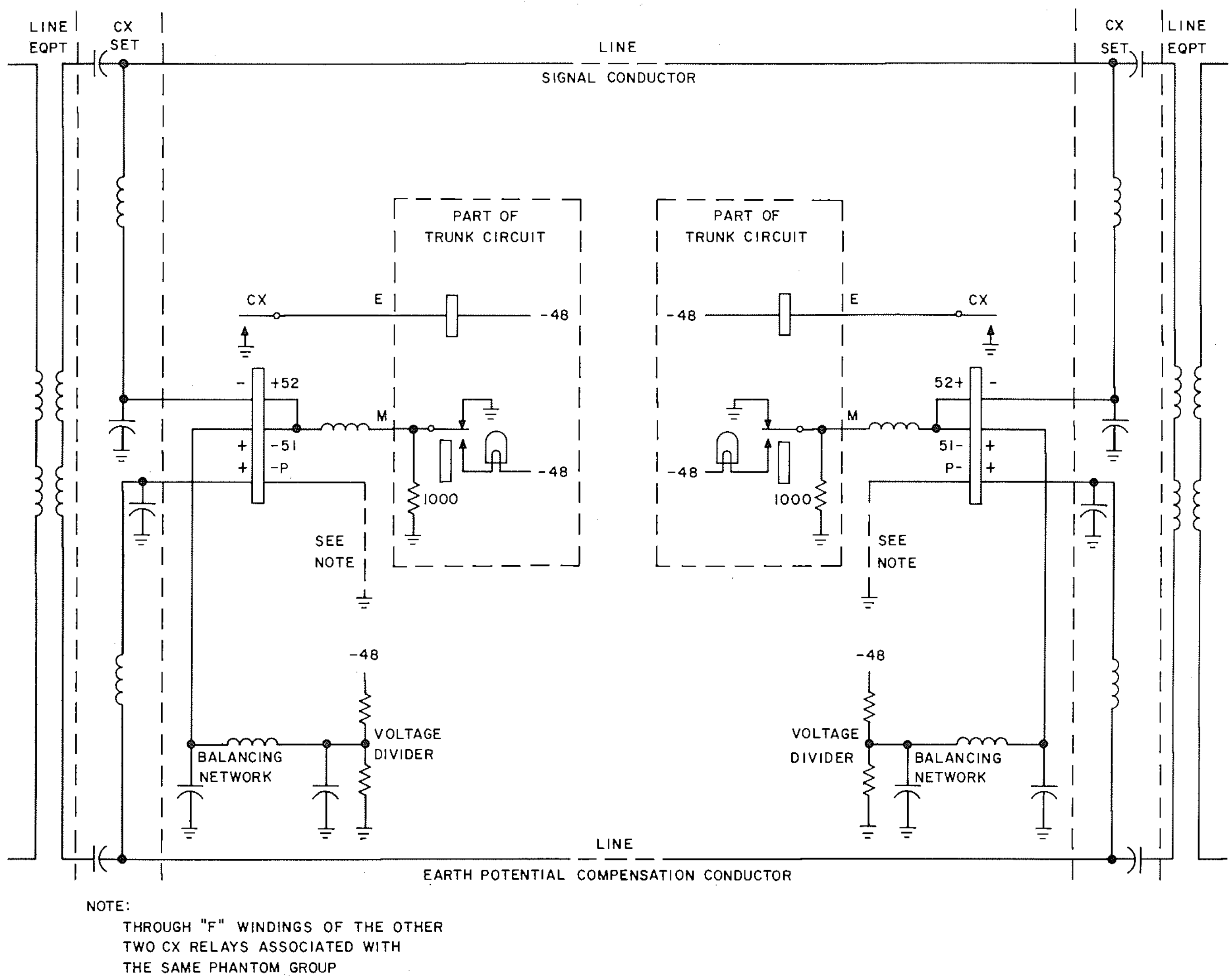


Fig. 16—Composite Signaling for One Voice Channel

4.20 Dial pulsing on CX signaling circuits is normally at a rate of 10 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 percent break at this speed, are as follows:

	PERCENT BREAK		PULSING SPEED
	INPUT M LEAD	OUTPUT E LEAD	(PPS)
Adjust	58	59	12
Test	58	57-61	12
Expected Performance	58	55-63	12

Note: 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.

4.21 Under normal service conditions, the input to CX signaling equipment should be limited to the range of 47 to 67 percent break or a narrower range under unfavorable conditions. When testing at 12 pulses per second, the output limits of the contact that pulses the (A) relay of a step-by-step selector in the same office are 44 to 72 percent break.

4.22 Dial signaling without intermediate senders or registers is not expected to be transmitted through more than four signaling links connected in tandem. This limitation applies to all types of trunk signaling. An example of this would be an N1 carrier channel, a T1 carrier channel, a DX section, and a CX section in tandem.

4.23 The CX signaling circuits have been designed on the basis of total minimum insulation requirements of 160,000 ohms per mile per conductor for open-wire circuits less than 25 miles long and 200,000 ohms per mile per conductor for circuits over 25 miles. The requirements are based upon both the minimum insulation between conductors and a conductor to ground. These values also apply to circuits operating over combinations of cable and open wire. For cable circuits, the total minimum insulation resistance requirement for conductors is generally 60,000 ohms. At an intermediate voice repeater, such as one of the V type, either two sets of CX equipment and an auxiliary pulse link may be provided or bypass equipment must be used to provide a signaling path around the repeater.

4.24 DX signaling is based upon a balanced and symmetrical circuit that is identical at both ends. It is patterned after CX signaling but DX does not require a composite set. Figure 17 shows a trunk embodying the DX signaling features.

4.25 A DX signaling circuit uses the same conductors as the talking path and does not require a composite set or filter to separate the signaling frequencies from the voice transmission. One conductor in the DX system carries the supervisory and pulsing signals. Both conductors individually carry currents resulting from differences in terminal ground potentials and battery supply voltages so that current in the second conductor can cancel the effect of this unwanted current in the first conductor. This arrangement allows for self-compensation against differences in ground potential and partial compensation for battery supply variations. It is also balanced against ac induction.

4.26 The DX signaling system may be used on both 10- and 20-PPS dial pulsing trunks. With proper balancing network adjustment, DX signaling circuits will repeat 12 pulses per second of 58 percent break with a distortion not exceeding plus or minus 4 percent break. This performance is better than most loop signaling arrangements and is equal to that of CX signaling. DX signaling is often used instead of loop signaling on longer local and tandem trunks and instead of CX or SX on short intertoll trunks. It can be used through E-type (negative impedance) repeaters. If V-type repeaters are used, bypass equipment is required.

4.27 A single DX signaling section is limited to a maximum loop resistance of 5000 ohms. Although the signaling range of DX is less than that of CX or SX, the signal distortion is so small that two DX circuits can be used in tandem for one trunk. As presently designed, Bell System DX circuits are restricted to 2- or 4-wire line facilities composed of cable pairs equipped at both ends with repeating coils and having a minimum insulation resistance of 100,000 ohms.

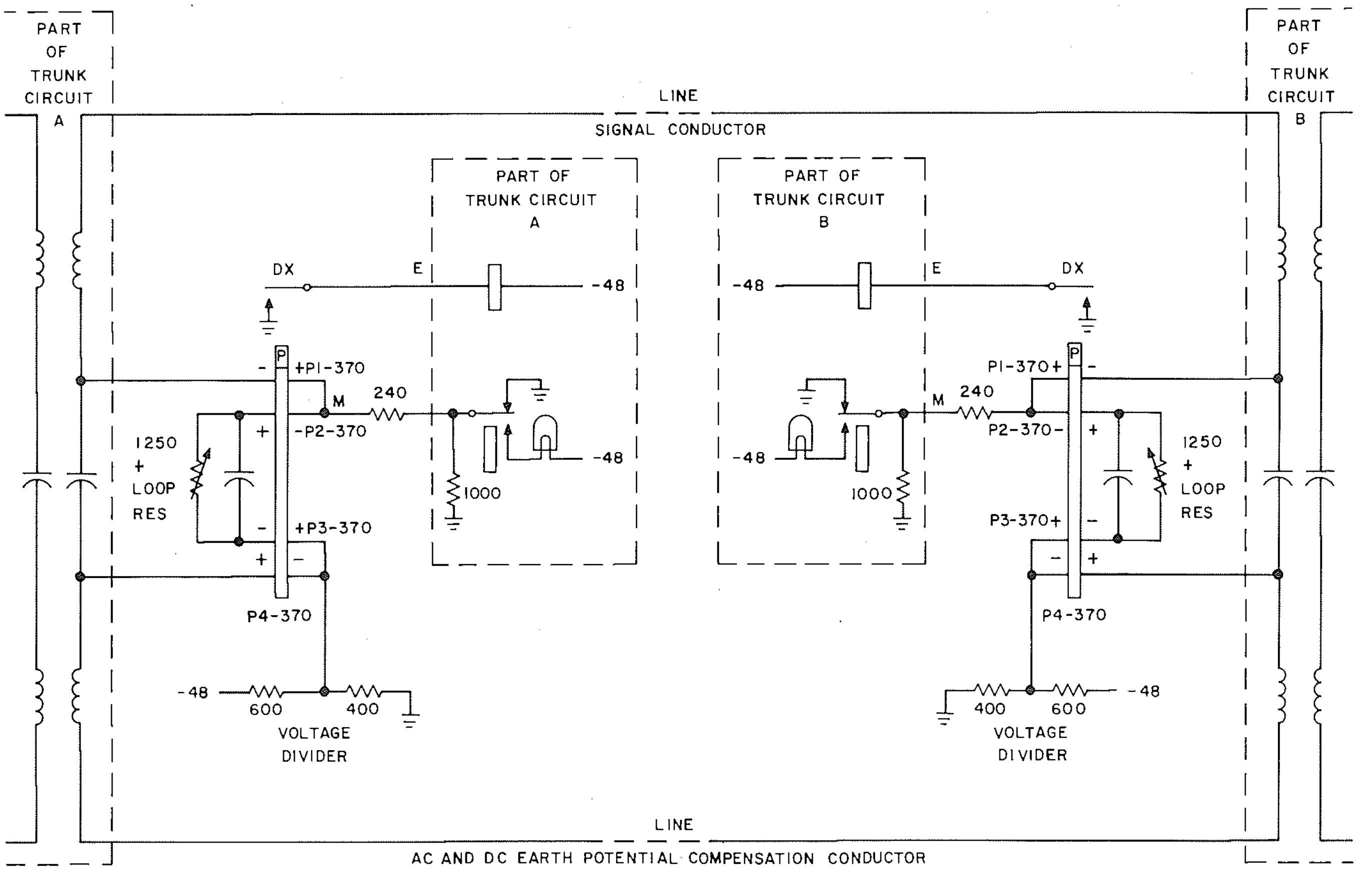


Fig. 17—DX Signaling Circuit

4.28 Sometimes is is necessary to extend signaling circuit E&M leads beyond their normal limitations. For this purpose, signal lead extension circuits are used to secure adequate range. In effect, this circuit consists of a DX signaling circuit with an additional relay. This circuit, often designated DX2, converts signals from signaling circuit E-lead conditions to signaling circuit M-lead conditions.

SIMPLEX (SX) SIGNALING

4.29 Simplex (SX) signaling requires the use of two conductors for a single channel. A center tapped coil or its equivalent is used at both ends of the pair for this purpose. The arrangement may be a one-way signaling scheme suitable for intraoffice use or the simplex legs may be connected to full duplex signaling circuits which function like the CX signaling circuits with E&M lead control.

4.30 Earth potential compensation requires the use of one conductor of an additional pair for each five signal channels. Thus, only five SX signaling circuits are derived from six physical pairs. The signaling currents in the line side induce no voltage in the equipment since they flow in opposite directions in the two halves of the repeat coil winding and, conversely, voice currents in the equipment cause no current flow in the simplex leg. Simplex signaling has been largely superseded for new work by the DX signaling system previously described.

5. AC SIGNALING SYSTEMS

5.01 Alternating current signaling systems have been designed to convey the basic trunk supervision and numerical signaling functions required by switching systems. They are used over distance dialing trunks where dc signaling is not feasible or economical such as long-haul circuits and short-haul circuits equipped with carrier. Two-state ac signaling can handle trunk supervision and numerical signaling where the latter is coded by dial pulsing. Three-state ac signaling has been designed to handle revertive pulsing trunks. Multistate ac signaling, in the form of multifrequency pulses, is used for numerical signaling only and must be coordinated with 2-state signaling systems, either ac or dc for supervision.

5.02 Signaling systems using both inband and out-of-band signaling frequencies are in use. Inband systems could use frequencies in the voiceband from about 500 Hz to about 2600 Hz and signaling equipment is required only at the terminals of a transmission path. In the Bell System, only the upper portion of this range is used. Inband signals are usually of the same order of amplitude as voice currents so as not to overload voice amplifiers or cause crosstalk in adjacent channels.

5.03 Out-of-band signaling systems are those which use signals outside the band customarily used for speech transmission on telephone channels. In a sense, this includes dc methods of transmission as discussed previously in this section but more usually it is taken to include ac systems such as the type referred to in 5.36 through 5.40. It can also be construed to include Common Channel Interoffice Signaling (CCIS).

5.04 One of the chief problems with inband signaling is the prevention of the mutual interference between voice and signals. Voice-frequency signals are audible and, consequently, signaling should not take place during the time the channel is used for conversation. Signal receiving equipment, however, must remain on the channel during conversation to be ready to respond to incoming signals and it may thus be subject to false operation from voice sounds which resemble the tones used for signaling. Protection against voice interference can be accomplished a number of ways.

(1) Signal tones of a character not likely to occur in normal speech may be used.

(2) Time delay may be used to prevent false operation due to voice frequencies.

(3) Voice-frequency energy, other than the signaling frequency, may be detected and used to prevent the operation of the signaling receiver.

SINGLE-FREQUENCY SIGNALING

5.05 Single-frequency (SF) signaling systems are designed to pass the necessary signals for telephone trunks over voice-frequency transmission line facilities without impairing the normal use of these facilities for speech. These systems deliver and accept dc signals to and from the switching trunk equipment in the form of loop or E&M lead controls. The dc signals are transformed to ac on the line side and vice versa.

5.06 In modern SF signaling, the same voice frequency, 2600 Hz, is employed for signaling on the transmission facility in both directions. Consequently, SF signaling may be applied to any voice grade channel of any length and makeup provided that it is 4-wire from end to end.

5.07 Former SF signaling units, designed only for E&M dc signaling circuits, were able to use 1600, 2000, and 2400 Hz for line signaling as well as 2600 Hz. In some instances, they were arranged to operate at one line frequency in one direction and at another frequency in the other direction and could, therefore, be used on 2-wire line facilities as well as 4-wire facilities. However, long-haul metallic facilities are being rapidly replaced by improved multiplex systems which provide 4-wire equivalent voice grade channels and improved dc signaling circuits make DX systems economically attractive for the remaining metallic facilities which cannot be adequately served by loop signaling circuits. The need for SF signaling on 2-wire facilities no longer exists, therefore, and SF units for 2-wire facilities have been discontinued.

5.08 The original and some subsequent designs of SF signaling circuits employed electron tubes. Current designs, however, use transistors and other solid-state devices exclusively. The on-hook and off-hook conditions for all Bell System types of 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

5.09 Since the single-frequency (SF) system uses voice-frequency signals on the 4-wire voice path, the characteristics of SF signaling are quite different from those of dc signaling systems. The major differences are as follows:

(1) SF systems have longer delay in signaling time as compared to the dc signaling systems.

(2) SF systems have smaller signaling speed and percent break range than the dc systems.

(3) SF signaling system interrupts the voice path at various times.

(4) Continuous tones can cause the signaling system to malfunction.

E-TYPE SIGNALING

5.10 The simplified schematic, Fig. 18, illustrates the major features of the E-type transistorized 2600-Hz SF system. The keyer relay, M, is operated and released by signals on the M lead and alternately removes or applies 2600 Hz to the transmit line of the facility. The M relay operates the high-level relay HL to remove the 12-dB pad in order to permit a high-level initial signal to secure an improved "signal-to-noise" operating environment. The HL relay is slow to release and, hence, dial pulses, which operate the M relay, are transmitted at an augmented level. In addition, a cutoff relay, CO, operates to block any noise which may be present from the office side of the circuit.

5.11 The Bell System SF signaling units will accept and transmit dial pulses at speeds from 8 to 12 pulses per second with from 56 to 69 percent break. If the range of percent break presented to the M lead is outside these limits, means must be provided to bring it within. In general, this is done with an M-lead pulse corrector but, in some cases, other means can be used such as correcting problems in plant where the pulses originate. Limitations in percent break for loop-type SF signaling units are usually overcome by the use of units incorporating a built-in transmitting pulse corrector.

5.12 The receiving portions of the SF unit include a voice amplifier, appropriate band elimination networks, and a signal detection circuit. The voice amplifier's primary function is to block any noise or speech present in the office equipment from interfering with the operation of the signal detector and also to make up for the insertion loss of the SF unit in the receive speech path. The signal detector circuit includes an amplifier-limiter, a signal-guard network, appropriate rectifiers, a dc amplifier, and a pulse-correcting circuit, the output of which operates a relay to repeat signals to the E lead of the trunk relay equipment.

5.13 The receiver sensitivity is −29 dBm at the zero transmission level point for 4-wire line facilities. The signal-guard network provides the necessary frequency discrimination to separate signal and other-than-signal (guard) voltages. By combining the voltage outputs of the signal and guard detectors in opposing polarity, protection against false operation from speech and noise is secured. The guard feature efficiency is changed between the dialing and talking condition to secure optimum overall operation.

5.14 An incoming signal is separated into signal and guard components by the signal and guard detectors. The width of the band of the signal component is approximately 100 Hz, centering on 2600 Hz. The guard component is made up of all other frequencies in the voiceband. These components produce opposing voltages with a resultant net voltage in the signal detector. In the talking condition (tone off in both directions), the guard detector sensitivity is such that almost a pure 2600-Hz tone is required to operate the receiver since other-than-signal frequencies will produce a voltage opposing its operation. The guard principle is an important feature in avoiding signaling imitation by speech. It is, however, insufficient by itself to assure that a speech-simulated signal will not cause false operation of the receiver.

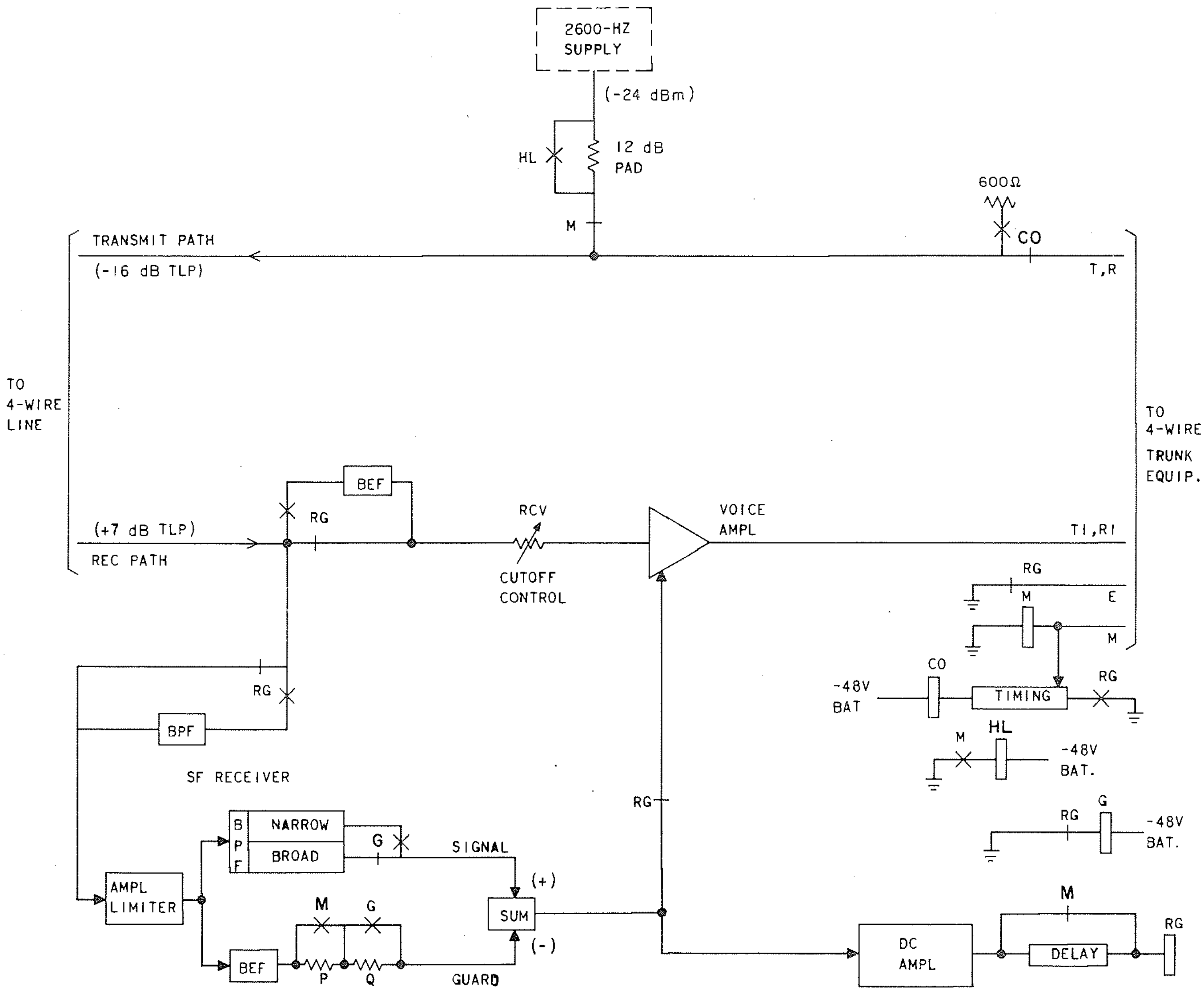


Fig. 18—Simplified Diagram of the E-Type 2600-Hz SF Signaling System Connection to a 4-Wire Transmission Channel

An additional electronic time delay is, therefore, provided so that, during the dialing condition, the receiver will just operate the RG relay on a tone pulse of 35 milliseconds. When the RG relay operates, it causes a slow relay (G) to release, greatly decreasing the sensitivity of the guard channel and making the signaling channel responsive to a wider band of frequencies.

5.15 On calls for which no charges are made (where the called end does not return an off-hook signal), such as business office, repair, or service calls, the tone in the backward direction is not removed but a band elimination filter prevents the tone from reaching the calling customer. On transmission systems equipped with compandors, the presence of the backward-going tone may reduce the compandor crosstalk and noise advantage. A somewhat similar increase in noise may occur in digital carrier systems though for other reasons. An important reason for removing the frequency selectivity along with guard sensitivity is the necessity for talking to intercept operators or hearing recorded announcements under tone-on conditions. In addition, the band elimination filter, which is inserted under any on-hook condition, prevents the tone from interfering with voice transmission.

F-TYPE SIGNALING

5.16 E-type SF signaling circuits are being discontinued and F-type signaling circuits are now being used for new installations. The basic principles of operation of F units are the same as those of E units. The differences are primarily in the packaging of the components and the sophistication of the electronic design. In the F family of SF signaling units, there are two single-module units for E&M applications only, one (FWB) for use with MF signaling trunks and the other (FWA) for dial pulse as well as MF signaling trunks.

5.17 There are many varieties of 2-module units. In the 2-module units, the FUA module makes the basic conversion between the 2600-Hz line signal and the dc signal to be used, after appropriate modification, by the central office circuits. The FUA is required in all signaling applications. Associated with the FUA is always an auxiliary module which converts between the dc signal furnished by the FUA and the dc signal required by the connected circuit. The auxiliary module also provides conversion of the speech path between the 4-wire circuit of the FUA and the 2- or 4-wire speech path of the connected circuit equalization for 4-wire metallic facility extension, impedance matching, and other transmission functions.

5.18 The F signaling circuits have signaling, transmission, and stability characteristics similar but superior to those of E signaling circuits. A simplified diagram of an FUA with an FBB auxiliary is shown in Fig. 19 and 20.

SIGNALING DELAY

5.19 The signaling delay through an SF system consists of the delay from the change of state of the dc input to application or removal of signaling tone, the transit time of the transmission facility, and the response time of the distant unit to presence or absence of tone.

5.20 With F-type E&M units, for senderized dial pulsing (ie, without built-in pulse correction) or for MF pulsing only, the delay from on-hook to off-hook is 14 to 20 milliseconds from the time the M lead is changed from ground battery until signaling tone is removed plus the transit time of the facility plus 39 to 61 milliseconds for recognition of tone removal and grounding the E lead (a total of 53 to 81 milliseconds plus transit time).

5.21 With F-type E&M lead units without built-in pulse correction that are suitable for senderized dial pulsing, the delay from off-hook to on-hook is 14 to 20 milliseconds from the time the M lead is changed from battery to ground until tone is transmitted plus the transit time of the facility plus 31 to 35 milliseconds for recognition of tone presence and removal of ground from the E lead (a total of 45 to 55 milliseconds plus transit time).

5.22 With F-type E&M lead units suitable for only MF pulsing, the delay from the off-hook to on-hook is also 14 to 20 milliseconds from the time the M lead is changed from battery to ground until tone is transmitted plus the transit time of the facility plus 48 to 52 milliseconds for recognition of tone presence and removal of ground from the E lead (a total delay of 62 to 72 milliseconds plus transit time).

5.23 When loop signaling, pulse correction, or other auxiliary features are added, the overall transit time for signals becomes longer. For the F signaling units other than those discussed here, the delay from on-hook to off-hook is 13 to 35 milliseconds from the time the dc state is changed until signaling tone is removed plus the transit time of the facility plus 40 to 65 milliseconds recognition of tone removal and changing dc state (a total of 53 to 100 milliseconds plus transit time).

5.24 For the F signaling units other than those in 5.23 and 5.24, the delay from off-hook to on-hook is 13 to 35 milliseconds from the time the dc state is changed until tone is transmitted plus the transit time of the facility plus 30 to 110 milliseconds for recognition of tone presence and changing the dc state (a total of 43 to 145 milliseconds plus transit time).

5.25 Chart 7 gives typical response time for the F-type E&M unit suitable for sender dial pulsing. Chart 8 shows the typical transmission characteristics of the F-type 4-wire E&M unit. The signaling delay and response times for the E-type SF units are not exactly the same but comparable to the times for the F-type units. Signaling speed is limited to a maximum of 12 pulses per second for SF signaling.

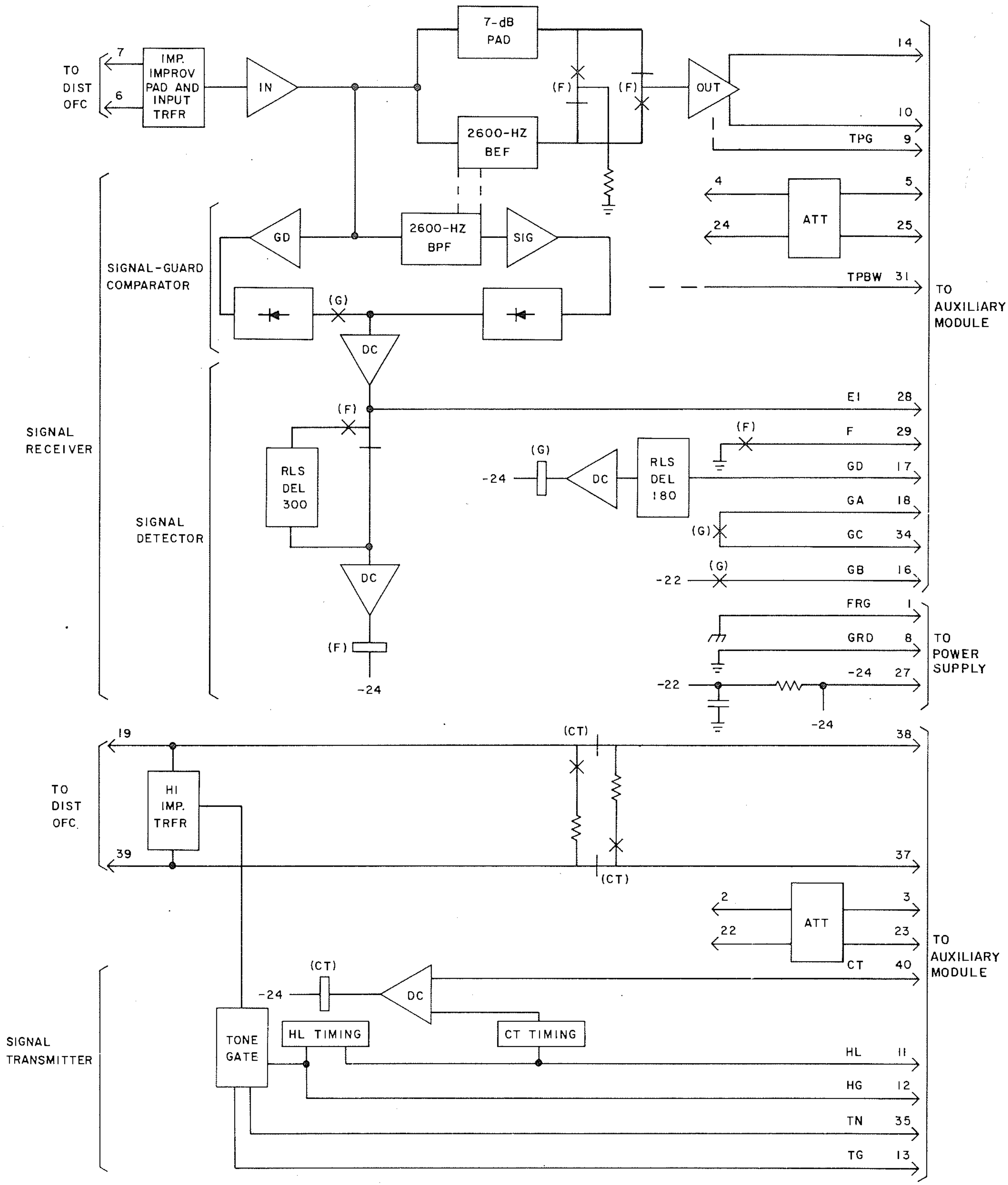


Fig. 19—FUA Signaling Converter

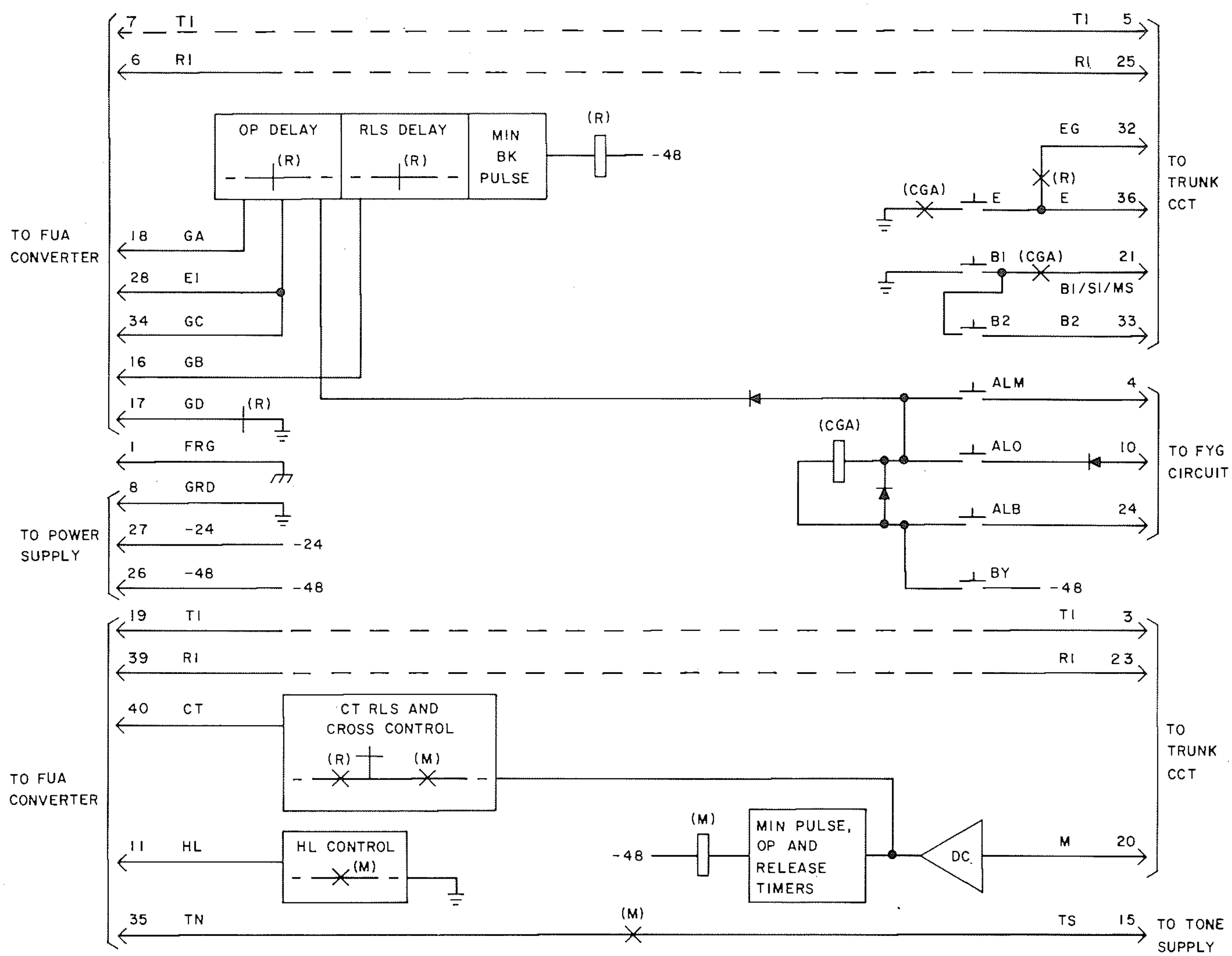


Fig. 20—FBB Signaling Auxiliary Module

5.26 When using SF signaling without pulse correction in the transmitting unit or in the transmitting M lead, the percent break range is limited to sender outpulsing. In addition, because of the pulse-shaping methods in the sender, most loop dial pulsing units also require built-in pulse correction.

5.27 The pulse correction used with SF units lengthens the short pulses and insures a minimum interpulse interval. A typical pulse corrector lengthens any pulse over 17 milliseconds to an output of at least 46 milliseconds. In addition, the pulse corrector guarantees an interpulse output interval of at least 23 milliseconds between pulses. The distortion from M lead to tone in F-type units is +1 millisecond and on E-type units is a few milliseconds.

5.28 When converted to tone in either an E-type or an F-type signaling unit, dc pulses corrected by the pulse corrector should properly operate an E-type or an F-type unit capable of dial pulsing at the far end of the circuit.

VOICE PATH CUTS

5.29 The E- and F-type signaling units interrupt the voice path on both the receiving and transmitting sides. The receiving path of the E type is cut every time 2600 Hz is first received. This prevents signaling tone from entering the next signaling link. The receiving path is cut until a 2600-Hz band elimination filter is inserted. After the filter is inserted, the voice path is restored. That of the F type is not cut because filter insertion is more rapid.

5.30 Cut circuits within the signaling units are used to cut and terminate the transmitting transmission path when both ends are on-hook and also momentarily after any change in signaling state. The duration of this cut must be considered when tones are sent from the switching equipment after a change in signaling state.

5.31 The E-type and F-type signals are not identical but the following is a typical example of the transmission cut timing in an F-type unit. The F-type unit has the transmitting path continuously cut when both ends are on-hook; when the near end goes off-hook, the transmitting path at the near end is reestablished in 90 to 155 milliseconds. At the far end, the transmitting transmission path is reestablished in 500 to 750 milliseconds. If the far end goes off-hook during this interval, the cut timing is changed to the shorter 90- to 155-millisecond interval.

5.32 If both ends are off-hook and the near end goes on-hook, the transmitting transmission path is cut and then reestablished in 500 to 750 milliseconds. Most E-type and all F-type units have the transmit path cut feature. Audible tone with flash cannot be sent through SF signaling systems. The flash will be reproduced but the tone will either be shortened or eliminated in F-type signaling. In E-type signaling, tone and flash are mutually interfering. Flashing signals are no longer used. See 2.59.

5.33 Standard MF pulsing is not affected by these cuts because the signaling delay of the SF system plus the time required to attach a register is in excess of the cut timing.

CONTINUOUS TONE

5.34 Continuous tones can interfere with the proper operation of SF signaling. It is obvious that pure tones near 2600 Hz will cause the far-end (receiving) unit to go on-hook. It is also true that continuous tones that are not 2600 Hz will act as guard signals and keep the signaling units off-hook even though 2600 Hz is also present. Continuous tones can also hold a unit on-hook after the 2600-Hz signaling tone is removed.

5.35 Most signaling units have the cut circuits described above that permit use with continuous tone. However, some intertoll and many toll-connecting units do not have these cut circuits. As a result, provision must be made to interrupt tone sources on a periodic basis or when supervisory state is changed. The 102 test line, for instance, would not give accurate results if the test tone and off-hook were applied at the same time because the tone would hold some SF units on-hook and keep the 2600-Hz filter in the circuit. For this reason, the tone on the 102 test line should be applied 300 milliseconds after the off-hook for proper operation.

OUT-OF-BAND

5.36 Certain N, O, and ON carrier channels have built-in signaling capabilities. These employ 3700 Hz as the signaling frequency which modulates the channel or twin-channel carrier frequency associated with the voice channel for which it signals. During the trunk-idle condition, the 3700-Hz tone is present in both directions of transmission and supervisory signals are transmitted by interrupting the tone in a fashion similar to that already described for inband SF systems. Since the signaling frequency is outside of the voiceband, no provision is required for protection against voice operation. In addition, compandors are not affected by the tone and signaling, if required, during the talking condition.

5.37 Speech and signaling frequencies are separated by 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, after 10 seconds, the trunks using the carrier facilities are made busy to prevent lost calls.

5.38 The 3700-Hz signaling system referred to above normally is modulated from dc to tone and demodulated from 3700 Hz to dc at the same points where speech modems are located. In some cases, however, carrier channels are connected in tandem. If these channels have conventional channel units, the associated two signaling sections have to be connected in tandem on a dc basis. To avoid this, "through channel units" should be used at such intermediate points. These units provide demodulation and modulation of the speech channel and the 3700-Hz signaling tone together and, instead of recovering the dc signals, the 3700-Hz tone is connected through to the following carrier system on an ac basis.

5.39 The channel units of time-division-multiplex transmission systems using pulse code modulation (T-carrier systems with D channel banks) have built-in signaling functions and employ out-of-band signaling. (The eighth bit of the time slots assigned to a channel and normally used for the transmission of speech is used for indicating the on-hook state during a signaling sequence in a manner analogous to the transmission of 2600-Hz tone representing the on-hook state in inband signaling.) The channel units contain the circuitry for making the necessary conversions between the digital signal on the transmission line and the form of dc signal (loop, E/M, ring, etc) required by the terminating and/or switching equipment. In respect to signaling features, D channel bank units resemble SF signaling units. However, the signal delay and signaling distortion of the D channel banks are more like CX or DX signaling than SF.

5.40 One of the problems with the signaling associated with D channel banks is the accuracy with which the system transmits pulses. Many metallic loop signaling circuits have momentary splits in the pulses. These are not always seen at the far end of the circuit because the characteristics of the metallic pair smooth out these signals. However, the signaling of the D channel bank does not provide this smoothing and the split pulse can arrive at the far office where it can cause wrong numbers or other problems.

6. MULTIFREQUENCY PULSING

6.01 The multifrequency pulsing (MF) system consists of transmitting and receiving equipment for transferring valid number information over telephone trunks by various combinations of two, and only two, of five frequencies in the voiceband. Each combination of two frequencies represents a pulse and each pulse represents a digit. The pulses are sent over the regular talking channels and, since they are in the voice range, are transmitted as readily as speech. MF receivers detect the pulses and transfer the digital information to control equipment which establishes connections through the switches. MF pulsing is also used to transmit calling number information in CAMA-ANI operation. In this case, the calling number is MF pulsed forward from the originating office to the CAMA office following the forwarding of the called number whether the called number is transmitted by MF or dial pulsing.

6.02 The MF system transmits only numerical information; hence, another signaling system, such as DX, SF, or loop, must be provided for supervision. Additional signals for control functions are provided by combinations using a sixth frequency. The six frequencies are spaced 200 Hz apart. These six frequencies provide 15 possible 2-frequency combinations. Ten combinations are used for the digits 0 to 9 inclusive and one each for signals indicating the beginning (KP) and end (ST) of pulsing. The remaining three combinations are used for special signals. Table 2 shows the digits or other usages, the associated frequencies, and the explanation for the 6-tone MF keypulsing code.

6.03 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 pulse senders. Consequently, MF signaling requires less holding time per call and, as a result, a relatively small number of MF senders or registers can be used as common equipment for a large number of trunks.

6.04 A typical plan of MF pulsing from a switchboard position to a crossbar office is shown in Fig. 21. In such an arrangement, MF pulses are generated by an operator using a keyset usually keying 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 attached. When a 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.

6.05 With some switchboards, the KP pulse is not sent automatically and the KP key,

TABLE 2

FREQUENCIES FOR MF PULSING

DIGIT	FREQUENCIES
1	700 + 900
2	700 + 1100
3	900 + 1100
4	700 + 1300
5	900 + 1300
6	1100 + 1300
7	700 + 1500
8	900 + 1500
9	1100 + 1500
0	1300 + 1500

USE	FREQUENCIES	EXPLANATION	
KP	1100 + 1700	Preparatory for digits	
ST	1500 + 1700	End of pulsing sequence	
STP	900 + 1700	Traffic Service Position System (see below)	
ST2P	1300 + 1700		
ST3P	700 + 1700		
Coin Collect	700 + 1100	Coin Control	
Coin Return	1100 + 1700	Coin Control	
Ringback	700 + 1700	Coin Control	
Code 11	700 + 1700	Inward Operator	CCITT Signaling System No. 5
Code 12	900 + 1700	Delay Operator	
KP1	1100 + 1700	Terminal Call	
KP2	1300 + 1700	Transit Call	

ADDITIONAL EXPLANATION FOR TSPS TRUNK TYPE

	COMBINED COIN	COMBINED NONCOIN	COMBINED COIN AND NONCOIN
ST	1 + digits	1 + digits	1 + digits (coin)
STP	0, 0 + digits	0, 0 + digits	0, 0 + digits (coin)
ST2P			1 + digits (noncoin)
ST3P			0, 0 + digits (noncoin)

ST* indicates that any of the usable ST signals will be accepted.

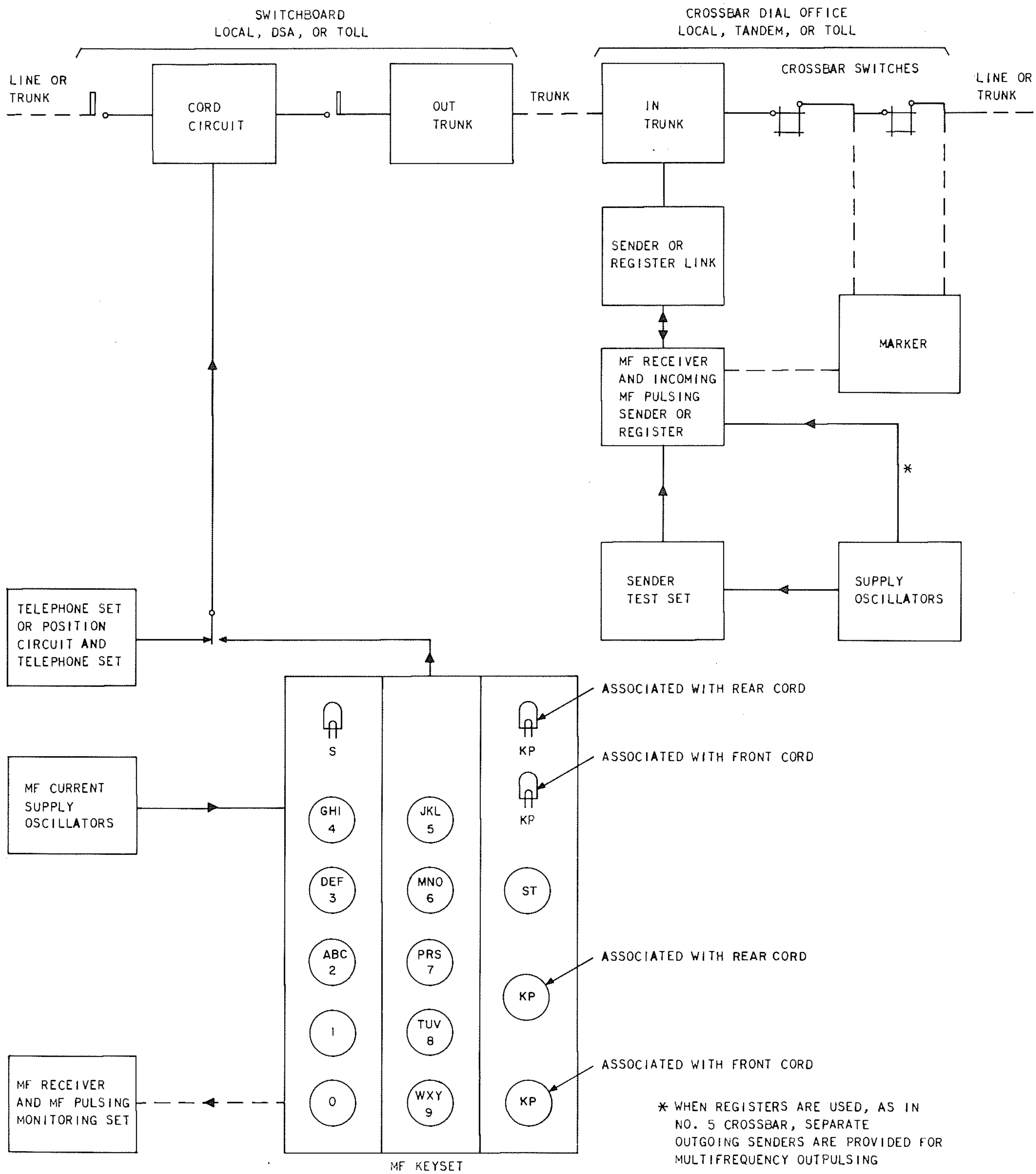


Fig. 21—MF Pulsing From a Switchboard to a Crossbar Central Office

therefore, is 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 lamps.

6.06 MF pulses are also transmitted by senders. The senders receive numbers from subscribers or from operators or other senders by MF pulsing or DP pulsing and transmit these numbers as MF pulses. MF senders, in general, are arranged to outpulse with pulses and interdigital periods of 68 ± 7 milliseconds each (a rate of approximately seven digits per second). This rate is increased to ten pulses per second for intercontinental dialing using CCITT signaling system number 5.

6.07 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. Figure 22 shows the major components of a typical receiver used in electromechanical offices including an input circuit, a volume-limiting amplifier, a biasing circuit, a signal present and unlocking circuit, and the receiving channel circuits.

6.08 A check circuit in the receiver verifies that two, and only two, channel relays operate for each digit. If more or less than two channel relays are operated, a reorder signal is returned. There are also situations where operator's keysets MF pulse to senders which, in turn, transmit dial pulses to step-by-step equipment. This permits operators at positions equipped for MF pulsing to establish calls through SXS as well as crossbar equipment.

6.09 The normal power output of MF transmitters presently used in toll switchboards, testboards, test frames, and senders is -6 dBm per frequency at the zero transmission level point. The frequencies of the supply oscillators should be within ± 1.5 percent of nominal.

6.10 The engineering limit for operating sensitivity of the MF receiver is -22 dBm per frequency. These margins permit the use of MF pulsing on trunks having switch-to-switch losses of 14 dB including allowances for trunk variations, etc, when connected to switchboards, testboards, and senders. Little interference from crosstalk, noise, and echo on the line is encountered.

6.11 To permit the use of MF pulsing by operators who may send a very short pulse or have a very short interdigital interval, the MF receiver will accept a minimum signal duration of 30 milliseconds (both tones are present simultaneously) and a minimum interdigital interval (no tone) of 25 milliseconds. This does not imply, however, that the MF receiver would accept a string of pulses of 30 milliseconds tone and 25 milliseconds no tone.

6.12 In electromechanical offices, MF receivers are tested for slow pulsing at approximately two digits per second with 230-millisecond no-tone and 260-millisecond tone intervals. Fast pulsing is tested at ten digits per second with intervals of 35 milliseconds tone and 65 milliseconds no tone. This test is also made with the tone and no-tone intervals interchanged. Receivers are also tested for sensitivity range and for their ability to operate with maximum allowable slope in frequency transmission of 6.5 dB. Tests are also made at high-input levels to check that false operation of a channel does not result from modulation products. In ESS offices, each MF receiver is tested with each MF transmitter through an environmental test circuit. The receiver is checked for sensitivity range, 6.0 dB of slope, false operation resulting from modulation products, timing (speed), and ability to detect operator double keying.

6.13 The nominal KP signal duration 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 outpulse a 100 ± 10 milliseconds KP pulse.

6.14 Bell System senders are so arranged that, under normal conditions, the two tones comprising an MF signal pulse are applied to the trunk simultaneously and neither tone is transmitted if either tone source should fail. MF signal receivers, however, will recognize an MF pulse as a valid signal if the two tones arrive within 6 milliseconds of each other. If either tone is received alone

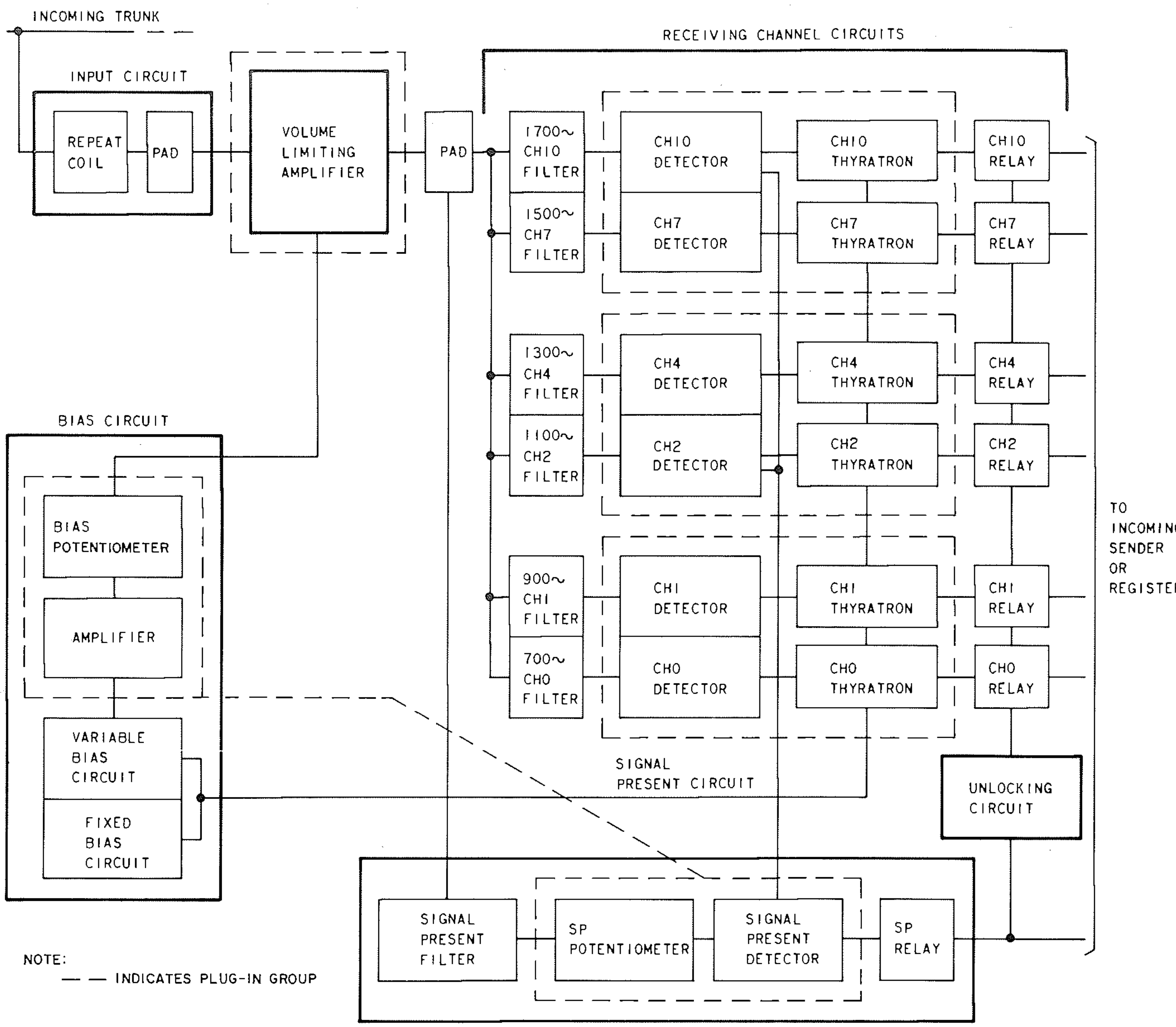


Fig. 22—MF Receiver Plan

for a period longer than 6 milliseconds, the call is routed to reorder tone.

6.15 Delay-dialing/start-dialing or wink-start 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 after MF pulsing begins.

7. SIGNALING TO CAMA AND TSP(S) OFFICES

7.01 Toll switching CAMA (Centralized Automatic Message Accounting), Traffic Service Position (TSP), and Traffic Service Position System No. 1 (TSPS) offices provide ability to record call details for customer billing. Toll switching CAMA offices handle noncoin customer-dialed DDD calls; TSPS is arranged to handle toll calls from noncoin and coin stations requiring operator assistance and can also operate as a CAMA office.

7.02 The CAMA equipment records the called number as it is pulsed from the local office. It also records the calling number as it is pulsed from the local office if it is equipped with Automatic Number Identification (ANI). If ANI equipment is not available at the local office, or if the calling subscriber is on a 4-party or multiparty line, or if there is an identification failure at the local office, an operator is temporarily connected to the call to record the calling number. This method of operation is called Operator Number Identification (ONI).

7.03 The signaling from a local office to a CAMA or TSPS is divided into the sending of the called number and the sending of the calling number. The called number is sent on either an immediate-dial basis for dial pulse calls or on a wink-start basis on MF pulsing calls. After the called number has been received, the CAMA or TSPS incoming trunk goes off-hook toward the local office. This off-hook is the start signal for outpulsing the ANI information. MF pulsing is always used to send the ANI information.

7.04 The pulsing requirements for the called and calling number are the same as the requirements for the called number in normal DDD service. However, the signaling formats are somewhat different than in DDD pulsing. The signaling formats for called and calling number are covered later in this section.

7.05 On non-ANI calls, the CAMA or TSPS incoming trunk goes off-hook toward the local office after the called number has been received. This indicates to the local originating office that the call is being processed satisfactorily. Once the trunk has gone off-hook for either an ANI or ONI call, it will remain off-hook for the rest of the call.

7.06 The trunk may be forced into the off-hook toward the local office for maintenance reasons. This off-hook should make the local office trunk busy. This feature is known as reverse make busy. There is no guarantee, however, that the local office will always receive an off-hook on every call to CAMA or TSPS. Certain calling sequences such as permanent signal, partial dial, or vacant code will not result in an off-hook toward the local office.

7.07 The trunk circuit in the local office must disconnect the customer if the CAMA or TSPS office goes on-hook for at least 140 milliseconds after the off-hook has been received. (This feature is known as winkoff.) These two features prevent subscriber line conditions from holding the CAMA or TSPS trunks out of service.

7.08 The following Bell System switching machines may be arranged as CAMA serving offices·

(1) SXS Intertoll

(2) No. 5 Crossbar

(3) No. 1 ESS

(4) Crossbar Tandem

(5) No. 4A/4M Crossbar

(6) No. 4 ESS.

7.09 When trunks from end offices home on a CAMA serving office, there are two basic trunk classes.

(1) ONI—Local office not equipped for ANI

(2) ANI—Local office equipped for ANI.

The ONI pulsing format is the same as the normal DDD format. The ANI pulsing format is covered in Table 3.

7.10 On an immediate dialing (dial pulse) call from a crossbar tandem office, all but the units digit of the calling number can be outpulsed before the calling number is recorded. On a normal ANI call, the last digit of the called number is held until the calling number is recorded. On an ANI failure, the call is routed to an operator who must record the calling number before the called office times out. In step-by-step, this condition is no problem because there is no time-out in step-by-step. If an office times out in less than 15 to 25 seconds, calls may be lost.

7.11 About the same action takes place on ONI calls in crossbar tandem. However, the call is routed to the operator more quickly than in the ANI case because it is not necessary to wait for ANI information. Using the immediate dial class from crossbar tandem-CAMA to a local office that times for dialing completion should be avoided where possible. One method of avoiding this

TABLE 3

CAMA ANI PULSING FORMAT

TYPE OF CALL	CALLED NUMBER	CALLING NUMBER
Immediate Dial (DP)	7 or 10 digits	KP — I — 7 digits — ST
Controlled Outpulsing (MF)	KP — 7 or 10 digits — ST	KP — I — 7 digits — ST

The information digit "I" has the following meanings:

	INFORMATION DIGITS	
	NONOBSERVED	OBSERVED
Automatic Identification (AI)	0	3
Operator Identification (OI)	1	4
Identification Failure (IF)	2	5

AI — Automatic Identification of the calling number has been done in the originating office; the 7-digit calling number (NNX XXXX) will follow.

OI — The calling number cannot be identified by the originating office because it is a multiparty line; Operator Identification of the calling number is required.

IF — An Identification Failure has occurred in the originating office; operator identification of the calling number is required.

Note: The above mentioned procedure is the preferred method but on OI and IF calls, the ST is optional.

situation is to convert the local office to delay-dial or wink-start operation as recommended. However, there will be situations, such as a SXS intertoll between the crossbar tandem-CAMA and the local terminating office, that require the immediate class outpulsing since crossbar tandem cannot operate delay dial-stop dial as can a 4A Crossbar office. In these cases, the time-out in the local office should be as long as possible. In any case, the time-out should be not less than the 15 to 25 seconds given in 7.10.

7.12 In the nonimmediate dialing case in crossbar tandem, the outpulsing of the called number does not start until the first digit of the calling number is recorded. For calls from the No. 4A Crossbar, No. 5 Crossbar, step-by-step, and TSPS CAMA systems, the called number is not outpulsed until the first digit of the calling number is recorded.

7.13 On an ANI failure, the call is delayed until the operator completes recording the calling number. This delay is longer than for normal calls. As a result, registers with a short time-out could release before the outpulsing is completed. For this reason, registers should not time out in less than 15 to 25 seconds on normal calls and not less than 5 seconds on overload conditions.

7.14 Table 4 gives information on time from request for ANI until call is connected to an operator.

7.15 TSPS has two different trunking plans. The first combines all coin traffic on one trunk group and all noncoin traffic on a second trunk group. The second trunking plan combines all traffic (coin and noncoin) on one trunk group. In each case, the type of call is identified by using distinctive MF start digits from the local office as

TABLE 4

CAMA-ANI-TIME FROM REQUEST

FOR ANI UNTIL CONNECTED TO AN OPERATOR

Step-by-Step	5.00 to 9.00 Seconds
No. 5 Crossbar	4.04 to 8.04 Seconds
No. 1 ESS	1.00 to 8.00 Seconds
Crossbar Tandem	6.50 to 10.0 Seconds
No. 4A/4M Crossbar	5.00 to 10.0 Seconds
TSPS	12.0 to 18.0 Seconds

shown in Table 2. For dial pulsing calls, the identifying start pulse is associated with the ANI information. For MF pulsing calls, the identifying start pulse is associated with the address information.

7.16 When it is desired to reach an operator (0 call), 0 is dialed. When special toll handling is desired, eg, collect, person-person, credit card, etc (0+ call), 0 followed by the called number is dialed. The 0 and 0+ calls use the same start pulse for identification. As a result, other means have to be used to separate these two categories of calls. In dial pulsing calls, a dialing pause of over 4 seconds after dialing 0 is considered a 0 operator call. In MF pulsing calls, KP followed by a start signal of STP or ST3P, depending on the trunking arrangement but with no called number, is outpulsed to identify a 0 call. Signaling formats for TSPS using a combined coin and noncoin trunk group are given in Table 5. Complete signaling formats for TSPS are in Table 6.

SIGNALING TO AUTOMATIC INTERCEPT SYSTEM

7.17 The Automatic Intercept System (AIS) serves Class 5 offices. Numbers disconnected, in trouble, or not equipped are wired in the Class 5 office to route incoming calls reaching these numbers to outgoing intercept trunks. The outgoing intercept trunks can be arranged to identify the type of intercept and to transmit the information to AIS. Class 5 offices can be served by AIS on an ONI basis without modification and with their existing outgoing trunks. The features required in the trunks and interoffice signals are shown in Chart 6. The sequence of operation from the new outgoing trunk is shown in Table 7. Signals from a local office to an AIC for three classes of intercept traffic on one trunk are shown on Table 8.

8. CARRIER GROUP ALARM

8.01 Carrier Group Alarm (CGA) is used to minimize the effects of carrier failure on the switching system and on service. Ideally, a CGA system should: (1) busy out the failed circuits, (2) release the customer from the failed circuits, (3) stop charging, and (4) prevent the failed circuits from seizing the central office equipment. Several vintages of CGA systems exist in the Bell System. The oldest are for use with E&M lead signaling only. The newer CGA systems handle loop reverse battery signaling as well as E&M signaling.

8.02 The operation of a CGA system can be divided into three parts. First is the detection of the carrier failure. The second is conditioning the failed trunk. The third is the reaction of the switching equipment to the processing of the failure.

8.03 The carrier failure detection circuit is always in the carrier terminal. The trunks processing equipment is associated with the carrier or signaling equipment for electromechanical switching equipment. Electronic systems do at least part of the trunk processing within the switching machine. The electronic systems can also use the same processing equipment as the electromechanical systems when supervisory signal trunk conditioning is used.

8.04 The CGA equipment can be collocated with or, where calling party control is used, remote from the switching equipment. Where there is more than one link of signaling equipment in a

TABLE 5

PULSING FORMAT FOR TSPS FROM LOCAL OFFICE

MULTIFREQUENCY PULSING

TYPE OF CALL	CUSTOMER DIALS	MF – PULSED CALLED NUMBER	ANI CALLING NUMBER
Noncoin			
DDD	1* + 7 or 10 digits	KP — 7 or 10 digits — ST2P	KP — I — 7 digits — ST
Operator Assist	0 (zero)	KP — ST3P	KP — I — 7 digits — ST
Special Toll	0 + 7 or 10 digits	KP — 7 or 10 digits — ST3P	KP — I — 7 digits — ST
Coin			
DDD	1* + 7 or 10 digits	KP — 7 or 10 digits — ST	KP — I — 7 digits — ST
Operator Assist	0 (zero)	KP — STP	KP — I — 7 digits — ST
Special Toll	0 + 7 or 10 digits	KP — 7 or 10 digits — STP	KP — I — 7 digits — ST

DIAL PULSING

TYPE OF CALL	CUSTOMER DIALS	DIAL – PULSED CALLED NUMBER	ANI CALLING NUMBER
Noncoin			
DDD	1* + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — ST2P
Operator Assist	0 (zero)	Seizure — No digits	KP — I — 7 digits — ST3P
Special Toll	0 + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — ST3P
Coin			
DDD	1* + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — ST
Operator Assist	0 (zero)	Seizure — No digits	KP — I — 7 digits — STP
Special Toll	0 + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — STP

* The number 1 is optional.

Note: Information digit I has the following meaning:

	NONOBSERVED	OBSERVED
Automatic Identification (AI)	0	3
Operator Identification (OI)	1	4
Identification Failure (IF)	2	5
Hotel-Motel	6	7

TABLE 6

REQUIRED TSPS MULTIFREQUENCY PULSING FORMATS

KP — ST	KP — ST* — KP — I — 7 digits — ST
KP — ST*	KP — STP — KP — I — 7 digits — ST
KP — STP	KP — ST3P — KP — I — 7 digits — ST
KP — ST3P	KP — 7 or 10 digits — ST — KP — I — 7 digits — ST
KP — 7 or 10 digits — ST	KP — 7 or 10 digits — ST* — KP — I — 7 digits — ST
KP — 7 or 10 digits — ST*	KP — 7 or 10 digits — STP — KP — I — 7 digits — ST
KP — 7 or 10 digits — STP	KP — 7 or 10 digits — ST2P — KP — I — 7 digits — ST
KP — 7 or 10 digits — ST2P	KP — 7 or 10 digits — ST3P — KP — I — 7 digits — ST
KP — 7 or 10 digits — ST3P	
Seizure only — No digits	
KP — I — 7 digits — ST	KP — ST* — KP — 6 — 7 digits — ST
KP — I — 7 digits — ST*	KP — STP — KP — 6 — 7 digits — ST
	KP — ST3P — KP — 6 — 7 digits — ST
KP — 6 — 7 digits — ST	KP — 7 or 10 digits — ST — KP — 6 — 7 digits — ST
KP — 6 — 7 digits — ST*	KP — 7 or 10 digits — ST* — KP — 6 — 7 digits — ST
	KP — 7 or 10 digits — STP — KP — 6 — 7 digits — ST
	KP — 7 or 10 digits — ST2P — KP — 6 — 7 digits — ST
	KP — 7 or 10 digits — ST3P — KP — 6 — 7 digits — ST

REQUIRED TSPS DIAL PULSING FORMATS

Seizure — No digits — No ANI	Seizure — No digits — KP — 6 — 7 digits — ST*
Seizure — No digits — KP — I — 7 digits — ST*	Seizure — No digits — KP — 6 — 7 digits — STP
Seizure — No digits — KP — I — 7 digits — STP	Seizure — No digits — KP — 6 — 7 digits — ST3P
Seizure — No digits — KP — I — 7 digits — ST3P	
7 or 10 digits — No ANI	7 or 10 digits — KP — 6 — 7 digits — ST
7 or 10 digits — KP — I — 7 digits — ST	7 or 10 digits — KP — 6 — 7 digits — ST*
7 or 10 digits — KP — I — 7 digits — ST*	7 or 10 digits — KP — 6 — 7 digits — STP
7 or 10 digits — KP — I — 7 digits — STP	7 or 10 digits — KP — 6 — 7 digits — ST2P
7 or 10 digits — KP — I — 7 digits — ST2P	7 or 10 digits — KP — 6 — 7 digits — ST3P
7 or 10 digits — KP — I — 7 digits — ST3P	

TABLE 7

SEQUENCE OF OPERATIONS FOR OUTGOING INTERCEPT TRUNKS

CONDITION	LOCAL OFFICE	AIS	TIMING
Idle	On-Hook	On-Hook	
Seizure	Off-Hook	On-Hook	
AIS MF receiver attached — start of wink	Off-Hook	Off-Hook	
Wink completion	Off-Hook	On-Hook	Min 160 ms Max. 9 to 12 sec
Local Office			
ANI outpulsing begins	Off-Hook	On-Hook	MF Outpulsing
ANI outpulsing ends	Off-Hook	On-Hook	
Transmission cut-through	Off-Hook	Off-Hook	Start Announcement
	Off-Hook	On-Hook	Complete Announcement
Audible ring or connection to operator	Off-Hook	Off-Hook	4-1/2 sec later if customer stays on line
Disconnect	The AIS does not generate a unique disconnect signal. The disconnect is under control of the calling party. The local office trunk must be held busy a minimum of 450 ms before reseizure to allow time for the AIS trunk to restore to the idle state.		

facility, there can be CGA equipment collocated with the switching equipment and one or more CGA equipments remote from the switching equipment. These several CGA equipments would perform the CGA trunk processing for a trunk into a switching machine. Each CGA equipment would perform the trunk processing where the associated carrier link failed.

8.05 The typical sequence of events when a carrier equipped with CGA fails and then recovers is as follows:

(1) After the carrier fails but before the carrier group alarm trunk conditioning begins, the associated signaling equipment can either be on-hook, off-hook, or alternating between on-hook and off-hook states. Off-hook signals will seize central office equipment and may cause false charging where the called customer has not answered at the time of carrier failure.

(2) Carrier group alarm trunk conditioning begins from about 300 milliseconds to 2 seconds after carrier failure.

8.06 There are two methods of trunk conditioning. The first uses supervisory signals and the second uses auxiliary signals forwarded directly to the trunk circuit or to the central control of an electronic switching system.

TABLE 8

SIGNALS FROM LOCAL OFFICE TO AUTOMATIC INTERCEPT CENTER

CLASS	ANI			ONI	
		DC SIGNALING TIP	DC SIGNALING RING	DIAL PULSE SIGNALING	MF
Regular	KP + 3*+ 7d + ST	B	G	One Pulse	KP + 6 + ST
Trouble	KP + 1 + 7d + ST or KP + 1 + ST	G	B	Two Pulses	KP + 8 + ST
Blank or Unassigned Number	KP + 0 + 7d + ST or KP + 0 + ST	Momentary +130V on T and R followed by B on Tip, G on Ring		Three Pulses	KP + 7 + ST
Failure to Identify	KP + 2 + ST				
Spin off to Announcement Machine					KP + 5 + ST

* Information Digit.

Note:

1. ST signal is standard DDD frequency.
2. DP signal is optional for AIS.

(1) Where trunk conditioning is accomplished with supervisory signals, the associated signaling system is forced on-hook. If the connected trunk is an incoming circuit or a 2-way trunk circuit used in the incoming mode, the on-hook will force the release of the associated switching system. The release of the switching system will disconnect established calls. The on-hook toward an outgoing trunk has no effect in systems with calling party control because the calling party can always release from the connection. Where joint hold is used, the on-hook permits the calling party to release. As will be seen later in this discussion, if supervisory conditioning is the only trunk conditioning used, a subsequent off-hook would trap the customer in the trunk for the duration of the carrier failure. As a result, joint hold trunks should be used with auxiliary trunk conditioning signals to busy out the trunk during carrier failure.

(2) After about 10 seconds, an auxiliary signal from the carrier terminal applied to the trunk circuit of all outgoing and 2-way trunks with calling party control forces them off-hook to make them busy to the switching machine. The one-way incoming and joint hold circuits remain on-hook.

8.07 The disadvantage of the supervisory busy out of the trunk circuits is that all 2-way trunks in the failed condition are a permanent signal to the switching machine. A large failure can tie up the office for a short period of time. In the absence of this kind of carrier failure trunk conditioning, however, repeated seizures on the trunks can occur during the total period of the carrier failure.

8.08 Supervisory conditioning can be used either collocated with the switching equipment or at a remote location for calling party control. The only requirement for remote trunk conditioning is that provisions are made to control the supervisory state of the signaling during the failure of the carrier system. Supervisory conditioning can be the sole method of trunk conditioning for calling party control. Incoming trunks and trunks using joint hold control stay on-hook during the carrier failure.

8.09 Where the trunk conditioning is accomplished using auxiliary signals, the trunk circuit is made busy by closing a contact between two auxiliary signaling leads. This auxiliary signal is applied at the time trunk processing begins and remains until the carrier is restored. Since these auxiliary leads usually have rather short resistance ranges, this method is usually limited to situations where the CGA and switching equipment are collocated. The auxiliary signals for both No. 1 ESS and No. 4 ESS are for a carrier group rather than a single circuit. Except for step-by-step and No. 4 ESS, the auxiliary signal makes the trunk circuit busy for any future usage but does not disconnect the call presently using the trunk.

8.10 Local step-by-step is a special case because the circuit is made busy by grounding the sleeve lead. This will, of course, lock the step-by-step switches to the ground on the sleeve and lock any subscriber trapped on that trunk out of service for the duration of the carrier failure. To prevent this, the existing call must be winked off the circuit. The sleeve lead from the step-by-step outgoing repeater to the selector is wired through the CGA equipment. In a carrier failure, the subscriber is winked off the circuit by removing the ground from the sleeve lead for 40 milliseconds to release the step-by-step switching train. The CGA trunk conditioning equipment applies a ground to busy out the trunk as soon as the winkoff is completed. The ground remains on the trunk sleeve lead for the duration of the call.

8.11 The winkoff signal can occur any time after the carrier failure is recognized. Most existing CGA circuits wink off the subscriber after about 10 seconds of forced on-hook. As long as the subscriber is not locked to the failed trunk for an excessive time, the winkoff timing is not critical.

8.12 Joint hold circuits require the use of an auxiliary signal to busy out the trunk during the carrier failure. The signal is required because the supervision must remain on-hook during the failure to prevent locking a subscriber to the trunk circuit. When the carrier failure ends, all signaling circuits are returned to on-hook and all supervisory signals restored to normal.

8.13 The several ways that CGA can be applied are as follows:

(1) Carrier group alarm on E&M lead signaling with supervisory conditioning as the sole busy-out method is the most frequently used CGA arrangement on intertoll and toll-connecting trunks. It has the advantage that the carrier terminal and the switching equipment do not have to be collocated. All E&M lead incoming and 2-way trunk circuits having calling party control will operate in this mode. Many Bell System E&M lead outgoing trunk circuits will also function in this mode. Development is now underway to increase the number of outgoing trunk circuits that will accept this make-busy mode of operation. Where outgoing trunk circuits with this make-busy mode are not available, 2-way trunk circuits can be used.

The disadvantage of this mode of make busy is that the 2-way trunks are seized on carrier failure. This can cause a shortage of common equipment in common control offices until the permanent signal arrangements clear the condition.

This make-busy method should not be used with joint hold trunks.

(2) Carrier group alarm with E&M lead supervisory signaling and auxiliary signaling trunk conditioning has the disadvantage of requiring collocation of signaling and switching equipment. It has the advantage of not seizing the switching equipment once the carrier failure is detected. In the interval between actual carrier failure and the detection of the failure, the failed circuits can seize switching equipment. The false seizure only lasts for about 2 seconds so the effect on an office would be very small.

This method can also be used for joint hold trunks.

Only the latest signaling equipments (F-type SF and D3 channel banks) have the ability at this time to apply the auxiliary signal. As a result, this is not a widely used CGA trunk conditioning method.

(3) Carrier group alarm on loop-reverse-battery signaling trunks with supervisory conditioning as the sole busy-out mode is a method of trunk conditioning. Since only one-way trunks are available, the false seizure of switching equipment, as was mentioned with supervisory conditioning on E&M lead signaling, is eliminated.

Use of this method requires a reverse make-busy feature in the outgoing trunk circuit. These trunk circuits are limited to CAMA and TSPS trunks at present. Since the TSPS trunk circuit is joint hold supervision, only CAMA trunks are available for this method. Development is proceeding on an applique that would provide the reverse make-busy feature for existing trunks.

(4) Carrier group alarm on trunk using reverse battery signaling with both supervisory and auxiliary signaling conditioning is a standard method for many loop trunks including No. 5 Crossbar and step-by-step. It does not require collocation of the signaling and switching equipment. However, it is the only effective method for step-by-step and joint hold 2-wire trunk circuits.

8.14 Carrier group alarm on trunks to No. 4 ESS or No. 1 ESS use the central control for at least part of the processing. In each switching system, connecting of two auxiliary signaling leads together starts processing on a whole trunk group. No. 4 ESS does all trunk processing. No. 1 ESS requires on-hook supervision from the failed trunk.

8.15 At the present time, ground on the E lead is the most often used signal on facilities that might interconnect between an Independent Telephone Company and the Bell System. All of the carrier, signaling, and switching components of this system are available now. Except for joint hold trunk circuits, this method of carrier group alarm trunk conditioning is the most universally used trunk conditioning arrangement.

8.16 To date, CGA has been limited to short-haul carrier systems. The broadband (L) systems have not had CGA capability. In the near future, a carrier failure signal will be available at the broadband carrier channel bank on a per-group (12 circuits) basis. In addition, trunk conditioning will be available for broadband carrier. The trunk conditioning will use the supervisory method of conditioning by inserting 2600-Hz SF signaling tone for an on-hook and no tone for an off-hook.

9. AUDIBLE TONE SIGNALS

9.01 Signals in this category give information regarding the progress or disposition of telephone calls to operators and subscribers. The audible signals must, of course, be easy to interpret and must conform to the transmission system design requirements for signal levels and freedom from interference effects with respect to: (1) voice currents, (2) circuit noise, or (3) other signaling systems.

9.02 The Bell System adopted a ***precise tone plan*** based on four pure tones which, in central office applications, will be held to ± 0.5 percent frequency tolerence and ± 3 dB amplitude variation. These tones are 350, 440, 480, and 620 Hz. They are assigned singly or in pairs (not modulated) to represent standard audible tone signals as described in the following paragraphs. In the period of transition to the precise tones, the older tones will continue to be used. Except for dial tone, the new and old tones sound nearly alike.

9.03 Standard levels for the precise tone plan have been established as indicated in the appropriate paragraphs which follow. As before, levels for the old tones should lie in the range of 61 to 71 dBrnC. The tone level should be measured where it is applied to the voice transmission path at the calling customer's side of the incoming line or trunk equipment. Refer to Charts 2 and 7 of this section.

DIAL TONE

9.04 Dial tone consists of 350 plus 440 Hz at a level of -13 dBm per frequency. The difference in frequency of 90 Hz gives this tone its buzzing sound. Old dial tone consists of 600 Hz modulated by 120 Hz when supplied by a tone alternator or by 133 Hz when supplied by an interrupter. In this case, the modulating frequency gives this tone its low-pitched sound. Other combinations were also used.

HIGH, LOW, AND CLASS-OF-SERVICE TONES

9.05 High tone consists of 480 Hz at -17 dBm. Old high tone is nominally 500 Hz when supplied from a tone alternator or 400 Hz from an interrupter.

9.06 Low tone gets its name from the prominent 140-Hz beat and the low power level. It consists of 480 plus 620 Hz at a level of −24 dBm per frequency. Interrupted low tone is used for line busy, reorder, and no-circuit tone signals reached by the customer.

9.07 Class-of-service tones are used at switchboards to indicate the class of service of the calling subscriber when more than one class is served by the same trunk group. Class of service may be indicated by either a high tone, low tone, or absence of tone.

LINE BUSY

9.08 Line busy is a low tone interrupted at 60 IPM with approximately equal tone-on and tone-off times. It indicates that the called customer line has been reached but that it is busy.

REORDER, PATHS BUSY (ALL TRUNKS BUSY), NO CIRCUIT

9.09 This is low tone interrupted at 120 IPM which indicates that the local switching paths to the calling office or equipment serving the called customer are busy or that no toll circuit is available. This signal may also indicate a condition such as a timed-out sender or unassigned code dialed.

9.10 To a limited extent, the relative tone-on and tone-off durations were varied at one time to differentiate between local and toll offices and between types of toll offices. The precise tone plan, where installed in new SXS, No. 5 Crossbar, and all ESS offices, calls for equal tone-on and tone-off times of 0.25 second. Taking into account all classes and types of offices at the present time, both the tone-on and the tone-off durations may range from 0.2 and 0.3 second provided that the sum of the two durations is 0.5 second. The named circuit conditions are indicated by the easily recognizable 120-per-minute interruption rate but no significance attaches to the relative tone-on and tone-off durations.

9.11 Tone should be provided at Class 5 offices for 60 and 120 IPM and at Class 4 and higher ranking offices for 120 IPM. These same tones are received by the calling customer on direct dialed calls. In general, customers are not instructed on the significance of each tone. They try completing their calls again regardless of the tone received. However, detailed instruction concerning tone signals is sometimes given to PBX attendants.

AUDIBLE RINGING

9.12 Audible ringing consists of 440 plus 480 Hz at a level of −19 dBm per frequency. This signal indicates that the called line has been reached and ringing has started. It is also used on calls to operators (special service, long distance, information, etc) during the "awaiting-operator-answer" interval. Old audible ringing typically consists of 420 Hz modulated by 40 Hz. Other combinations were also used.

COIN TONES

9.13 These tones are produced by gongs or tone pulse generators in a coin telephone as nickles, dimes, and quarters are deposited. The tones are introduced to the line by separate transmitters in the coin box or by tone oscillators and enable the operator to check the amount deposited. On prepay service, in addition to the tones, a dc signal is sent to the operator showing that coins have been deposited.

9.14 Coin collect tone is a low tone used to inform the originating operator that the B operator or coin control circuit has initiated the coin collection.

9.15 Coin return tone is a high tone used to inform the originating operator that the B operator or coin control circuit has initiated the return of the coin(s).

RECORDER WARNING

9.16 When recording equipment is used, a "beep" of 1400-Hz tone is connected to the line every 15 seconds for a 0.5-second interval to inform the distant party that the conversation is being recorded. The tone source is located within the recording equipment and cannot be controlled by the party applying the recorder to the line.

10. OTHER MISCELLANEOUS SIGNALS

RINGING

10.01 Ringing signals are used for alerting the called customer and are not used in interoffice signaling. 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.

10.02 While many trunks still require a ringing start signal, the use of this signal is declining. The use of delayed ringing trunks on a standard basis was discontinued several years ago in connection with the elimination of separate toll trains in step-by-step offices. However, many locations continue to provide them in new local offices for uniform operating procedures. TSPS does not provide a ringing start signal.

10.03 Two types of ringing start signals are employed, SX and 20 Hz. SX ringing start consists of +130 volts applied on a simplex basis to both conductors for a minimum of 0.1 second; whereas, 20-Hz ringing start consists of 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-Hz ringing start signal, however, cannot be sent until the line seizure signal has been received.

Ring Forward (Rering)

10.04 This is a signal used by an operator at the calling end to recall an operator at the called end on an established connection. It is originated by means of a ringing key in the cord circuit. On trunks arranged for use with E&M lead signaling systems, relays in the outgoing trunk equipment generate a single on-hook pulse for each pull of the ringing key. As applied to distance dialing circuits, ring forward is a momentary on-hook of 100 $\pm$30 milliseconds transmitted toward the called end (50 to 140 milliseconds received) which is converted at the destination office to a recall signal on the operator's answering cord.

10.05 The ring forward signal is converted to a +130 volt simplex signal on 2-wire physical trunks using loop signaling from crossbar tandem. This signal can cause false disconnects in the incoming office unless the incoming trunk circuit is equipped with balanced windings on the pulse receiving relays. See 3.33 of Section 4.

Ringback

10.06 This is a signal used by an operator at the called end of an established connection to recall the originating operator. The operation of the called operator's ringing key sends an on-hook pulse back to the calling end which is converted to a recall signal on the originating operator's cord lamp. Ringback continues as long as the called operator's ringing key is operated. Ringback is also a signal used by an operator to recall a subscriber.

10.07 Operator-controlled ringing is required on all coin lines to ring the telephone after the call is completed to alert the customer that an overtime deposit is necessary. Ringback has also been used to identify the calling line on emergency calls if the caller inadvertently hangs up before identifying the location of the emergency. This second use is not necessary and not provided for in TSPS because the TSPS operator has the calling number displayed on the position.

10.08 Interoffice coin trunks with the ringback feature can be arranged for unrestricted ringback or restricted ringback. With the former, ringing is applied whether the station is on- or off-hook. With the latter, the ringing is applied only if the station is off-hook.

10.09 Unrestricted ringback is provided in coin trunks but is not provided on noncoin trunks unless the office has no party lines, which is very rare. For the more general case, restricted ringback is used to guard against annoying a customer if the operator should attempt to ring back against an on-hook in error. The ringback against off-hook, however, is permitted to alert a PBX operator who has failed to remove her cord from a central office trunk jack at the end of a toll call.

10.10 Twenty hertz ringing or reverse battery is used with loop trunks to the local office as the ringback signal. Noncoin E&M trunks use a single wink while E&M coin trunks use MF tones or multiple winks as described later as a ringback signal.

10.11 An emergency ringback method is available for use with recording—completing trunks from some local offices. In this case, an operator, having determined that some emergency exists on a line that has gone on-hook after answered, can attempt to identify that line. By operating a common emergency ringback key in addition to the appropriate cord ringing key, the operator will cause that line to be rung sequentially with each possible ringing combination. If any party responds, the operator can determine a number and from this can identify all parties on the line from office or test desk records. Emergency ringback is not provided with TSPS and is classified "Manufacturer Discontinued" for other equipment arrangements.

COIN COLLECT AND COIN RETURN

10.12 Coin collect is usually +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. However, there are locations using −110 (or −130) for coin collect and +110 (or +130) for coin return. The circuit (in simplified form) for collecting and returning coins over a customer's line is shown in Fig. 23. Where ±130 volts are used, a series dropping resistor is added to the circuit. The value of the resistor is chosen so there is approximately a 20-volt drop across the resistor when collecting or returning coins.

10.13 The coin mechanism is polarized and diverts the coins 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.)

10.14 Where carrier facilities are used between the operator and the serving office, the normal dc coin collect and coin return signals and the ringback signal cannot be used. There are two methods of transmitting these signals on carrier. The first is "inband coin control" and the second is "multiple wink coin control."

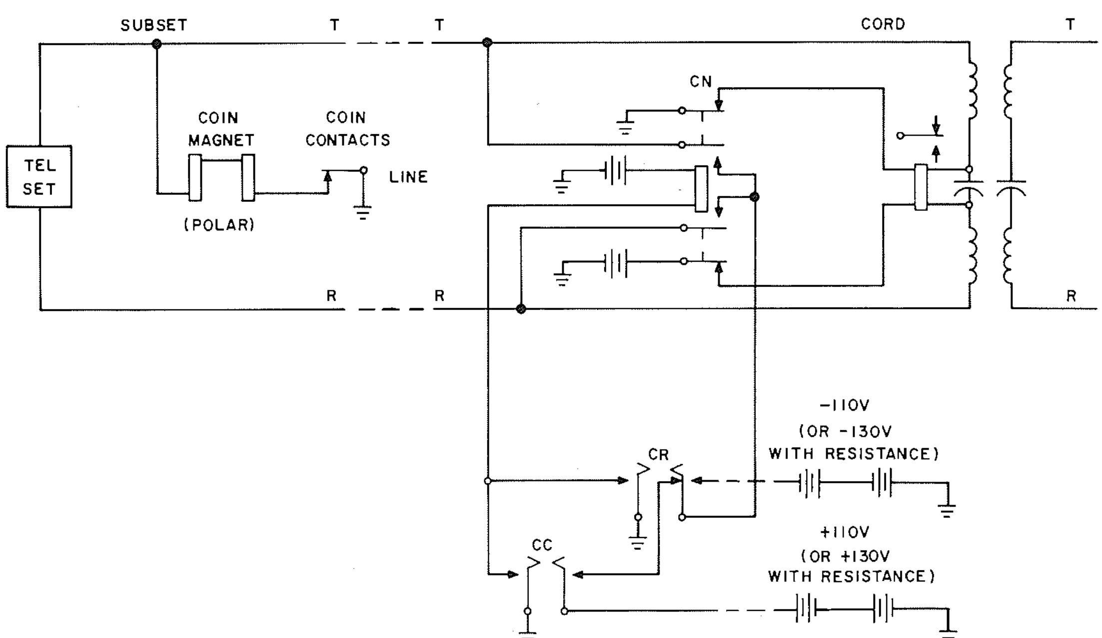


Fig. 23—Coin Collect and Return Circuit

INBAND COIN CONTROL

10.15 Inband coin control uses the MF signaling digits to control coins and ring back the coin station as follows:

FUNCTION	FREQUENCIES
Collect	700+1100
Return	1100+1700
Ringback	700+1700

An on-hook wink (off-hook, on-hook, off-hook) of 70 to 130 milliseconds is sent (60 to 140 milliseconds received) from the coin control circuit in the operator's location to prepare the receiver in the local office for the MF signal that begins approximately 60 milliseconds after the end of the wink. The MF signal will persist for at least 900 milliseconds. The receiver requirements are not completely defined. However, the requirements will not be more stringent than those for regular MF pulsings.

Multiple Wink Coin Control

10.16 Multiple wink coin control using multiple on-hook signals of 70 to 130 milliseconds is planned for use between a TSPS and local central offices. In addition to providing coin collect, coin return, and ringback signals, the new signaling format provides two new signals that indicate to the local office when an operator is attached or released.

10.17 The operator-attached signal is used to disable and the operator-released signal is used to restore the TOUCH-TONE® keyset in the coin station. The multiwink signaling format employs a series of one to five supervisory on-hook winks from the TSP(S) to the local office outgoing trunks. The signals and their use are as follows:

NUMBER OF ON-HOOK WINKS	FUNCTION
1	Operator Released
2	Operator Attached
3	Coin Collect
4	Coin Return
5	Ringback

Each wink is an on-hook wink of 70 to 130 milliseconds sent (50 to 150 milliseconds received). The winks are 100 to 150 milliseconds apart when sent (75 to 185 milliseconds apart received).

ANNOUNCEMENTS

10.18 Recording machines are used in the Bell System to provide announcements. A primary use of the recorded announcement machines is to provide an intercepting message to calls reaching vacant or disconnected customer numbers. 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 11 to 36 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 subcenters to which the announcements are transmitted.

10.19 A smaller machine is used 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, are connected to the machine. Normally, only one machine is provided. This machine operates on a stop-start basis. When once started, all subsequent calls requiring intercept in the announcement interval are cut in immediately to the machine at any stage of the announcement cycle. Provision can be made for subsequent transfers to an operator.

10.20 Direct distance dialed calls will reach these machines when required. The announcements are 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.

10.21 Crossbar tandem and No. 4 Crossbar switching systems are to be equipped so that appropriate recorded announcements may be returned to calls which fail to complete because:

(1) All trunks are busy due to heavy traffic or disaster.

(2) A switching system is overloaded.

(3) Vacant codes or unauthorized numbers are dialed.

(4) Operating or equipment irregularities are encountered.

Cut-through to an operator is not contemplated under these circumstances. Chart 7 contains some of the tones and announcements recommended for distance dialing.

TOUCH-TONE®

10.22 The Bell System TOUCH-TONE calling system provides a method for pushbutton signaling from customer stations using the voice transmission path. The code for this system provides 16 distinct signals. Each signal is composed of two voiceband frequencies, one from each of two mutually exclusive frequency groups of four frequencies each. The signal frequencies are geometrically spaced and were selected on the basis that the two frequencies of any valid signal combination are not harmonically related.

10.23 The frequency pairs assigned for TOUCH-TONE signaling are as follows:

		HIGH-GROUP FREQUENCIES (Hz)			
		1209	1336	1477	1633
LOW GROUP FREQUENCIES (HZ)	697	1	2	3	Spare
	770	4	5	6	Spare
	852	7	8	9	Spare
	941	*	0	#	Spare

Note: The * and # symbols are for future new services.

10.24 Various features which are provided in the TOUCH-TONE system include the following:

(1) Transistor generator in station set powered from customer loop

(2) A check by the receiver that two, and only two, of the tones are present, that one is from each group of four, and that they are present simultaneously for at least 40 milliseconds

(3) A guard against false pulsing due to voice signals.

11. SENDER AND REGISTER TIMING AND EFFECT ON SIGNALING

11.01 The senders and registers used in distance dialing 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 distant sender or register will route the call to recorder and release.

11.02 The requirements for digit pulsing which result from digit registration timing are given for the several systems in Chart 8. Delays exceeding these intervals do not always result in reorder routing since these limits are necessarily based on minimum timing in the senders and registers. In the No. 5 Crossbar system in the chart, some of the intervals are automatically reduced during periods of heavy traffic in order to conserve common control equipment.

11.03 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 9. It will be observed that, during periods of heavy traffic, some of the intervals are automatically reduced. This measure is designed to minimize the effect that delays in one office may have on other offices. Without reduced intervals, mutual delays between offices during periods of heavy traffic can pyramid, seriously impairing service.

SIGNALS REQUIRED IN DISTANCE DIALING

NAME OF SIGNAL	ON-HOOK	OFF-HOOK	DIRECTION CALLING END	DIRECTION CALLED END	USE OR MEANING	INDICATION TO CUSTOMER	INDICATION TO OPERATOR	SEE NOTE
Connect (Seizure)		√	—	→	Requests service and holds connection.			
Dial Tone			←	—	Equipment ready for dialing.	Steady tone	Steady tone	
Disconnect	√		—	→	No service is desired. Message is completed. Release connection.		Calling supv lamp lighted	
Answer (Off-Hook)		√	←	—	Called party has answered. Charge timing begins and depends on this signal.		Called supv lamp dark	
Hang-Up (On-Hook)	√		←	—	Called party has not answered. Line idle. Message is completed.		Called supv lamp lighted	
Delay Dialing (Delay Pulsing)		√	←	—	Called end not ready for digits.		Start dial or KP fwd lamp dark	1
Wink		√	←	—	Called end ready for digits.		Start dial or KP fwd lamp lighted	1
Start Dialing (Start Pulsing)	√		←	—	Called end ready for digits.		Start dial or KP fwd 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.			
TOUCH-TONE® (Pushbutton)			—	→	Indicates called number.			
Multifrequency Pulsing (MFP)								
Keypulse (KP)			—	→	Prepares receiving circuit for digits.			
Digits			—	→	Indicates called number.			
Start Pulse (ST)			—	→	Indicates that all necessary digits have been sent.			
Start Identification (ANI)		√	—	→	Indicates that CAMA sender is ready to receive calling number			
ANI Outpulsing								
Keypulse (KP)			—	→	Prepares CAMA sender for digits.			
Identification Digit			—	→	Indicates if service observed, whether automatic or operator identification, and identification failure.			
Digits			—	→	Indicates calling number if sent.			
Start Pulse (ST)			—	→	Indicates all digits sent.			4
Line busy			←	—	Called line is busy.	60-IPM tone	60-IPM tone	5
Recorder			←	—	All paths busy. All trunks busy. Blockage in equipment. Incomplete registration of digits.	120-IPM tone	120-IPM tone	2, 5

Chart 1—Signals Required in Distance Dialing

SIGNALS REQUIRED IN DISTANCE DIALING (Cont)

NAME OF SIGNAL	ON-HOOK	OFF-HOOK	DIRECTION (CALLING END — CALLED END)	USE OR MEANING	INDICATION TO CUSTOMER	INDICATION TO OPERATOR	SEE NOTE
Ringing			→	Alerts called customer to an incoming call.	Bell rings or other alerting signal		3
Audible Ringing			←	Called station is being rung or Awaiting operator answer.	Ringing tone		
Ring Forward	√		→	Recalls operator forward to the connection.		Steady or flashing lamp	
Ringback	√		←	Recalls operator backward to the connection.		Lighted lamp for duration of ring	
Ringing Start			→	Starts ringing when terminating equipment is of controlled ringing type.			
Wink-Off	√		→	Releases customer from operator trunk.			
Reverse Make Busy		√	←	Make busy from far end of trunk.			
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 or no 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 or no tone	
Coin Denomination Tones			→ ←	Indicates number and denomination of coins deposited in coin box.	Tones from gongs or oscillator in coin box		
Class of Service Tone			→	Indicates 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-Hz tone of 0.5-second duration applied every 15 seconds		
Recall (Customer Flashing)	√	√	→ ←	Manually recalls operator to connection.		Flashing lamp	6

Notes:

1. In cordboard operation, 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. In TSP operation, these signals are indicated on KP and Start lamps.

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

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

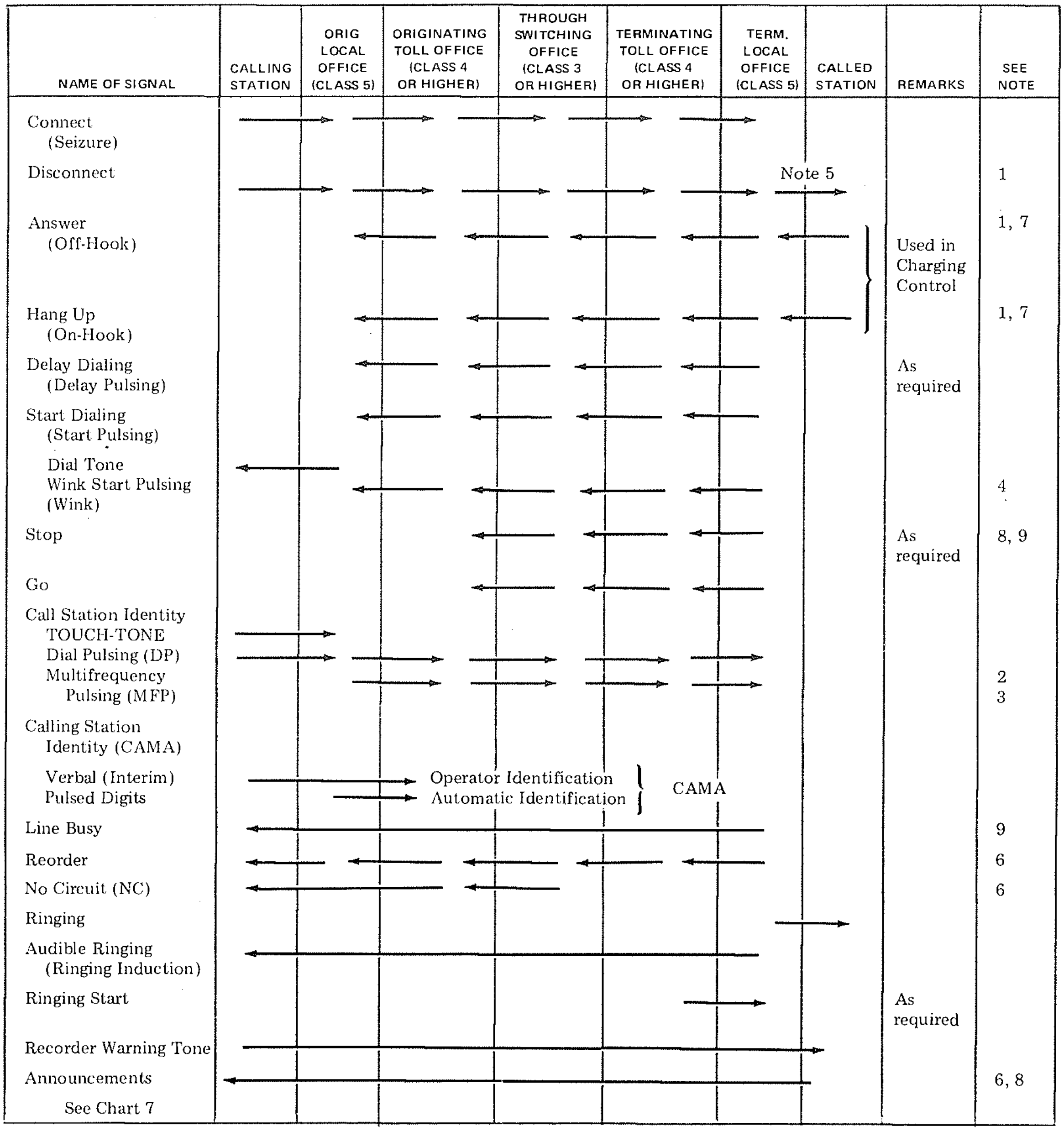
4. An ST pulse may not be sent on calls by multiparty customers or if there is an identification failure.

5. Some offices may still be returning flashes in synchronism with tone. Flashing signals should be eliminated and only audible tone signals used.

6. With Traffic Service Position operation, the effect of flashing can depend upon the circumstances, but in most instances, a flashing supervisory lamp will result.

Chart 1—Signals Required in Distance Dialing (Cont)

USE OF SIGNALS WITH DIRECT DISTANCE DIALED CALLS



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 10 to 32 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. It is desirable to return real or simulated answer supervision to the originating office in all cases if feasible.
8. Announcement may be by operator or by machine (recorded announcement).
9. Stop is returned when selector cuts in on the level having trunks which require this signal.

Chart 2—Use of Signals With Direct Distance Dialed Calls

SERVICE TRUNKS

FUNCTION	TYPE OF EQUIPMENT	LOCATION	DIRECTION	SUPERVISION	START	ADDRESS OF CALLED PARTY	ADDRESS OF CALLING PARTY	COIN CONTROL[1]	RINGING[2]	OTHER SIGNALS
Recording Completing—Special Service (Dial "0") Coin	3C-Type SWBD or Equivalent	Remote Building	To SWBD	E&M	None	None	None	Inband	Inband[3]	None
				LOOP Reverse Battery—High-Low	None	None	None	Tip and Ring	Tip and Ring	None
								Inband	Inband	None
		Same Building	To SWBD	Sleeve Lead	None	None	None	Tip and Ring	Tip and Ring	None
Recording Completing—Special Service (Dial "0") Noncoin	3C-Type SWBD or Equivalent	Remote Building	To SWBD	E&M	None	None	None	None	Inband — Wink Only and Wink and MF Tone	Emergency Ringback from Operator
				LOOP Reverse Battery—High-Low	None	None	None	None	Tip and Ring	Emergency Ringback
					None	None	None	None	Inband — Wink Only	Emergency Ringback
		Same Building	To SWBD	Sleeve Lead	None	None	None	None	Tip and Ring	Emergency Ringback
Recording Completing—Special Service Coin and Noncoin Combined	3C-Type SWBD or Equivalent	Remote Building	To SWBD	Same as RC Coin	None	None	None	Same as RC Coin	Same as RC Coin	Class of Service Tone to Operator, Emergency Ringback
TSP—Coin (a) 0+, 1+ (b) Dial 0 (c) 00 (d) Dial 0, 00.	TSP No. 100A	Remote Building	To TSP	LOOP Reverse Battery—High-Low	Wink	MF[4]	MF[4]	Inband	Inband	ANI Request Signal from TSP, Reverse Make Busy
					Wink	MF[4]	MF[4]	Multiple Winks	Multiple Winks	
				E&M	Wink	MF[4]	MF[4]	Inband	Inband	ANI Request Signal from TSP, Reverse Make Busy
					Wink	MF[4]	MF[4]	Multiple Winks	Multiple Winks	

Notes:

1. Coin control consists of two signals: coin collect and coin return.
2. Ringing — ringing the customer.
3. The inband signals will be preceded by a wink.
4. Special format. (See Tables 5 and 6.)
5. Also operator-attached and operator-released signals when multiple winks are used.

Chart 3—Service Trunks

SERVICE TRUNKS (Cont)

FUNCTION	TYPE OF EQUIPMENT	LOCATION	DIRECTION	SUPERVISION	START	ADDRESS OF CALLED PARTY	ADDRESS OF CALLING PARTY	COIN CONTROL	RINGING	OTHER SIGNALS
TSP—Noncoin (a) 0+ (b) Dial 0 (c) 00 (d) Dial 0, 00.	TSP No. 100A	Remote Building	To TSP	LOOP Reverse Battery—High-Low	Wink	MF[1]	MF[1]	None	Inband—Wink Only	ANI Request Signal from TSP Reverse Make Busy
				E&M	Wink	MF[1]	MF[1]	None	Inband—Wink Only and Wink and MF Tone	ANI Request Signal from TSP Reverse Make Busy
TSPS—Coin (a) 1+ (b) Some or all combined (Dial 0, 00, 0+, 1+) (c) Dial 0, 00 (d) Dedicated 00.	TSPS No. 1	Remote Building	To TSPS	LOOP Reverse Battery—High-Low	Wink	MF[1]	MF[1]	Inband	Inband	ANI Request from TSPS Reverse Make Busy[2]
					Wink	MF[1]	MF[1]	Multiple Winks	Multiple Winks	
				E&M	Wink	MF[1]	MF[1]	Inband	Inband	ANI Request from TSPS Reverse Make Busy[2]
					Wink	MF[1]	MF[1]	Multiple Winks	Multiple Winks	
TSPS—Noncoin (a) 1+ (b) Some or all combined (Dial 0, 00, 0+, 1+) (c) 0+ (d) Dial 0, 00 (e) Dedicated 00.	TSPS No. 1	Remote Building	To TSPS	LOOP Reverse Battery—High-Low	Wink	MF[1]	MF[1]	None	Inband—Wink Only	ANI Request from TSPS Reverse Make Busy
				E&M	Wink	MF[1]	MF[1]	None	Inband—Wink Only and Wink and MF Tone	ANI Request from TSPS Reverse Make Busy
TSPS—Coin and Noncoin Combined Some or all combined (Dial 0, 00, 0+, 1+)	TSPS No. 1	Remote Building	To TSPS	LOOP Reverse Battery—High-Low	Wink	MF[1]	MF[1]	Inband	Inband	ANI Request from TSPS Reverse Make Busy[2]
					Wink	MF[1]	MF[1]	Multiple Winks	Multiple Winks	
				E&M	Wink	MF[1]	MF[1]	Inband	Inband	ANI Request from TSPS and (RMB)[2]
					Wink	MF[1]	MF[1]	Multiple Winks	Multiple Winks	
Toll Switch Noncoin	3C-Type SWBD or Equivalent	Remote Building	From SWBD	E&M	Delay Dial	MF	None	None	Inband—Wink Only and Wink and MF Tone	None
				LOOP Reverse Battery—High-Low	Delay Dial	MF	None	None	Inband—Wink Only	None
						MF and Dial Pulse	None	None	Simplex	None
		Same Building	From SWBD	Sleeve Lead	Delay Dial	MF and Dial Pulse	None	None	Tip and Ring	None

Notes:

1. Special Format. (See Tables 5 and 6.)
2. Also operator-attached and operator-released signals when multiple winks are used.

Chart 3—Service Trunks (Cont)

SERVICE TRUNKS (Cont)

FUNCTION	TYPE OF EQUIPMENT	LOCATION	DIRECTION	SUPERVISION	START	ADDRESS OF CALLED PARTY	ADDRESS OF CALLING PARTY	COIN CONTROL	RINGING	OTHER SIGNALS
Toll Switching Noncoin Controlled Ring	3C-Type SWBD or Equivalent	Remote Building	From SWBD	Same as Toll Switch Noncoin	Delay Dial	Same as Toll Switch Non-coin	None	None	Same as Toll Switch Noncoin	Controlled Ring Signal from Operator
Toll Switching Coin	3C-Type SWBD or Equivalent	Remote Building	From SWBD	Same as Remote Bldg Toll Switch Noncoin	Delay Dial	Same as Toll Switch NC	None	Inband and Tip and Ring	Inband and Tip and Ring	None
		Same Building	From SWBD	Sleeve Lead	Delay Dial	MF and Dial Pulse	None	Third Wire	Tip and Ring	None
Intercept Operator (Regular)	3C-Type SWBD or Equivalent or No. 23C Operating Room Desk	Same or Remote Building	To Equip-ment	E&M	None	None	None	None	None	None
				LOOP	None	None	None	None	None	None
Trouble	Same as Operator	Same as Operator	Same as Operator	Same as Operator	None	None	None	None	None	None
Machine	Announcement Machine No. 11A	Same or Remote Building	To Machine	LOOP	None	None	None	None	None	None
Combined (Regular, Trouble, and Machine)	No. 6A Announce-ment System	Same or Remote Building	To System	LOOP Reverse Battery—High-Low	None	None	None	None	None	Signal to Ann. System Accompanying Sei-zure to Indicate Regular, Trouble Machine
Combined (Regular, Trouble, and Machine)	Automatic Inter-cept Center (AIC)	Same or Remote Building	To System	LOOP Reverse Battery—High-Low	Wink	MF[1]	None	None	None	Reverse Make Busy
				E&M	Wink	MF[1]	None	None	None	Reverse Make Busy
Repair Service	Repair Service Desk No. 2, 1C	Same or Remote Building	To RS Desk	LOOP High-Low	None	None	None	None	None	Make Busy Indi-cation from Repair Desk (RMB)
Testing	Local Test Desk No. 14 or Local Test Cabinet No. 3	Same or Remote Building	To Desk, Cabinet	Sleeve Lead and Reverse Battery	None	None	None	None	None	
			From Desk	Sleeve Lead and Reverse Battery	None	MF or DP	None	None	None	Test Signals from Test Desk (See Section 8.)

Note:

1. Special Format. (See Tables 5 and 6.)

Chart 3—Service Trunks (Cont)

TYPICAL RESPONSE TIMES OF F-TYPE E&M UNIT

TRANSMITTER SIGNALING CHARACTERISTICS

Tone Pulse Output	
Pulse Delay	17 ±2 milliseconds
Pulse Distortion	0 ±1.5 milliseconds
Transmit Cut	
Cut Delay	5 to 13 milliseconds
Effective Precut	14 to 2 milliseconds
"Break" Cut Duration	575 ±175 milliseconds
"Make" Cut Duration	125 ±35 milliseconds

RECEIVER SIGNALING CHARACTERISTICS

Detector	
Bandwidth	75 Hz
Initial Tolerance	±5 Hz
Aging Effect	±8 Hz
Center Frequency	±0.3 percent
Signal-Guard Ratio	10 dB
Sensitivity (min)	—25 ±1 dBm
(max.)	+8 ±1 dBm
Timing	
Filter Insertion	13 ±7 milliseconds
Duration	225 ±50 milliseconds
E Lead	
Operate Time	33 ±1.5 milliseconds
Release Time	32 ±1.5 milliseconds
Distortion	—1 ±1.5 milliseconds
Min Breakout	51 ±3.5 milliseconds
"G" Function Activation	225 ±50 milliseconds

Chart 4—Typical Response Times for F-Type E&M Unit for Sender Dial Pulsing

TYPICAL TRANSMISSION CHARACTERISTICS OF F-TYPE 4-WIRE E&M UNIT

TRANSMISSION CHARACTERISTICS – TRANSMITTING

Insertion Loss	
Nominal at 1000 Hz	0.1 dB
Initial Tolerance	±0.05 dB
Effect of Aging and Temperature	±0.02 dB
Frequency Characteristics 200 to 4000 Hz	±0.1 dB
Return Loss (Minimum)	
250 to 3000 Hz	30 dB
Longitudinal Balance (Minimum)	
250 to 3000 Hz	65 dB
Applied Tone Levels	
High Level	−24 dBm (−16 TLP)
Low Level	−36 dBm (−16 TLP)
Tolerance	±0.5 dB

TRANSMISSION CHARACTERISTICS – RECEIVING

Insertion Loss	
Nominal at 1000 Hz	0 dB
Initial Tolerance	±0.05 dB
Effect of Aging and Temperature	±0.1 dB
Frequency Characteristics 300 to 4000 Hz	±0.1 dB
Delay Distortion 500 to 3000 Hz	<20 μsec
Insertion Loss Through Filter	
Nominal at 1000 Hz	0 dB
Initial Tolerance	±0.15 dB
Effect of Aging and Temperature	±0.1 dB
Frequency Characteristics	
300 to 2000 Hz	±0.1 dB
2600 Hz	45 dB min
3000 to 4000 Hz	±0.5 dB
Accuracy of Center Frequency	±0.3 percent
Return Loss (Minimum)	
Line Receive 250 to 3000 Hz	30 dB
Equipment Receive 250 to 3000 Hz	30 dB
Longitudinal Balance (Minimum)	
Line Receive 250 to 3000 Hz	65 dB
Equipment Receive 250 to 3000 Hz	60 dB

Chart 5—Typical Transmission Characteristics of F-Type 4-Wire E&M Unit

INTEROFFICE SIGNALING FOR AUTOMATIC INTERCEPT SYSTEM (INCOMING 2-WAY LOOP TRUNK)

Automatic Number Identification (ANI):

(1) Battery and ground signaling.

(2) Reverse Battery Answer Supervision.

(3) Reverse make-busy feature to make the local office outgoing trunk busy from the Automatic Intercept Center (AIC).

(4) Idle condition (on-hook with battery on ring and ground on tip).

Operator Number Identification (ONI):

(1) One Class (single class of intercept traffic on one trunk):

- (a) With or without supervision.
- (b) Supervision could be Hi-Lo, Bridge, or dc signaling.
- (c) No reverse make-busy feature.
- (d) Idle condition same as ANI trunk.

(1) Three Classes (three classes of intercept traffic on one trunk; see Table 7):

- (a) DC signaling or dial pulse signaling. (See Table 8.)
- (b) No reverse make-busy feature.
- (c) Idle condition same as ANI trunk.

Directory Assistance:

(1) Same as One Class ONI.

Note: Local office E&M outgoing trunks are converted to Loop at the AIC.

Chart 6—Signaling for Automatic Intercept System

TONES AND ANNOUNCEMENTS RECOMMENDED FOR DISTANCE DIALING

The following table shows the recommended tones and announcements encountered by customers and operators on distance dialed calls. The texts of recommended or typical announcements are shown on the following page.

CUSTOMER AND/OR OPERATOR ENCOUNTERS	RECOMMENDED TONE OR ANNOUNCEMENT
Prior to start of dialing	Dial Tone
On connection to called line or to operator trunk	Audible Ringing Signal
Line Busy	60-IPM Low Tone
Switching Blockages	
Local	120-IPM Low Tone (Announcement similar to "N" or "X" may be used.)
Toll	
(a) No. 4 and Toll XBT	
Switching Paths Busy	Announcement P
Sender Overload	Announcement N
(b) Other	
Switching Paths Busy	120-IPM Low Tone
Sender Overload	120-IPM Low Tone
All Trunks Busy	
Local and Toll Connecting	120-IPM Low Tone
Intertoll	
Normal	120-IPM Low Tone
Heavy Calling (No. 4 and Toll XBT)	Announcement N
Disaster (No. 4 and Toll XBT)	Announcement X
Common control equipment irregularity caused by misdialing or trouble	
Local	120-IPM Low Tone
Toll	
No. 4 and Toll XBT	Announcement P
Other	120-IPM Low Tone
Vacant Number	Vacant Number Announcement or Operator
Vacant Code	Operator or Announcement L

Chart 7—Tones and Announcements Recommended for Distance Dialing

RECOMMENDED ANNOUNCEMENTS

ANNOUNCEMENT	TEXT
N	I'm sorry, (pause) all circuits are busy now. Will you try your call again later, please? This is a recording. [(Location code) — NPA + toll office number]
P	I'm sorry, your call did not go through. Will you please hang up and try again? This is a recording. [Location code — (NPA + toll office number)]
L	I'm sorry, we are unable to complete your call as dialed. Please check the number and dial again or ask your operator for assistance. This is a recording.
X	(With flexibility due to situation) I'm sorry, unexpected damage to telephone equipment in Kansas City (or near Kansas City) has delayed your call. Emergency calls may be placed with your operator. This is a recording.
Vacant Number	
(a) Announcement machine equipped with operator intercept cut-through.	I'm sorry, the number you have reached is not in service at this time. If you need assistance, please stay on the line and an operator will answer. This is a recording.
(b) Announcement machine not equipped with operator intercept cut-through (CDOs).	I'm sorry, the number you have reached is not in service at this time. If you need assistance, please hang up and dial your operator. This is a recording.

Chart 7—Tones and Announcements Recommended for Distance Dialing (Cont)

DIGIT TIMING REQUIREMENTS (MINIMUMS)

	4A AND 4M			4A AND 4M CAMA		CROSSBAR TANDEM (INCL CAMA)		NO. 5 CROSSBAR (INCL CAMA)		SxS CAMA		NO. 1 ESS	
	DP SENDER	DP REG	MF	DP	MF	DP φ	MF	DP	MF	DP	MF	DP	MF
First digit must be received in less than ______ seconds from seizure.	10	16	10	16		15		19 4.4 ##		15		16 10 ##	
Both second and third digits must be received in less than ______ seconds from registration of first digit.	10		10	—		—		—		—		—	
Second and third digits must each be received in less than ______ seconds from registration of previous digit.		16		16		15		19 4.4 ##		15		16 5 ##	
Fourth digit must be received in less than ______ seconds from registration of third digit.	3*	3		16		15				15		16 5 ##	
When total number of digits expected is indicated to register by classmarks or translation of one or two initial digits, each digit after third digit must be received in less than ______ seconds from registration of previous digit.		—		—		—		19 4.4 ##		—		—	
When total number of digits expected is not indicated to register, each digit after third digit must be received in less than ______ seconds from registration of previous digit.		3		—		—		2.8 *** (tube timer) 3.2 *** (trans. timer)		—		—	
Each digit after fourth digit must be received in less than ______ seconds from registration of previous digit.	3*	3		16 #		15 #, **		—		15 #		16 5 ##	
All digits must be received in less than ______ seconds from seizure.					10		20	19	19		19		16 10 ##
All remaining digits must be received in less than ______ seconds from registration of third digit.	10		10	—		—		—		—		—	

*Units not incorporating recent changes have comparable but not identical timing.
#In the future, the interval following the seventh digit will be subject to 3-second time-out if interchangeable code assignments make this necessary.
φIncludes both 3- and 10-digit register operation.
**Assumes discontinuation of timing for stations digit.
##Under overload conditions.
***Centrex (1XX and 0XX) only.

Chart 8—Digit Timing Requirements

SENDER, REGISTER, OR LINK ATTACHMENT TIMING REQUIREMENTS

		4A AND 4M	4A AND 4M CAMA	CROSSBAR TANDEM (INCL CAMA)	NO. 5 CROSSBAR (INCL CAMA)		SXS CAMA	NO. 1 ESS
					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	20	19	13	19	16
	Heavy Traffic	5 (Note 1)	5 (Note 1)	3, 5, or 8	4.4	4.4	4.6	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 2)	20	20	19	—	19	16
	Heavy Traffic	30 (Note 2)	20	3, 5, or 8	4.4	—	4.6	4

Notes:

1. This is present nominal adjusted interval. The range of adjustment is 3 to 8 seconds.
2. Twenty seconds in 4M.

Chart 9—Sender, Register, or Link Attachment Timing Requirements

NOTES ON DISTANCE DIALING

SECTION 6

COMMON CHANNEL INTEROFFICE SIGNALING

CONTENTS PAGE

1. GENERAL

1.01 Common Channel Interoffice Signaling (CCIS) is a system for exchanging information between processor-equipped switching systems over a network of signaling links. All signaling data, including the supervisory and address signals necessary to control call setup and takedown, as well as network management signals, will be exchanged by these systems over the signaling links instead of being sent over the voice path as done using present inband signaling techniques.

1.02 Block diagrams for systems using inband signaling and CCIS are shown, respectively, in Fig. 1A and 1B. With conventional inband signaling, a single-frequency (SF) unit is required at each trunk end. In addition, a number of multifrequency (MF) transmitters and receivers switched to these trunks are required to pass address information. With CCIS, both the SF units and the MF equipment will be supplanted by a signaling link between the two processors and a number of continuity-checking transceivers.

1.03 As shown in the figure, the signaling link will consist of two signaling terminals, two modems, and a Voice-Frequency Link (VFL). The signaling terminals store both outgoing signaling messages awaiting transmission and incoming messages until ready to be processed. The terminals also perform error control through redundant coding and retransmission of signaling messages found to be in error. Each modem forms a digital-analog interface between the terminal and voice-frequency link. The VFL is a conventional 4-wire message-grade transmission facility (type 3002 data channel). The Terminal Access Circuit (TAC) enables the processor to access the various signaling links, provides an interface between processor and terminal, and performs certain maintenance operations.

1.04 With CCIS, no signals are passed over the message trunks. Hence, trunk failures can no longer be detected by the loss of supervision as is done with SF/MF signaling. Instead, a number of tone transceivers are provided which are connected to CCIS trunks during call setup to check the continuity of the voice path.

1.05 Although a direct signaling link is shown in Fig. 1B, the signaling information will normally be routed through one or two Signal Transfer Points (STPs). These STPs act as signaling message processors which concentrate the signaling for a large number of trunks onto a few signaling links.

1.06 With CCIS, the signaling for many trunks will be sent over the same signaling links. Therefore, all portions of the signaling network will be sufficiently redundant and diversified so as to insure signaling availability. The functions performed by each of these components will be discussed in greater detail in later paragraphs.

2. ADVANTAGES OF CCIS

2.01 CCIS offers a number of important advantages over present inband signaling techniques.

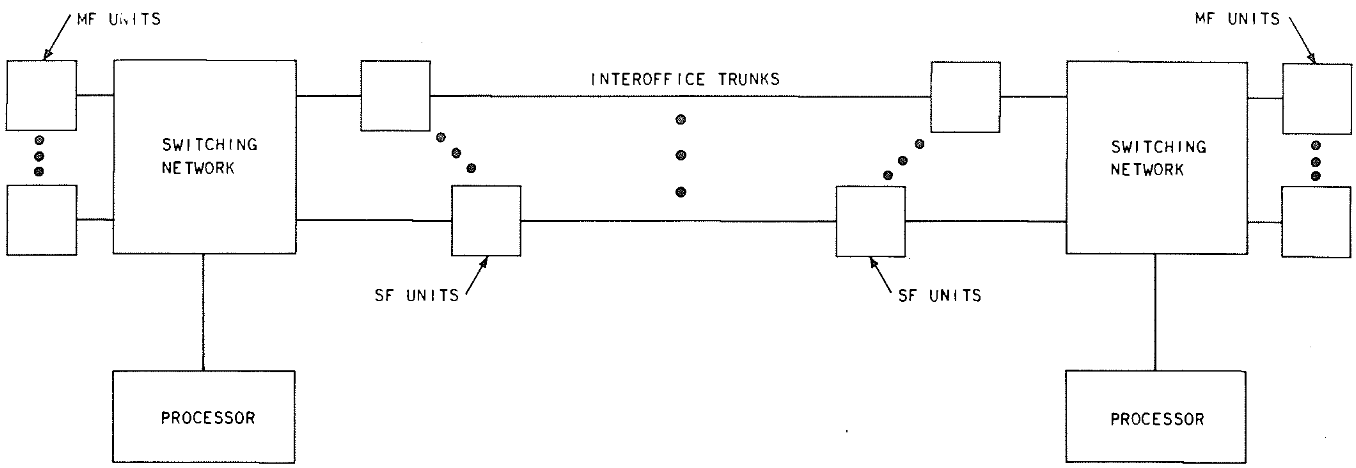


FIG. 1A - SF/MF SIGNALING

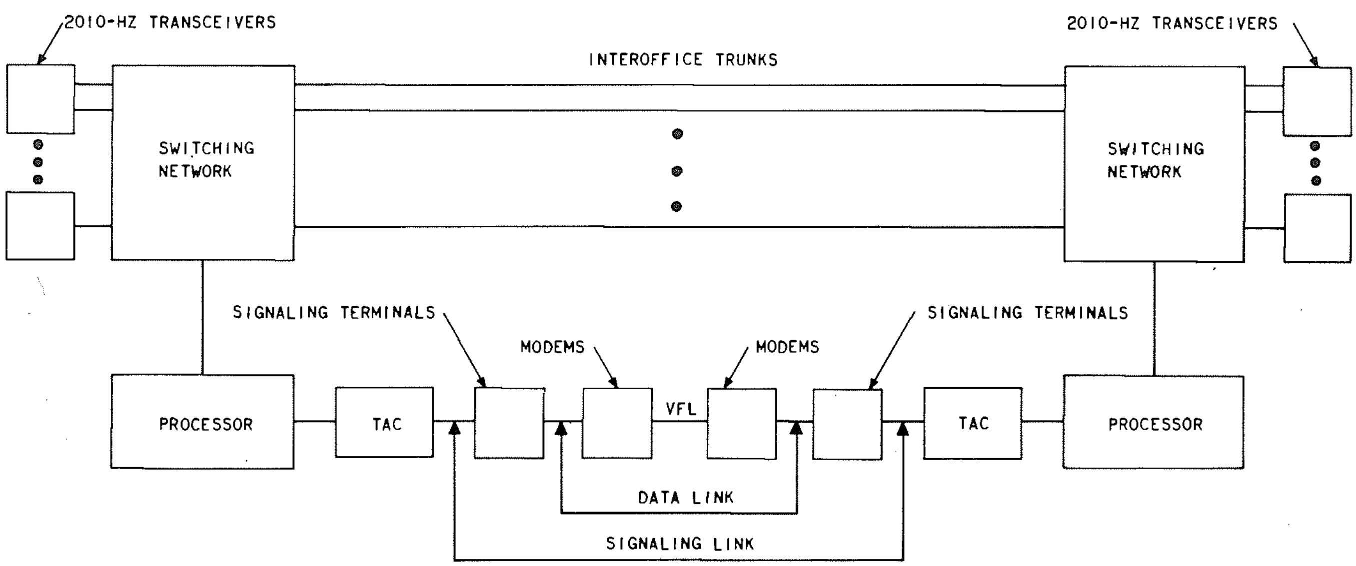


FIG. 1B - FUNCTIONAL BLOCK DIAGRAM - CCIS SYSTEM

Fig. 1—Signaling System Block Diagrams

The major advantages are described in the following paragraphs.

SIGNALING SPEED

2.02 Because CCIS passes signals at higher speeds than conventional signaling systems, calls can be set up and taken down faster. This has the beneficial effect of reducing post-dialing delay to the calling customer. In addition, the holding time of trunks and switching equipment is reduced leading to more efficient use of these facilities. Call setup times now vary with the number of links in the connection. This variation will decrease as the CCIS network grows with the result that the customer will experience more uniform call setup time, regardless of the number of links involved.

INFORMATION CAPACITY

2.03 CCIS inherently has more information carrying capacity than is now available in conventional signaling systems. Per-call information (traveling classmarks) can carry routing or control information unique to each individual message. Thus, new and improved customer services are made possible by CCIS. Some of these will be discussed in part 3. In addition, more efficient operation of the telephone network can be achieved by using CCIS links to transfer Network Management information.

2-WAY SIGNALING

2.04 CCIS uses a separate 2-way data link and signals can be sent in both directions of transmission simultaneously. In addition, signaling can take place during the period of conversation on the trunk. This would make it possible, for example, to process a request in the backward direction for the telephone number of the calling line (Calling Line Identification) if the switching machines were programmed to do so.

SEPARATE SIGNALING CHANNEL

2.05 Other advantages accrue because CCIS utilizes a path which is independent of the trunk voice path. Interactions between voice and supervisory signals such as "talk off" (disconnect of the talking path by voice signals) are eliminated. Also eliminated are present bandwidth restrictions on the use of the voiceband to insure data operation compatible with SF signaling; thus, in an all-CCIS connection, the network will be more transparent to the customer. In addition, the possibility of fraud by simulation of conventional inband tone signals is reduced and would, in an all-CCIS network, be eliminated. Another disadvantage of inband signaling eliminated by CCIS is the occurrence of mass seizures resulting from the loss of inband tones on idle trunks due to a carrier failure.

COMPATIBILITY WITH INTERNATIONAL SIGNALING

2.06 It is expected that international telephone traffic will make use of CCITT Signaling System No. 6, the most recent of the standard international systems. CCIS closely resembles CCITT No. 6 except for message format variations. By providing translation equipment at international switching offices, it will be possible to integrate international and domestic traffic more efficiently than is presently possible (perhaps in common trunk groups).

RELIABILITY

2.07 CCIS offers the potential of more reliable transfer of address information than present conventional methods.

FLEXIBILITY

2.08 Perhaps one of the outstanding characteristics of CCIS relating to network operation and customer service is that the CCIS message format allows considerable latitude and flexibility in transmitting all types of signaling information including signals that might be used for future services not yet defined.

3. INITIAL CCIS FEATURES

3.01 The advantages of CCIS in signaling speed, signal capacity, and flexibility permit the introduction of many new signaling/switching features. These new features, which, in general, are unavailable with conventional signaling systems, will be beneficial to both customers and operating companies. It is anticipated that new features will grow in number and usefulness as the CCIS network grows and its application spreads to local ESS offices and Traffic Service Position Systems (TSPSs).

3.02 The initial application of CCIS, although limited to the intertoll network, will have a variety of new and attractive features. Most of these features stem directly from CCIS's capability of transmitting additional information between machines rapidly and reliably. The paragraphs that follow contain those features which are currently being planned for the initial installations of CCIS in the toll network along with a brief description of each.

3.03 ***Additional Routing Information***—This added routing information will be part of the Initial Address Message (IAM) which contains the trunk identity and all the address digits. The additional routing information includes the following:

(1) ***Nature-of-Trunk Indicator***—Used to indicate whether or not a satellite trunk is in the connection and as such can be used by switching systems, via routing constraints, to preclude two satellite trunks on a given connection.

(2) ***Out-of-Chain Routing Indicator***—Used to indicate whether or not a given call has been routed in chain or out of chain.

(3) ***Link-Out-of-Chain Indicator***—Used to distinguish between out-of-chain status on a directly connected incoming trunk or on some previous trunk. The combination of these two indicators [(1) and (2)] can be used to show whether a given call has departed from normal hierarchical routing patterns and, on that basis, control subsequent routing to eliminate circular and shuttle routing (frequently called "ring-around-the-rosy").

3.04 ***CCIS History Indicator***—Used to indicate whether or not a given call has been served by CCIS on all previous links of a built-up connection. Initially, it will be used on domestic toll links in conjunction with the international inbound routing category (discussed under Routing Category) to differentiate between those calls requiring audible signals (for no circuit or reorder) to indicate ineffective attempts (not CCIS all the way) and those calls on which electrical (data) signals can be used (CCIS all the way). The use of electrical signals permits the release of the connection and the application of the audible signals at, in the case described, the originating outgoing international exchange.

3.05 ***Calling Party's Category***—Used to indicate either the call source (eg, unknown source, ordinary operator, or ordinary calling customer) or call type such as test call. Call source information will be useful in applications which require discrimination between operator- and customer-originated calls for screening or other purposes.

3.06 ***Routing Category***—Used to indicate type of call such as ordinary intertoll, international outbound, international inbound, or international transmit. The latter routing category, international transmit, will be especially useful in that it will provide the necessary discriminating information to permit handling international transit traffic over domestic trunk groups between International Switching Centers.

3.07 ***Ineffective Attempt Signals***—Several electrical signals transmitted in the backward direction, such as trunk congestion, switching congestion, address incomplete, vacant number, and call failure, are used in place of audible tones or announcements. By use of these signals, a switching system close to the call source can release the connection ahead and provide an appropriate audible signal or recorded announcement to the calling customer. This feature eliminates wasted trunk holding time for ineffective attempts. Electrical signals should also simplify the process of identifying ineffective attempts for subsequent analysis.

3.08 ***Trunk Blocking-Unblocking Signals***—By means of these signals, CCIS trunks can be blocked by maintenance personnel to remove them from outgoing service at the distant end. The ability to make a distant trunk "busy" facilitates testing of that trunk and reduces the need for coordination between testboards. The blocking signal can be initiated on a trunk that is in use. The trunk, in this case, will be blocked when the call terminates. Blocking of a trunk is automatic on failure of the continuity check (3.10). An unblocking signal is provided to restore the trunk to service. Maintenance personnel at each end of the trunk are notified when a trunk is taken out of service.

3.09 ***Elimination of Trunk Guard Timing***—Another signal transmitted in the backward direction, release guard, eliminates trunk guard timing at the outgoing end of a trunk. The receipt of the release guard signal, which is sent in response to the disconnect signal subsequent to making the trunk idle, is an indication that the trunk is available for a new call.

3.10 ***Continuity Check***—CCIS-equipped offices perform a continuity check of the selected trunk during call setup. If the terminating office is a 4-wire switching system, the originating processor attaches a 2010-Hz transceiver to the selected trunk concurrent with sending the Initial Address Message (IAM). The distant office, upon receipt of the IAM, connects the receive side of the trunk to the transmit side through a zero-loss loop. If the terminating office is a 2-wire No. 1 ESS, the originating office transmits 1780 Hz. The terminating office, upon receipt of the IAM, attaches a transponder to the incoming trunk and returns 2010 Hz upon recognition of the 1780-Hz tone. In either case, the originating office checks the level of the returning tone to verify that transmission loss is within acceptable limits. The sensitivity of this check is superior to the implied check obtained with conventional inband signaling systems and will thus provide an improved grade of service. If the check fails, a second trunk is selected, the failed trunk is automatically blocked, and a special test call is initiated to repeat the test. If the second test passes, the trunk is automatically unblocked. A second failure will initiate a teletypewritten maintenance request.

3.11 ***Repeat Attempt Capability***—With CCIS, provisions are made to rapidly initiate a repeat attempt at the outgoing end, when required, such as on detection of a continuity check failure. If glare is detected, the noncontrol end backs off, processes the incoming call on that trunk, and repeats the outgoing attempt on another trunk.

4. SYSTEM DESCRIPTION AND OPERATION

SIGNALING NETWORK STRUCTURE

4.01 The simplest and most direct form of CCIS is to provide a direct signaling link between the processors of all CCIS-equipped switching systems having interconnecting trunks. Such a configuration is known as "associated signaling," ie, the signaling link is associated with a specific trunk group. Studies have shown that because of the resulting sparse loading of the signaling links, providing CCIS on all candidate trunk groups on an associated basis would be uneconomical. Even so, direct links known as "Fully Associated" or "F" links may prove economical between switching systems with a sufficiently large number of interconnecting trunks.

4.02 In most cases, however, CCIS will be provided via a "signaling network." The nation will be divided initially into ten signaling regions which have been chosen to correspond to the existing regions of the DDD hierarchy. All CCIS-equipped switching systems within a switching region will concentrate the signaling traffic for all their CCIS trunks on a few well-loaded "Access" links ("A" links) to a pair of signal message concentrators in the region called Signal Transfer Points (STPs). (A links are always provided in fully-redundant pairs, one link to each of the two STPs in the region.) Between regions, one or more "Bridge" (or "B") links will connect each STP to its counterpart in the other region.

4.03 Because the signaling for many trunks will be sent over the same signaling link (approximately 3000 trunks per pair of A links), all signaling messages will include a label identifying the trunk for which signaling is being sent. The STPs will use this label to determine the outgoing link on which the received signaling message is to be forwarded. Both the coding format of the various signaling messages and the STP translation procedure will be explained in later paragraphs.

4.04 The basic (nonredundant) CCIS network thus takes the form shown in Fig. 2. Here, for simplicity, only two CCIS Switching Offices (SOs) are shown in each of two regions. This network, however, can be generalized to represent many SOs and signaling regions by imagining an A link between each STP and each SO in its region and a B link from each STP to each of the STPs in all other signaling regions. From this figure, for example, signaling from SO1 to SO2 (for trunk group TG1) would be sent over access link A1 to STP1 where it would be forwarded (after translation) over access link A2 to SO2. Interregional signaling, on the other hand, will normally involve two STPs; thus, signaling from SO2 to SO4 (for trunk group TG3) would be sent over access link A2 to STP1, then forwarded over bridge link B1 to STP2, and finally sent over access link A4 to SO4.

4.05 In some cases, a CCIS switching office in one region will have sufficient trunks to CCIS offices in another region to justify a direct signaling link from this office to the STP in the other region. Such a signaling link is known as an "Extension" (or "E") link. Such links are introduced to save processing capacity at the bypassed STP and, to some extent, to reduce signal transmission delays. In Fig. 2, SO4 has an E link (E1) to STP1 in Region I.

4.06 No signaling link redundancy is implied anywhere in Fig. 2, eg, a failure of link A1 would isolate SO1 from the network. Likewise, if link B1 were to fail, interregional signaling would be disrupted. For this reason, all signaling paths and STPs will be duplicated and fully redundant. The planned network structure is shown in Fig. 3. Here each STP is connected to the "mate" STP in its own region by "Cross" (or "C") links and to the mate STP in all other regions by "Diagonal" (or "D") links. Together, the four links between two regions are referred to as a "quad." Additional redundancy is achieved by providing access links from each SO to both STPs in the home switching region. "A11" and "A12" illustrate this redundancy. To achieve even greater reliability, two Voice-Frequency Links (VFLs) will be assigned to each A link.

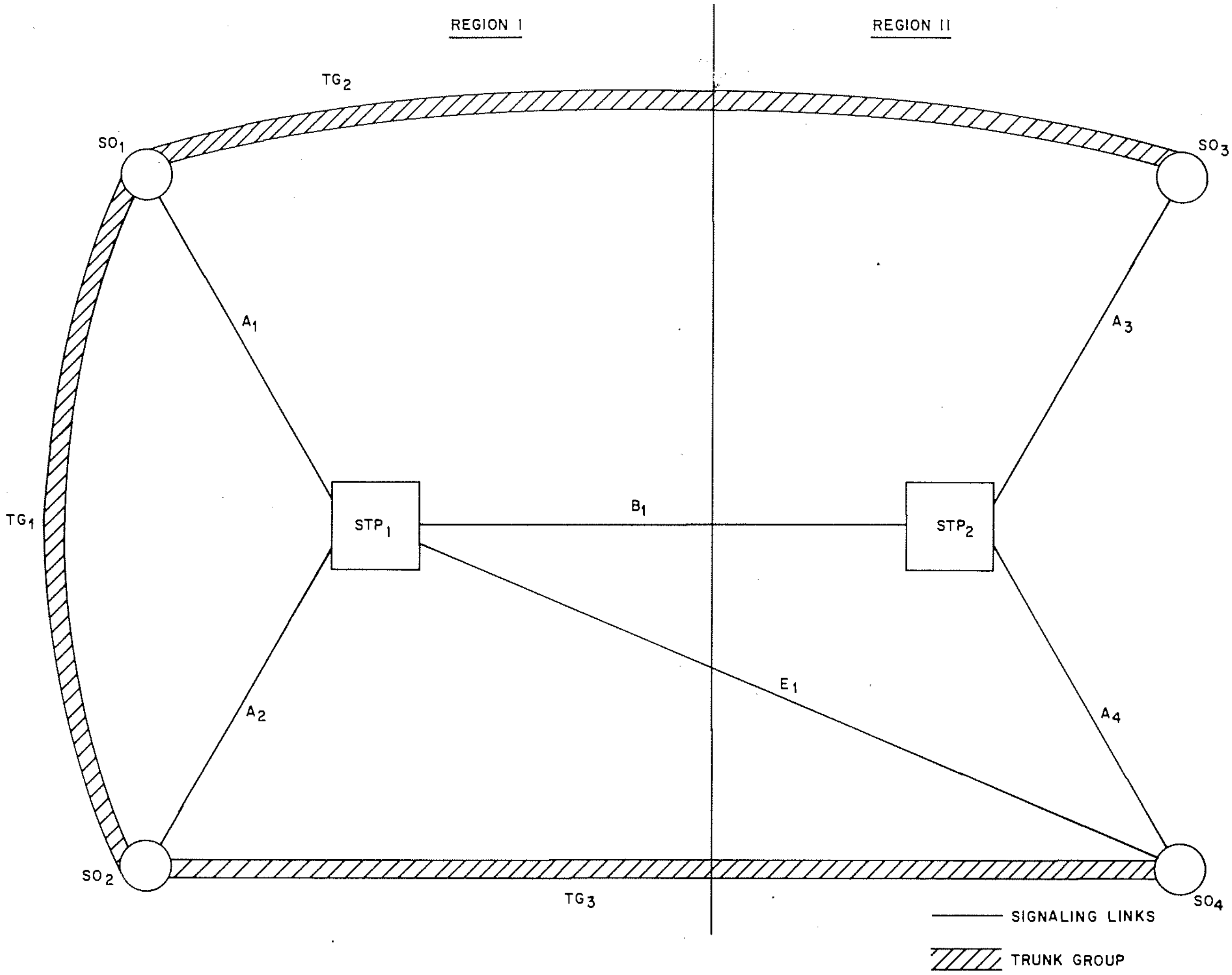


Fig. 2—Basic (Nonredundant) Signaling Network Structure

These VFLs will utilize diverse routes if possible. In the event of failure or high error rate on the regular VFL, the reserve is automatically switched into the signaling link under control of the processor.

4.07 With the above structure, intraregional signaling traffic can be sent on any of four paths; thus, signaling from SO1 to SO2 could be sent via A11-(STP I-1)-A21, A12-(STP I-2)-A22, A11-(STP I-1)-C1-(STP I-2)-A22, or A12-(STP I-2)-C1-(STP I-1)-A21. It can also be shown that interregional signaling traffic has 16 possible paths available. In the absence of link failures, however, signaling traffic is not transmitted on C links. The signaling network routing procedures and rerouting procedures during link failures are described later.

OPERATION OF SIGNALING LINKS

4.08 Refer to the block diagram of the CCIS system shown in Fig. 1B. Signal messages are generated by the processors of the switching systems in the form of one or more multibit Signal Units (SUs). The types and formats of these signal units will be described in the next section. These SUs are passed to a Terminal Access Circuit (TAC) along with instructions indicating on which outgoing link they should be sent and a relative priority (see following note) level. Since peripheral unit buses vary, the instruction format and the form of the SUs received by the TAC will vary according to the type of processor; thus, in order to use one type of signaling terminal for all systems, the TAC is different for different processors.

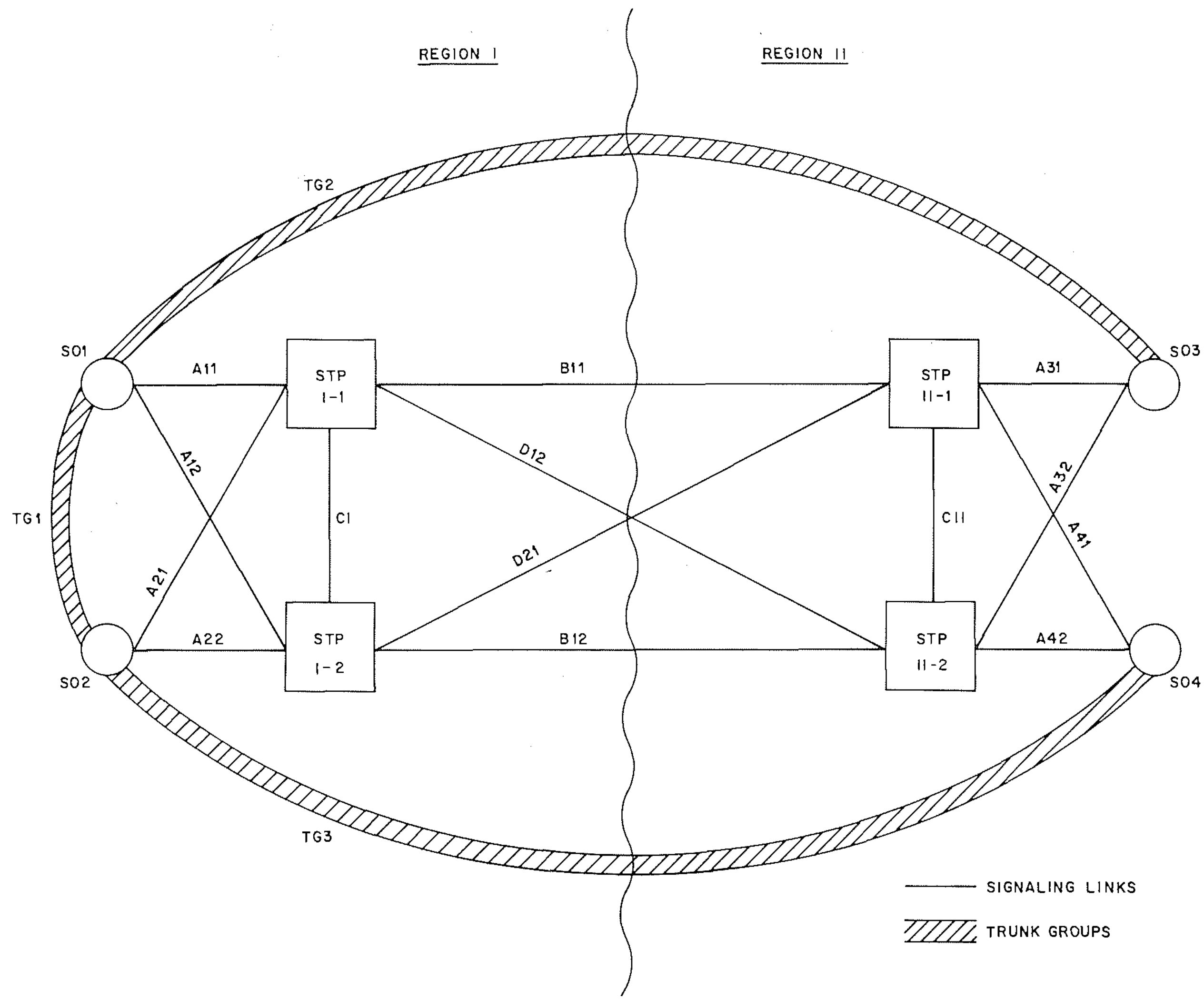


Fig. 3—Planned Signaling Network Structure

> *Note:* The relative priorities in descending order are: acknowledgment signals, faulty-link information, initial answer signals, other telephone signals, retransmissions due to errors, management signal messages, and synchronization signals.

4.09 The SUs are sent from the TAC to the signaling terminal corresponding to the indicated link and stored in a transmit buffer according to priority level. Each SU of a block of 12 remains in this buffer until it has been transmitted. It is then placed in the transmit record table until the terminal has received acknowledgment from the distant office that all SUs of the block have been correctly received.

4.10 When ready to be transmitted, each SU, in priority order, has eight check bits added and is passed serially to a modem for analog transmission over a 2-way VFL to the distant office or STP. This VFL is a 4-wire voice grade circuit meeting type 3002 data channel requirements and is operated full duplex; that is, both directions of transmission are used for signaling at the same time. Initially, a 4-phase modem, operating at 2400 bits per second, will be used.

4.11 At the far switching office or STP, a modem converts these SUs back into digital format and relays them to the receive portion of the signaling terminal. There, error checking is performed on the SUs utilizing the eight check bits. Error-free SUs, minus check bits, are stored in the receive buffer of the terminal until all SUs of the block have been received error free and the TAC indicates that the processor is ready to receive the message.

4.12 Correction of errors contributed by the data link is via retransmission. To accomplish this, all SUs are transmitted in blocks of 12, the first 11 of which contain signaling information. The twelfth SU of each block is an Acknowledgment Signal Unit (ACU) coded to indicate the number of the block in which it is included, the number of the block being acknowledged, and acknowledgment bits indicating whether or not each of the 11 signal units of the block being acknowledged was received without error.

4.13 As described in the previous paragraphs, primary error detection on the signaling links is achieved through use of redundant coding. In addition, a data carrier failure detector complements the bit error detector for detection of longer error bursts. Error-free messages are used without delay while a retransmission is requested of those found in error.

4.14 To insure continuity of service, provision is made for automatic transfer from a faulty link to an alternate link in event of a failure condition. The signaling terminal monitors the data carrier and the signal unit error rate continuously; either a total failure (exceeding 350 milliseconds) or excessive signal unit errors will initiate transmission of messages over the alternate signaling link. The error correction method chosen (retransmission) makes it possible to effect this transfer without the loss of signaling information. Signaling traffic is restored to the regular route automatically after the trouble clears.

To provide additional assurance of continuity of service on A links, provision is made for additional full-time reserve VFLs capable of being switched into service under processor control.

DATA MESSAGE FORMAT

4.15 In the CCIS system, the basic data word is the signal unit. A signal unit is 28 bits long with the last eight bits used for error checking. Therefore, each signal unit contains a 20-bit field used for signaling information. When no data-filled signal units are being transmitted, a Synchronization Signal Unit (SYU) is transmitted to maintain synchronization.

4.16 CCIS messages can be one or more signal units in length depending on the quantity of information to be sent. Single unit messages, referred to as Lone Signal Units (LSUs), are generally used for specific control information (eg, answer), whereas, Multiunit Messages (MUM) are generally used for passing address information (ie, digits).

4.17 Figure 4 shows the format fields for a lone signal unit and a miscellaneous multiunit message. The heading and signal information fields of the LSU contain information on the action the LSU is requesting. The trunk label is used to identify the trunk being served. The trunk label is subdivided into two fields, a band number, one or more of which is associated with a trunk group and which is used in determining the routing of the message in the signaling network, and a trunk number which identifies a specific trunk. The Initial Signal Unit (ISU) of the miscellaneous multiunit message has a unique heading code which identifies it as an initial signal unit and an ISU-type code which identifies the message as a miscellaneous multiunit message. The length indicator gives a count of how many Subsequent Signal Units (SSUs) may be expected. A unique heading code is used to identify a subsequent signal unit. The first subsequent signal unit of a miscellaneous multiunit message has a message category to identify the type of miscellaneous multiunit message. The miscellaneous multiunit message may be used for telephone signals, Network Management messages, and to furnish a special (header) message for routing signals via C links between intraregional signal transfer points.

4.18 An example of the structure of an initial address message for a 7-digit call is illustrated in Fig. 5A. The ISU contains the trunk identity in the label of the ISU. The first SSU contains a 16-bit field, routing information, which may be used for transmission of unique information related to the call. The second and third SSUs contain the 7-digit NXX-XXXX address. Most of the more common call types can be accommodated without furnishing full routing information shown in Fig. 5B. In this case, the IAM contains abbreviated routing information which is equivalent to a specific full routing information combination. This feature

		TRUNK LABELS		
HEADING	SIGNAL INFORMATION	BAND NO.	TRUNK NO.	CHECK
1-3	4-7	8-16	17-20	21-28

FIG. 4A - LONE SIGNAL UNIT (LSU)

INITIAL SIGNAL UNIT (ISU)

ISU CODE	(1)	(2)	BAND NO.	TRUNK NO.	CHECK
1-3	4	5-7	8-16	17-20	21-28

SUBSEQUENT SIGNAL UNIT (SSU)

SSU CODE	(3)	SIGNAL INFORMATION	CHECK
1-3	4-9	9-20	21-28

NOTES:

(1) ISU TYPE INDICATOR

(2) LENGTH INDICATOR

(3) MESSAGE CATEGORY

FIG. 4B - MISCELLANEOUS MULTIUNIT MESSAGE (MUM)

Fig. 4—Signal Unit Formats

reduces by one the number of signal units necessary to encode an IAM.

4.19 Figure 6 illustrates the initial address message and lone signal units associated with a routine 10-digit call and the actions performed at the originating and terminating CCIS offices. This figure is explained in more detail in part 5. Some messages, eg, Network Management, relate to groups of trunks and thus do not require the use of the trunk number in the label. In those messages, the trunk number field may be used to carry other signal information.

4.20 Those features presently planned for CCIS are coded into the format. Adequate allowance for new features is available in the format which will be coded as the features are defined and plans developed.

SIGNALING NETWORK ROUTING PROCEDURES

4.21 As mentioned previously, all telephone signaling messages contain a trunk label identifying the specific trunk by a combination band and trunk number. Labels will be assigned at the switching offices in such a way that all trunks with the same band number will be part of the same trunk group. In this way, routing at the STPs can be done using only the band number.

4.22 Signal routing at the STPs is done in the following way. All incoming and outgoing links at the STPs will be assigned a "link number." Furthermore, each STP will have stored in memory a "Band Translation" table for each A link and B, D link pair. Given the number of the link on which a message was received and the band number contained in the message label, the associated table gives the number of the desired outgoing link and an outgoing band number. The action taken by the STPs is as follows. When a message is received, the STP determines the incoming band and link number and, using the appropriate band translation table, determines the outgoing band and link number. The STP then replaces the received band number in the message label with a new band

INITIAL SIGNAL UNIT

			TRUNK LABELS		
ISU CODE	(1)	(2)	BAND NO.	TRUNK NO.	CHECK
1-3	4	5-7	8-16	17-20	21-28

1ST SSU

SSU CODE	(3)	ROUTING INFORMATION	CHECK
1-3	4	5-20	21-28

2ND SSU

SSU CODE	(4)	DIGIT 1	DIGIT 2	DIGIT 3	CHECK
1-3	4-8	9-12	13-16	17-20	21-28

3RD SSU

SSU CODE	(4)	DIGIT 4	DIGIT 5	DIGIT 6	DIGIT 7	CHECK
1-3	4	5-8	9-12	13-16	17-20	21-28

NOTES:

(1) ISU TYPE INDICATOR - (IAM)

(2) LENGTH INDICATOR (IE; 3 SSU'S)

(3) FULL ROUTING INFORMATION INDICATOR

(4) NO INFORMATION - ALL "0"S

FIG. 5A - INITIAL ADDRESS MESSAGE (WITH FULL ROUTING INFORMATION)

INITIAL SIGNAL UNIT

			TRUNK LABELS		
ISU CODE	(1)	(2)	BAND NO.	TRUNK NO.	CHECK
1-3	4	5-7	8-16	17-20	21-28

1ST SSU

SSU CODE	(3)	ROUTING INFORMATION	DIGIT 1	DIGIT 2	DIGIT 3	CHECK
1-3	4	5-8	9-12	13-16	17-20	21-28

2ND SSU

SSU CODE	(4)	DIGIT 4	DIGIT 5	DIGIT 6	DIGIT 7	CHECK
1-3	4	5-8	8-12	13-16	17-20	21-28

NOTES:

(1) ISU TYPE INDICATOR - (IAM)

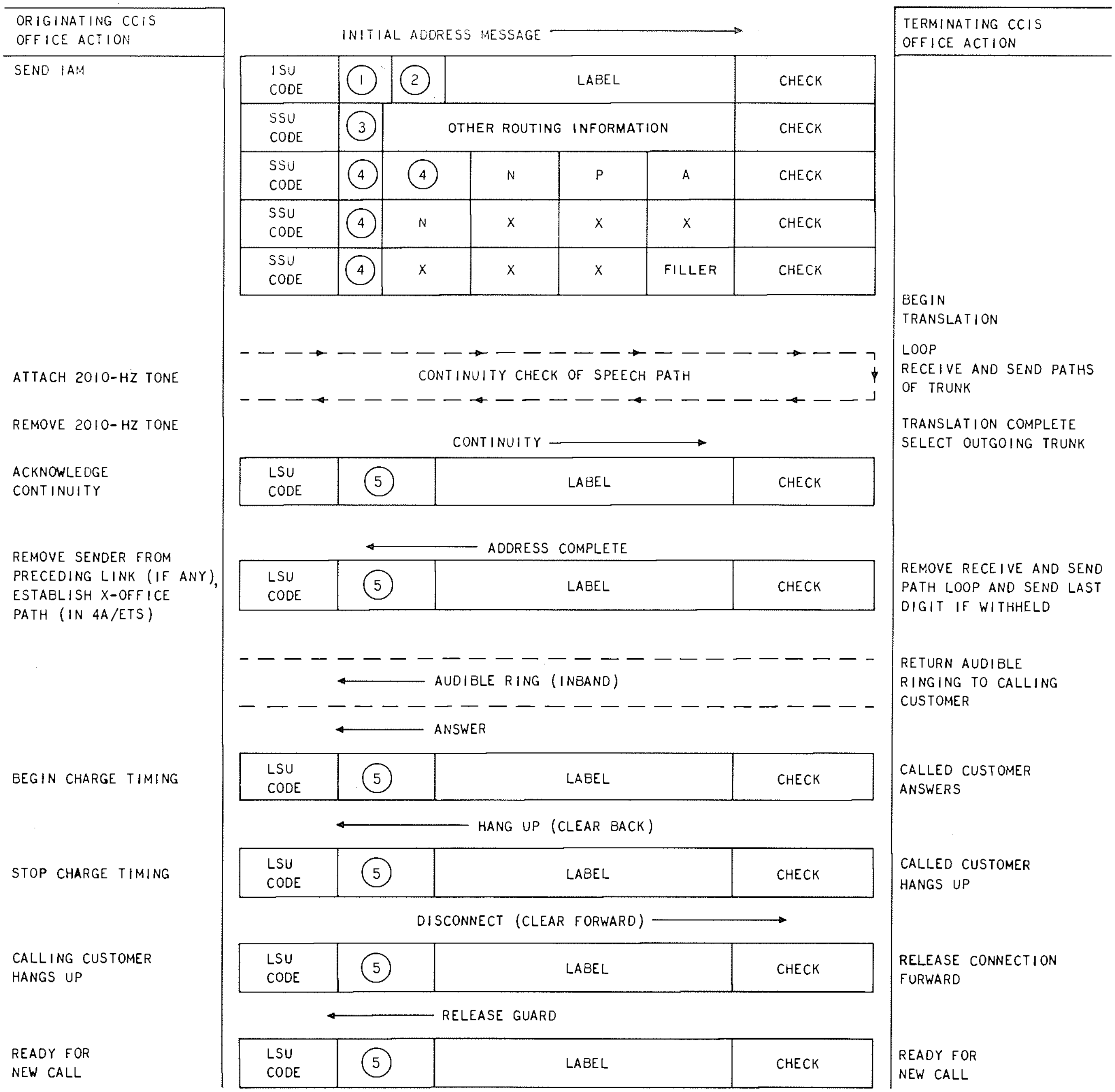
(2) LENGTH INDICATOR (IE; 2 SSU'S)

(3) ABBREVIATED ROUTING INFORMATION INDICATOR

(4) NO INFORMATION - "0"S

FIG. 5B - INITIAL ADDRESS MESSAGE (WITHOUT FULL ROUTING INFORMATION)

Fig. 5—Initial Address Message Formats



NOTES - ALL ACTIONS WITHIN DOTTED LINES ARE INBAND:

(1) ISU TYPE INDICATOR (IAM)

(2) LENGTH INDICATOR

(3) FULL ROUTING INFORMATION INDICATOR

(4) NO INFORMATION - ALL "0"S

(5) SIGNAL INFORMATION (IE, ANSWER, DISCONNECT, ETC)

Fig. 6—Generalized Signal Sequence—10-Digit CCIS Call

number and transmits this modified message on the indicated outgoing link.

4.23 Note from the previous discussion that only the processors at the two ends of a link need agree on which band number is assigned to a given trunk. This is important in regard to the required length of the band labels since, in general, the links on which a message enters and leaves an STP will carry signaling for different sets of trunks.

4.24 From Fig. 3 it is seen that, under normal conditions, both the SO originating a signaling message and the first encountered STP (for interregional traffic) will have a choice of outgoing links to the destined SO. Delays in the input buffers of the signaling terminals are directly related to the traffic load on the link; thus, in order to minimize delay, the loads on A link pairs and on the four links of a quad should be balanced as much as possible. This will be accomplished in the following way. At the originating office, one of the bits in the trunk number part of the label is examined. All trunk messages for which this bit is "1" will be sent on one A link and all other messages on the other A link. Since trunk numbers are not examined at the STPs, outgoing interregional messages at the STPs will be divided between the B and D links according to the value of a low order bit in the band number part of the label.

ROUTING DURING LINK FAILURES—SIGNALING NETWORK CONTROLS

4.25 The signaling network is designed to immediately reroute signaling around most link failures. Whenever an A link fails, all outgoing signaling at the affected SO will be rerouted on the mate A link. Similarly, traffic for a failed B (D) link will be routed on the D (B) link. Traffic at an STP for a failed A link or outgoing interregional signaling at an STP with both B and D links failed will be routed to the mate STP over the C link.

4.26 Note that, in this last case, less overall delay would have been incurred if the signaling traffic had been sent directly to the mate STP. Moreover, if, in the above case, the C links themselves were also in failure, no outgoing path for the received signaling would have existed. For this reason, a group of signals known as Signaling Network Management Signals have been developed. These signals communicate information among STPs and CCIS switching offices allowing the network to reconfigure itself to bypass failures whenever possible. The status of the various links and paths in the network is determined by, and stored at, the STPs and transmitted to appropriate switching offices and other STPs. Examples of such signals are Transfer Prohibited (TFP) and Transfer Restricted (TFR) messages. Transfer prohibited messages are sent by an STP to appropriate STPs and SOs whenever it determines that it has no outgoing path available for signaling of trunks with a given band number. Similarly, receiving a transfer restricted message from an STP indicates that all signaling which that STP receives with the indicated band number will be routed over C links.

4.27 The correctness and consistency of these control signals are verified periodically by an audit procedure which causes the retransmission of the correct signals. The audit is also automatically initiated at any time there is evidence of an incorrect network control state or upon recovery of a failed signaling link.

SIGNALING NETWORK OVERLOAD CONTROLS

4.28 In addition to the signaling network controls, there will exist signaling network overload controls to help prevent overtaxing the real-time capacity of STP processors or the overflowing of the available message buffering for signaling links. Either event should be rare on a properly engineered network. These control signals cause the rerouting of signaling traffic or the reduction of new telephone traffic, if necessary, depending on the location of the overload and the condition of the other elements of the network.

PROVISIONS FOR CCIS SWITCHING OFFICE FAILURE AND RECOVERY

4.29 When a CCIS switching office experiences a serious processor failure, the CCIS terminals at that office signal the STPs in the signaling network to cut off all CCIS signaling traffic to that office. The STPs then notify all offices with CCIS trunks to the failed office of the failure. This allows appropriate rerouting or cancellation of telephone traffic. During the process of recovery, certain trunks may have to be initialized (all trunks in the case of manual intervention in connection with Phase 4 recovery action of an ESS office). For non-CCIS trunks, this is achieved by the return of the on-hook condition on the trunks which ultimately forces the trunks to be idle at both ends. For CCIS trunks, special signals and signaling procedures are used to achieve this end. CCIS telephone traffic to the recovered office may continue to be withheld, if desired, while these housekeeping actions take place.

4.30 The network reaction to an STP processor failure, initiated by the link terminals at the failed STP, is to route signals in the same manner as if all links to the failed STP were simultaneously failed.

5. GENERAL DESCRIPTION OF THE CCIS SWITCHING FUNCTION

5.01 Basic switching functions are, in general, invariant with the type of signaling system utilized. Such basic functions as address analysis, routing, trunk seizure, forwarding of the address, supervision, and control are essential to call processing. With CCIS, however, the increased signaling information transfer leads to an expansion of these basic functions creating a more versatile and efficient method of processing calls.

5.02 Figure 6 illustrates the IAM and LSUs associated with a routine 10-digit call and the actions performed at the originating and terminating CCIS office. Note that, as part of the normal call setup signaling sequence, a continuity check is performed. (This function is described in 3.10.)

5.03 For simplicity, Fig. 6 does not break down the "other routing information" field in the IAM. It should be clearly understood, however, that all routing with CCIS is no longer exclusively based on analyzing the digits of the called number but on analysis of the "other routing information" contained in the IAM as well. As previously described (part 3), in-chain (or out-of-chain) indicators, nature-of-trunk indicators, calling party's category, and routing category influence the selection of an outgoing route. Similarly, added backward signals such as release guard (shown in Fig. 6) and ineffective attempt indicators require added call processing beyond that required with conventional signaling systems. These signals lead to more efficient use of the trunking network. To illustrate this latter expansion of functions, if trunk or equipment congestion is encountered at an incoming CCIS office, the appropriate congestion signal is sent to the originating CCIS office. On receipt of this signal at an intermediate office, the forward connection is released (disconnect signal sent) and the signal relayed to the originating CCIS office. At this office, the disconnect signal is sent and the appropriate audible tone or announcement is sent back to the originating customer.

5.04 Although the signaling links have built-in error control by error detection and retransmission, occasionally an undetected error will occur. This is expected to occur only once in approximately 10^8 signal units. In addition, the error control method will occasionally allow messages to get out of sequence. Safeguards, in the form of processor reasonableness checks, are provided by the system to make CCIS a more reliable signaling system than any now in service.

6. ADMINISTRATION OF THE SIGNALING NETWORK

6.01 As the CCIS network grows, planning for this growth becomes increasingly important. So too, the day-to-day administration of the network becomes a larger and more complex job as the network grows in size and complexity.

6.02 In order for trunk forecasting requirements to be properly analyzed, procedures have to be implemented that will give adequate administrative controls. A centralized approach will provide these controls in an economical and efficient manner. This approach calls for the establishment of a CCIS Assignment and Planning Center (CAPC), operated by AT&T Long Lines, to perform these functions. Two functional activities must be performed by the CAPC. They are Planning Analysis and Current Administration.

PLANNING ANALYSIS

6.03 This activity will analyze the CCIS requirements as indicated by the Bell System and Independent Telephone Companies' trunk forecasts. It will show where additional data link facilities and STPs are required and when they are needed in order to meet the forecasted requirements of the message network. The results of this analysis will then be forwarded to the appropriate carrier and equipment engineers for action.

6.04 The value of a CAPC is enhanced by the fact that multiple engineering entities cannot identify the total load impact on equipment or carrier facilities of the interregional quad. By having the CAPC analyze all the forecasts and comparing them with the existing CCIS network, a more thorough analysis can be made. Also, the CAPC will be in a better position to know the current and planned condition of the CCIS network. It should know of any impact the network might suffer due to new toll switching systems being added as well as any rehoming or conversion activity. It should also be able to insure that good diversity is maintained. It is felt that, under supervision of a centralized group, proper administration can be given to the planning analysis portion of CCIS.

CURRENT ADMINISTRATION

6.05 This functional job is concerned with the day-to-day activities of CCIS administration. This function has been called "Current Administration" because it deals with the day-to-day job. It will react to the current Long Lines and Associated Company requirements. The primary responsibilities of this job will be the assigning of labels, bands, and signal paths as well as maintaining their respective files.

6.06 This CAPC function will enable a close evaluation of how the links, quads, and equipment are being loaded. Proper administration is vital to the successful and economical growth of the CCIS network. The group will work with the Long Lines Circuit Layout people in coordinating the CCIS assignment job with the makeup of associated circuit orders. Label and band numbers pertaining to Associated Company requirements will be given directly to the concerned groups by the CAPC.

7. MAINTENANCE

OVERALL CONTROL AND COORDINATION

7.01 The maintenance control and coordination of the CCIS signaling network and its parts will generally follow the plan in use today in the Bell System and commonly referred to as the Control Office Plan. Inherent in the plan is a hierarchy of maintenance control and assignment of responsibilities to insure orderly administration and maintenance of the network.

7.02 Included in the plan is the designation of one of the CCIS offices on each signaling link as the Plant Control Office. This office is responsible for the overall maintenance of the link and for the coordination of all activities which may affect the serviceability of the link.

7.03 Each signaling link is divided into smaller components for assignment of subcontrol and repair responsibilities. These are the Terminal/Modem (T/M) combinations at each CCIS office and the interconnecting VFL.

AREAS OF MAINTENANCE RESPONSIBILITY IN CCIS-EQUIPPED OFFICES

7.04 A CCIS signaling link being a communication path between two switching or signaling processors logically puts the responsibility for the overall link in the area of other switching maintenance functions, that is, the Maintenance Operations Center (MOC), or the equivalent, in the CCIS-equipped office. This could be the overall Plant Control of the link or the supporting role of the noncontrol office.

7.05 To assist the MOC in its responsibilities, the Trunk Operations Center has a subcontrol responsibility for the VFL portion of the signaling link. The Trunk Operations Center operates in parallel support of the MOC, that is, as overall plant control or noncontrol end of the VFL.

7.06 Further allocation of maintenance responsibility within a typical CCIS-equipped office is described as follows:

(1) Switching Equipment Maintenance—Includes all equipment from the processor through and including the signaling terminals and modems or digital interface units. Test access circuits for VFL access where used are also included.

(2) Terminal Equipment Maintenance—Includes all transmission equipment such as pads, gain devices, equalizers (if used), and any other equipment not classed as switching equipment or transmission systems. This terminal equipment is considered to be a part of the VFL.

(3) Transmission Systems Maintenance—Includes all equipment considered to be part of the transmission facility portion of the VFL.

7.07 Variations from the typical office will no doubt exist. Smaller offices may combine switching and terminal equipment maintenance forces. The physical location of T/M equipment in some offices may be such that terminal equipment maintenance forces may do the actual repair work. However, the functional control will always reside in the MOC area.

MAINTENANCE PROCEDURES

7.08 These are the procedures, both automatic and manual, instituted subsequent to the detection and recovery procedures previously described for sectionalization and repair of troubles. The objectives are that, when failures occur, it should be possible without manual direction to sectionalize a failure to the T/M combination at either end or the interconnecting VFL and to institute repairs and return to normal service with a minimum of man-to-man interoffice communication.

7.09 The basic sectionalization technique will rely on automatic diagnostic tests of the T/Ms of failed signaling links. Failures will be presumed to have been sectionalized to the VFL when diagnostic tests are successful at both ends of the link. Test results will be automatically reported to the home office MOC and, on the basis of these results, the MOC will initiate T/M repair action or further testing of the VFL as required.

7.10 Most signaling link failures are expected to be due to transmission facility failures. Studies indicate that only about one failure in 37 will not be in the VFL. In addition, about 95 percent of facility failures are 2 minutes or less in duration. Therefore, to conserve processor time, an interval of time will be allowed to elapse between recognition of failure and start of diagnostic tests since, in most cases, service is restored without the need for such tests. The time interval, including a 1-minute proving period, will be set at 3 minutes. During this interval, the failed link is monitored for errors. If ten or fewer signal units are received in error in a 1-minute period (a maximum error rate of about 0.2 percent), the signaling load is restored to the link. If this criterion has not been met at the end of the 3-minute interval, diagnostic tests of the T/M will be automatically requested.

7.11 A CCIS office with a diagnosed T/M trouble is responsible for instituting repairs without further direction while the office having no trouble will return its T/M to a standby state to await resynchronization and automatic return to service.

7.12 As previously stated, failures will be presumed to be sectionalized to the VFL when automatic diagnostic tests indicate no trouble in the T/Ms at both ends of the system. Access to VFLs for testing at the Trunk Operations Center will be on a manually-requested basis. Access will always be denied if the VFL is carrying signaling traffic. This is to prevent interruptions due to inadvertent or unauthorized connections. In addition, some diagnosed VFL troubles will come clear before actual testing begins and the link will be automatically returned to service. Subsequent attempts to gain test access will, therefore, be denied and an appropriate report made to maintenance personnel.

7.13 There will be situations where recurring intermittent failures cause an excessive number of automatic changeovers and changebacks of signaling load. Also, the need to manually remove signaling load for rearrangements or other administrative reasons will exist. The capability will be provided for the MOC to manually control the removal or return of signaling load for trouble investigations or administrative reasons.

TESTING ACCESS

7.14 Terminals and modems are tested with processor-controlled diagnostic tests on an automatic basis when failures occur or on a manually-requested "demand" basis. Only the MOC in the CCIS-equipped office will be able to initiate demand tests as this involves the removal of signaling load if the link is in service.

7.15 Testing access to VFLs will be on a manually-requested basis under control of the Trunk Operations Center and will involve an access path not normally part of the working VFL. For reliability reasons, VFLs will not be looped in and out of manual test positions in the Trunk Operations Center. Also, since it is not practical in trouble testing to perform tests from the actual VFL modem interface, the tests will be performed over an essentially transparent access path to the Trunk Operations Center and will be inferred to have been performed at the point of VFL modem interface. However, jack access will be provided on the T/M frames at this interface point for initial lineups, precise measurement of office losses, or for subsequent testing of possible office wiring troubles should they occur.

7.16 VFL test access implementation in 4A/ETS and No. 4 ESS offices will be different. 4A/ETS offices will essentially employ a dedicated wired path between modems and VFLs via a dedicated per-link test access circuit which, among other things, permits testing access to be established to the VFL from the Trunk Operations Center over a dedicated test access path. In the No. 4 ESS system, however, modems will be connected to VFLs via semipermanent connections through the No. 4 ESS trunk switching network. Testing access paths will, therefore, be set up by temporarily taking down this connection and connecting the VFL via the switching network to the TOC manual test position. Other test connections will be established through the network in a similar manner such as connecting a VFL to a passive loop-back or connecting a modem to the manual test position to verify office wiring. When maintenance operations are complete, the proper configurations will again be established via the network.

7.17 As mentioned in 4.06, two VFLs are normally assigned to each A link. Each VFL is a nonsynchronized reserve for the other and a transfer operation is required to connect the T/M to the reserve VFL before synchronization can start. For reasonable assurance that reserve VFLs will be serviceable when needed, they will be tested on a scheduled routine basis. The test will be initiated at the STP and will be a loop-back type test. passive loop-back will be connected at the switchin office and a maintenance T/M connected at th STP. An automatic processor-controlled test wi then be made.

7.18 If the test fails, a notification will be give to maintenance personnel at the STP MOC. The same type of test is automatically performed subsequent to a working mode failure as a trouble verification test. If the test fails, notification will be given to MOC personnel. The test can also be initiated by the STP or the switching office on a demand basis. The results of a demand test will be presented at the initiating office.

8. MESSAGE FORMATS AND CODING

8.01 Additional Routing Information and Data Message Format have been discussed in parts 3 and 4, respectively. The message formats and coding for all types of messages will now be described.

8.02 The heading field of three bits (bit positions 1 through 3) provides eight different codes in order to discriminate between a number of signal groups. The codings are:

HEADING CODE	SIGNAL UNIT TYPE
000	Lone Signal Unit — Telephone Signals
001	Lone Signal Unit — Telephone Signals
010	Lone Signal Unit — Telephone Signals
011	Acknowledge Signal Unit
100	Lone Signal Unit — Telephone Signals
101	Initial Signal Unit
110	Subsequent Signal Unit
111	Lone Signal Units: Telephone Signals System Control Signals Management Signals Maintenance Signals

8.03 As an aid and reference guide to the various signals and formats presented in this section, the following alphabetical listing of signals is included. It is divided into sections (telephone signals, management signals, etc) and provides the standard abbreviation, definition, and paragraph of the text in which the signal appears.

8.04 Lone Signal Unit, Telephone Signals:

ADC ***Address-Complete Signal, Charge*** (8.16)—A signal sent in the backward direction indicating that all address signals required for routing the call to the called party have been received, no called-party's-line-condition signals (electrical) will be sent, and the call should be charged on answer.

ADX ***Address-Complete Signal, Coin Box*** (8.16)—A signal sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received, that no called-party's-line-condition signals (electrical) will be sent, that the call should be charged on answer, and that the called number is a coin (box) station.

ADN ***Address-Complete Signal, No Charge*** (8.16)—A signal sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received, that no called-party's-line-condition signals (electrical) will be sent, and that the call should not be charged on answer.

ADI ***Address-Incomplete Signal*** (8.16)—A signal sent in the backward direction indicating that the number of address signals received is not sufficient for setting up the call. This condition may be determined in the incoming international office (or in the national destination network):

(1) On examination of the address signals,

(2) Immediately after the reception of an ST signal, or

(3) On time-out after the latest digit received.

ANC ***Answer Signal, Charge*** (8.15)—A signal sent in the backward direction indicating that the call is answered and subject to charge.

In semiautomatic operation, this signal has a supervisory function. In automatic operation, the signal is used:

(1) To start charging the calling customer

(2) To start the measurement of call duration for international accounting purposes if this is desired.

ANN ***Answer Signal, No Charge*** (8.15)—A signal sent in the backward direction indicating that the call is answered but is not subject to charge. It is used for calls to particular destinations only. In semiautomatic operation, this signal has a supervisory function. In automatic operation, the reception of this signal shall not start the charging to the calling customer but may or may not be used to start the measurement of call duration for international accounting.

BLO ***Blocking Signal*** (8.13)—A signal sent for maintenance purposes to the office at the other end of a trunk to cause that trunk to appear busy to subsequent calls outgoing from that office. An office receiving a blocking signal must be capable of accepting incoming calls on that trunk unless it also has sent a blocking signal.

BLA ***Blocking-Acknowledgment Signal*** (8.15)—A signal sent in response to a blocking signal indicating that the trunk has been blocked.

CFL ***Call-Failure Signal*** (8.14)—A signal sent in the backward direction indicating the failure of a call setup attempt due to the lapse of a time-out or a fault not covered by specific signals.

CB1 CB2 CB3 ***Clear-Back (Hang-Up) Signals*** (8.15)—Signals sent in the backward direction, the first of which indicates that the called party has hung up. Subsequent hang-up signals indicate that the called party has hung up following a reanswer, eg, switchhook flashing.

In semiautomatic operation, they perform a supervisory function. In automatic operation, they initiate a timing interval which, if exceeded, stops the charging and causes release of the established connection.

CLF ***Clear-Forward (Disconnect) Signal*** (8.13)—A signal sent in the forward direction to terminate the call or call attempt and release the trunk concerned. It is normally sent at the end of a call when the calling party hangs up.

COF ***Confusion Signal*** (8.14)—A signal sent in the backward direction indicating that an office is unable to act upon a message received from a preceding office because the message is considered unreasonable.

COT ***Continuity Signal*** (8.13)—A signal sent in the forward direction to indicate continuity of the preceding CCIS trunk(s) and a successful check of the selected trunk to the following office including verification of the speech path across the office with the specified degree of reliability.

SSB ***Customer-Busy Signal (Electrical)*** (8.16)—A signal sent in the backward direction indicating that the line(s) connecting the called party with the office is (are) busy. The customer-busy signal will also be sent in case of completion uncertainty about the place where the busy or congestion conditions are encountered and in the case where a discrimination between customer-busy and national-network congestion is not possible.

MRF ***Message-Refusal Signal*** (8.14)—A signal sent by a signal transfer point in response to the reception of a telephone signal which it is unable to deal with as a consequence of the transfer-prohibited situation.

NSC ***National-Switching-Congestion Signal*** (8.14)—A signal sent in the backward direction to indicate that the failure of the call setup attempt is due to congestion in national switching equipment.

NTC ***National-Trunk-Congestion*** (8.14)—A signal sent in the backward direction to indicate that the failure of the call setup attempt is due to congestion encountered on a national (domestic) trunk group.

RA1 RA2 RA3 ***Reanswer Signals*** (8.15)—Signals sent in the backward direction to indicate that the called party, after having hung up, again lifts his receiver or in some other way reproduces the answer condition, eg, switchhook flashing.

RLG ***Release-Guard Signal*** (8.15)—A signal sent in the backward direction in response to the disconnect (clear-forward) signal when the trunk concerned has been brought into the idle condition.

RST ***Reset Signal*** (8.14)—A signal that is sent to release a trunk when, due to memory mutilation or other causes, it is unknown whether a disconnect or hang-up signal is appropriate and in certain other abnormal circumstances when the normal disconnect sequences have failed.

UBL ***Unblocking Signal*** (8.13)—A signal sent to the office at the other end of a trunk to cancel in that office the busy condition of that trunk caused by a preceding blocking signal.

UBA ***Unblocking-Acknowledgment Signal*** (8.15)—A signal sent in response to an unblocking signal indicating that the trunk has been unblocked.

8.05 Two-Unit Telephone Signals:

CGC ***Circuit-Group-Congestion Signal, International*** (8.39)—A signal sent in the backward direction indicating that the failure of the call setup attempt is due to congestion encountered on an international trunk group.

SST ***Customer- (Subscriber) Transferred Signal (Changed Number)*** (8.39)—A signal sent in the backward direction to indicate that the national number received has ceased to be used and that the customer (subscriber) to whom it was allocated must be reached via another number (international outbound and transit only).

FOT ***Forward-Transfer (Ring-Forward) Signal*** (8.39)—On international semiautomatic calls, this signal is sent in the forward direction when the outgoing international office operator wants the help of an operator at the incoming international office. The signal will normally serve to bring an assistance operator into the trunk. When a call is completed via an operator (incoming or delayed call operator) at the incoming international office, the signal should preferably cause this operator to be recalled. On national operator-to-operator handled (manual) calls, the signal may be used by the originating operator to recall the incoming operator.

LOS ***Line-Out-of-Service Signal*** (8.39)—A signal sent in the backward direction indicating that the called party's line is out of service or faulty.

NNC ***National-Network-Congestion Signal, Non-US*** (8.39)—A signal sent in the backward direction indicating that the failure of the call setup attempt is due to congestion encountered in the national destination network [excluding the busy condition of the called party's line(s)].

SEC ***Switching-Equipment-Congestion Signal, International*** (8.39)—A signal sent in the backward direction indicating that the failure of the call setup attempt is due to congestion encountered in the international switching equipment.

VNN ***Vacant-National-Number Signal*** (8.39)—A signal sent in the backward direction used to indicate that the received national number is not in use (for example, spare level, spare code, vacant customer's number).

8.06 Lone Signal Units, Signaling-System-Control Signals—Signals used for the proper functioning of the signaling system via the common signaling link.

ACU ***Acknowledgment Indicator*** (8.45)—Information indicating whether or not an error has been detected in a received signal unit.

COV ***Changeover Signal*** (8.56)—A signal sent to indicate a failure on a synchronized signaling link. If this signal is sent on a link carrying signaling information, it also indicates that a changeover to the next reserve signaling link is required.

ELT ***Emergency-Load-Transfer Signal*** (8.56)—A signal sent on as many signaling links as possible to indicate that the error rate on those links has met the requirements of the emergency proving period and that emergency transfer can take place to one of these links.

LTR ***Load-Transfer Signal*** (8.56)—A signal sent on a link to indicate that the error rate on that link has met the standard requirements of the 1-minute proving period and that signaling traffic should be transferred to that particular link.

LTA ***Load-Transfer-Acknowledgment Signal*** (8.56)—A signal sent on a link in response to a load-transfer signal or to an emergency-load-transfer signal to indicate that the load transfer will take place to that particular link.

MCO ***Manual-Changeover Signal*** (8.56)—A signal sent to initiate a changeover to a reserve signaling link because of need for rearrangements, changes, or maintenance.

MCA ***Manual-Changeover-Acknowledgment Signal*** (8.56)—A signal sent in response to a manual-changeover signal to indicate that manual changeover can take place.

MVT ***Manual-Voice-Frequency-Link-Transfer Signal*** (8.55)—A signal sent in either direction between a switching office and an STP indicating that the active voice-frequency link should be interchanged with the inactive voice-frequency link.

SRD ***Standby-Ready Signal*** (8.56)—A signal sent on a standby reserve link to indicate that the error rate on that link has met the requirements of the 1-minute proving period.

SRA ***Standby-Ready-Acknowledgment Signal*** (8.56)—A signal sent on the standby reserve link in response to a standby-ready signal and indicating that the error rate on that link has met the requirements of the 1-minute proving period.

SYU ***Synchronization Signal*** (8.48)—A signal sent in order to establish and maintain synchronization between the two ends of a signaling channel.

TSV ***Test-Voice-Frequency-Link Signal*** (8.55)—A signal sent in either direction between a switching office and an STP indicating that the sending end is prepared to test the standby voice-frequency link and requesting the other end to prepare for the test.

VLF ***Voice-Frequency-Link-Test, Failed Signal*** (8.55)—A signal from an STP to a switching office indicating that the standby voice-frequency link is not satisfactory for use.

VLP ***Voice-Frequency-Link-Test, Passed Signal*** (8.55)—A signal sent from an STP to a switching office indicating that the standby voice-frequency link is satisfactory for use.

8.07 Lone Signal Units, Signaling-Network-Management Signals—Information regarding the conditions of signaling links which may be required to modify signal routings. This excludes information relevant to the signals concerned with individual calls or individual trunks.

ESU ***End-of-Status-Update Signal*** (8.66)—A signal sent by STP after transmitting the last-band status signal to notify other STP or switching office of the completion of the band status update.

LKF ***Link-Failed Signal*** (8.64)—A signal sent by an STP to a mate STP identifying a failed signaling link.

LKN ***Link-Normal Signal*** (8.64)—A signal sent by an STP to a mate STP whenever a signaling link is restored to service.

RAB ***Request-All-Band-Status-of-STP Signal*** (8.66)—A signal sent by switching office or STP to an STP requesting a status update of all bands for the signaling link on which it is transmitted.

RLK ***Request-Link-Status-of-STP Signal*** (8.66)—A signal sent by STP to its mate STP requesting status of all the signaling links terminating on the mate STP.

RPB ***Request-Particular-Band-Status-of-STP Signal*** (8.64)—A signal sent by a switching office or an STP to an STP requesting a status update of the particular band indicated. The signal applies to the signaling link on which it is transmitted.

TAA ***Transfer-Allowed-Acknowledgment Signal*** (8.63)—A signal sent in response to the reception of a transfer-allowed signal.

TFA ***Transfer-Allowed Signal*** (8.63)—A signal sent by an STP when it is again ready to transfer signals for a particular group of trunks.

TFP ***Transfer-Prohibited Signal*** (8.63)—A signal sent by an STP for each label band of a failed signaling link when it is unable to transfer signals for those bands.

TFR ***Transfer-Restricted Signal*** (8.64)—A signal sent by an STP for each label band of a failed signaling link to request other STPs and switching offices to transfer the affected signaling traffic to an alternate signaling route because the STP is rerouting traffic via an additional STP.

8.08 Lone Signal Units, Network-Management Signals—Information regarding the conditions of trunk groups or switching equipment sent from one point in the network to one or more other points. This excludes information relevant to individual calls or individual trunks.

DOC 0
DOC 1
DOC 2
DOC 3 ***Dynamic-Overload-Control (DOC)*** (8.62)—Signals sent from one switching office to another indicating the degree of traffic congestion in the transmitting office. The levels of congestion range from normal (DOC 0) to most severe (DOC 3).

DOCA 0
DOCA 1
DOCA 2
DOCA 3 ***Dynamic-Overload-Control Acknowledgment (DOCA) Signals*** (8.62)—Signals sent in response to the corresponding DOC signals.

8.09 Multiunit, Network-Management Signals:

OTO ***Out-of-Chain-Routing- Turnoff Signal*** (8.70)—A signal sent to notify an office sending out-of-chain calls to another office that no more calls to an NPA or office code should be routed to it for some time period.

Selectivity Signals (8.70)—Signals used to indicate difficulty of routing traffic to various destinations.

(1) SHR Selectivity, hard-to-reach

(2) SLN Selectivity, normal.

8.10 Special Signals:

Header Signal (8.74)—A signal prefixed by an STP to each single or multiunit message rerouted via an additional STP. It identifies rerouted messages as alternate routed signaling traffic and indicates the outgoing link required at the mate STP.

8.11 Additional Signals Used for Routing CCIS Traffic:

Routing Category (8.30)—Information is sent in the forward direction to identify the source and destination of calls. The categories for calls are:

(1) Ordinary Intertoll—Originates and terminates in the North American Numbering Plan Area

(2) International Inbound—Originates outside the North American Numbering Plan Area but terminates within it

(3) International Outbound—Originates in the North American Numbering Plan Area but terminates outside of it

(4) International Transit—Originates and terminates outside the North American Numbering Plan Area.

Nature-of-Trunk Indicator (8.31)—Information sent in the forward direction about the nature of the trunk or any preceding trunk(s) already engaged in the connection:

(1) Satellite trunk, or

(2) No satellite trunk.

An office receiving this information will use it (in combination with the appropriate part of the address information) to determine the nature of the outgoing trunk to be chosen.

Echo-Suppressor Indicator (International Transit Only)—Information sent in the forward direction indicating whether or not an outgoing half echo suppressor is in the connection. This is not used in CCIS for domestic calls.

Out-of-Chain-Routing Indicator (8.31)—Information transmitted in the forward direction to indicate whether the call has been routed out of the hierarchical chain. The indications are:

(1) In chain,

(2) Out of chain on this link, or

(3) Out of chain on a previous link.

Calling-Party's-Category Indicator (8.31)—Information sent in the forward direction about the category of the calling party and, in the case of semiautomatic international calls, about the service language to be spoken by the incoming, delayed call, and assistance operators. The following categories are provided:

CCITT NO. 6, INTERNATIONAL TRANSIT	INTERTOLL, INTERNATIONAL INBOUND, AND INTERNATIONAL OUTBOUND
Operator, various service languages	Ordinary operator
Ordinary calling subscriber	Ordinary calling customer
Calling subscriber with priority	Unknown source
Data call	
Test call	

Continuity Check Cancellation Indicator (Forward) (8.31)—A signal sent in the forward direction in conjunction with the calling party's category indicator for intertoll calls indicating that the continuity check will not be made on the trunk for this connection. This signal will be utilized during processor overload conditions.

End-of-Pulsing (ST) Signal (8.34)—A signal sent in the forward direction to indicate that there are no more address signals to follow. This signal is not used in CCIS for national calls.

SIGNAL UNIT FORMATS

8.12 In the following format representations of signal units, it should be noted that bit number 1 is transmitted first, the rest following in the order shown. The first bit in each field is the most significant and in a horizontal presentation of the format will be on the left.

Format of a Lone Signal Unit (LSU)

The format of a lone signal unit is shown in Fig. 7.

The heading field is used to identify groups of signals including those that do not correspond to the lone signal unit format. The headings used for Lone Signal Unit Telephone Signals are 000, 001, 010, 100, and 111. These headings are associated with specific signal information which is coded in bits 4 through 7.

```
                                 TRUNK LABEL
                        /------------------------------\
X X X / X X X X / X X X X X X X X X / X X X X / X X X X X X X X

 1-3       4-7           8-16            17-20         21-28
HEADING  SIGNAL      BAND NUMBER         TRUNK         CHECK
         INFOR-                          NUMBER
         MATION
```

Fig. 7—Format of a Lone Signal Unit

8.13 ***Telephone Signals With Heading Code 000***—The following codes assigned to signals sent in the forward direction are associated with heading code 000:

0000	Spare (restricted to uses where a 20-bit, all-zero code cannot occur)	
0001	Continuity	(COT)
0010	Spare	
0011	Spare	
0100	Spare	
0101	Spare	
0110	Spare	
0111	Spare	
1000	Clear-forward	(CLF)
1001	Blocking	(BLO)
1010	Unblocking	(UBL)
1011	Spare	
1100	Spare	
1101	Spare	
1110	Spare	
1111	Spare	

8.14 ***Telephone Signals With Heading Code 001***—The following codes assigned to signals in the backward direction are associated with heading code 001:

0000	Call-failure	(CFL)
0001	Message-refusal	(MFR)
0010	Confusion	(COF)
0011	Spare	
0100	National-Trunk-Congestion	(NTC)
0101	National-Switching-Congestion	(NSC)
0110	Spare	
0111	Spare	
1000	Reset	(RST)
1001	Spare	
1010	Spare	
1011	Spare	
1100	Spare	
1101	Spare	
1110	Spare	
1111	Spare	

8.15 ***Telephone Signals With Heading Code 010***—The following codes assigned to signals in the backward direction are associated with heading code 010:

0000	Blocking-acknowledgment	(BLA)
0001	Unblocking-acknowledgment	(UBA)
0010	Spare	
0011	Spare	
0100	Spare	
0101	Spare	
0110	Release-guard	(RLG)
0111	Answer, no charge (priority)	(ANN)
1000	Answer, charge (priority)	(ANC)
1001	Spare	
1010	Clear Back (No. 1)	(CB1)
1011	Reanswer (No. 1)	(RA1)
1100	Clear Back (No. 2)	(CB2)
1101	Reanswer (No. 2)	(RA2)
1110	Clear Back (No. 3)	(CB3)
1111	Reanswer (No. 3)	(RA3)

8.16 ***Telephone Signals With Heading Code 100***—The following codes assigned to signals sent in the backward direction are associated with heading code 100:

0000	Spare	
0001	Spare	
0010	Spare	
0011	Spare	
0100	Customer-busy (electrical), (subscriber-busy)	(SSB)
0101	Spare	
0110	Spare	
0111	Spare	
1000	Spare	
1001	Spare	
1010	Address-complete, no charge	(ADN)
1011	Address-complete, coin-box	(ADX)
1100	Address-complete, charge	(ADC)
1101	Address-incomplete	(ADI)
1110	Spare	
1111	Spare	

8.17 ***Telephone Signals With Heading Code 111***—Heading code 111 is associated with synchronization and system control signal units along with network-management-international, signaling-network-management-international, network-management-national, and signaling-network-management-national. In addition, there are 11 spare codes that can be used for telephone signals. At present, there are no telephone signals coded in this category.

Format of the Initial Signal Unit (ISU) of a Multiunit Message (MUM)

8.18 The format of the initial signal unit of a multiunit message is the same for all multiunit messages and is shown in Fig. 8.

8.19 The heading code 101 is used for all initial signal units. The ISU type indicator is used to discriminate between initial address messages and all other multiunit messages. It is located in bit 4 of an ISU of a multiunit message. The codes of the initial signal unit type indicator are:

Bit 4—Initial Signal Unit Type Indicator

0	Initial Address Message
1	Miscellaneous Multiunit Message

8.20 The length indicator in bits 5 through 7 of the initial signal unit shows the length of the multiunit message.

Bits 5 Through 7—Length Indicator

000	One subsequent signal unit
001	Two subsequent signal units
010	Three subsequent signal units
011	Four subsequent signal units
100	Five subsequent signal units
101	Six subsequent signal units
110	Seven subsequent signal units
111	Eight subsequent signal units (header message only)

Bits 8 Through 20—Trunk Label

8.21 All 8192 labels are available to identify trunks. The 13 label bits are broken into two groups: (1) the band number (512 bands) contained in bits 8 through 16 and (2) a trunk number (16 trunks) contained in bits 17 through 20. Each band number may be used to designate only one group of trunks but a group of trunks may use more than one band number if that group has more than 16 trunks. This technique reduces translation memory requirements and simplifies translation at the STPs. The label codes will be assigned by the CAPC. (See part 6.)

Format of a Subsequent Signal Unit (SSU) of a Multiunit Message (MUM)

8.22 The format of a subsequent signal unit of a multiunit message is shown in Fig. 9.

```
                                  TRUNK LABEL
                       ┌──────────────────────────────┐
1 0 1 / X / X X X / X X X X X X X X X / X X X X / X X X X X X X X

 1-3      4    5-7         8-16          17-20          21-28
HEADING*       **       BAND NUMBER      TRUNK          CHECK
                                         NUMBER

        *  = INITIAL SIGNAL UNIT TYPE INDICATOR

      * *  = LENGTH INDICATOR
```

Fig. 8—Format of the Initial Signal Unit of a Multiunit Message

```
 1 1 0 / X X X X X X X X X X X X X X X X X / X X X X X X X X
  1-3                    4-20                        21-28
HEADING          SIGNAL INFORMATION                  CHECK
```

Fig. 9—Format of a Subsequent Signal Unit of a Multiunit Message

8.23 The subsequent signal unit of a multiunit message has a heading code of 110. The form of the signal information in a subsequent signal unit varies as to its usage. The various forms of the subsequent signal unit will be covered under the Initial Address Message and Miscellaneous Multiunit Message.

8.24 The format of a subsequent signal unit does not contain a label field which has already been included in the initial signal unit of the multiunit message since the multiunit message will only carry telephone signals belonging to the same call (trunk label). The signal information field, therefore, has a length of 17 bits in order to carry as much signal information as possible.

Format of an Initial Address Message

8.25 Due to the inclusion of other information for routing purposes in the initial address message (the first message of each call), the format of the initial address message differs from the format of other address messages.

8.26 As the main purpose of a subsequent signal unit of an initial address message is to carry address signals, the last 16 bits of the signal information field may be considered to consist of four subfields of four bits each. According to the arrangements made, each subfield may carry an address signal or other routing information.

8.27 There are two different groups of subsequent signal units that may be used in an initial address message. The first group of SSUs that may occur contains expanded routing information. The other group of SSUs contains abbreviated routing information and address signals (eg, digits). The two groups are differentiated by the routing information indicator in bit 4. The format of an initial address message containing both code groups with four signal units is shown in Fig. 10.

Note 1: If additional subsequent signal units of expanded routing information are needed in the future, they shall immediately follow the first subsequent signal unit with the routing information indicator set to 1.

Note 2: An initial address message of six signal units, including one unit of expanded routing information, has the capability of carrying up to 15 address signals.

8.28 The format of an initial address message that does not require expanded routing information is shown in Fig. 11.

8.29 The subsequent signal units of an initial address message can have three different forms and will be taken in the order in which they occur. The first four bits of an initial address message subsequent signal unit always have the same format, the heading code of 110 and the routing information indicator in bit 4 which is coded as follows:

Bit 4—Routing Information Indicator

0 Abbreviated routing information and address digits

1 Expanded routing information

```
                               TRUNK LABEL
                        ┌─────────────────────────┐
ISU  1 0 1 / 0 / 0 1 0 / X X X X X X X X X / X X X X / X X X X X X X X
        HEADING*      * *     BAND NUMBER       TRUNK          CHECK
                                                NUMBER

1ST SSU 1 1 0 / 1 / X X X X X X X X X X X X X X X / X X X X X X X X
        HEADING  †  EXPANDED ROUTING INFORMATION         CHECK

2ND SSU 1 1 0 / 0 / 0 0 0 0 / X X X X / X X X X / X X X X / X X X X X X X X
        HEADING  †     * * *     1ST       2ND       3RD            CHECK
                               ADDRESS   ADDRESS   ADDRESS
                               SIGNAL    SIGNAL    SIGNAL

3RD SSU 1 1 0 / 0 / X X X X / X X X X / X X X X / X X X X / X X X X X X X X
        HEADING  †   4TH       5TH       6TH       7TH          CHECK
                   ADDRESS   ADDRESS   ADDRESS   ADDRESS
                   SIGNAL    SIGNAL    SIGNAL    SIGNAL

    * = INITIAL SIGNAL UNIT TYPE INDICATOR
  * * = LENGTH INDICATOR
* * * = ABBREVIATED ROUTING INFORMATION
    † = ROUTING INFORMATION INDICATOR
```

Fig. 10—Format of an Initial Address Message Containing Expanded Routing Information and With Three Subsequent Signal Units

```
                                   TRUNK LABEL
                         /‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾\
ISU     1 0 1 / 0 / 0 0 1 / X X X X X X X X X / X X X X / X X X X X X X X

        HEADING  *     **      BAND NUMBER        TRUNK       CHECK
                                                  NUMBER

1ST SSU   1 1 0 / 0 / X X X X / X X X X / X X X X / X X X X / X X X X X X X X

        HEADING  †   * * *    1ST        2ND        3RD           CHECK
                              ADDRESS    ADDRESS    ADDRESS
                              SIGNAL     SIGNAL     SIGNAL

2ND SSU   1 1 0 / 0 / X X X X / X X X X / X X X X / X X X X / X X X X X X X X

        HEADING  †   4TH      5TH        6TH        7TH           CHECK
                     ADDRESS  ADDRESS    ADDRESS    ADDRESS
                     SIGNAL   SIGNAL     SIGNAL     SIGNAL

     * = INITIAL SIGNAL UNIT TYPE INDICATOR

   * * = LENGTH INDICATOR

 * * * = ABBREVIATED ROUTING INFORMATION

     † = ROUTING INFORMATION INDICATOR
```

Fig. 11—Format of an Initial Address Message Without Expanded Routing Information With Two Subsequent Signal Units

8.30 The first type of subsequent signal unit that can occur is one that contains expanded routing information. For as many subsequent signal units as bit 4 remains at 1, the information which is needed in combination with the address signals for setting up a call will be contained in bits 5 through 20. However, this type of subsequent signal unit is not always required in an initial address message. At present, only the first subsequent signal unit of this type is coded. The coding of bits 5 through 16 is dependent on bits 17 through 20 which are coded as follows:

Bits 17 Through 20—Routing Category

0000	Ordinary intertoll
0001	Spare
0010	Spare
0011	Spare
0100	Spare
0101	Spare
0110	Spare
0111	Spare
1000	International inbound
1001	International outbound
1010	International transit
1011	Spare
1100	Spare
1101	Spare
1110	Spare
1111	Spare

8.31 The initial applications of CCIS will be with intertoll use only. Intertoll use of the expanded routing information, bits 17 through 20 coded 0000, is limited to calls that originate and terminate in the North American Numbering Plan Area. The codes for bits 5 through 16 of the expanded routing information for ***intertoll*** use are:

Bit 5—Out-of-Chain-Routing Indicator

0	In chain
1	Out-of-chain (See bit 7.)

Bit 6—Nature-of-Trunk Indicator

0	No satellite trunk in the connection
1	Satellite trunk in the connection

Bit 7—Link-Out-of-Chain Indicator

0	This link
1	On a previous link

Bits 8 Through 12—Spare*

*All spare bits are coded 0.

Bits 13 Through 16—Calling Party's Category

0000	Unknown source, normal
0001	Ordinary operator, normal
0010	Spare
0011	Spare
0100	Spare
0101	Spare
0110	Ordinary calling customer, normal
0111	Spare
1000	Unknown source, continuity check canceled
1001	Ordinary operator, continuity check canceled
1010	Spare
1011	Spare
1100	Spare
1101	Test call
1110	Ordinary calling customer, continuity check canceled
1111	Spare

8.32 The second type of subsequent signal unit has bit 4 coded as 0 and bits 5 through 8 used for abbreviated routing information. The abbreviated routing information makes available just 16 combinations of routing information in four bits. When the routing information that would normally be carried in the first type of SSU (expanded routing information) is the same as one of the 16 abbreviated routing information combinations, then bit 4 is set to 0. The four bits are normally assigned to those routing combinations that have the highest probability of occurring. The most common call category expected initially is a domestic originating and terminating call from an unknown source with no satellite in the connection following normal routing patterns and no operator interaction. Sometime in the future, particularly after CCIS capability is available in local offices, the same combination, except that the calling party's category is ordinary customer, will be desirable.

8.33 The codings of bits 5 through 8 of the first subsequent signal unit with bit 4 being 0 are listed below:

Bits 5 Through 8—Abbreviated Routing Information

0000	Expanded routing information present
0001	In-chain, no satellite, unknown source, ordinary intertoll
0010	In-chain, no satellite, ordinary calling customer, ordinary intertoll
0011	Spare
0100	Spare
0101	Spare
0110	Spare
0111	Spare
1000	Spare
1001	Spare
1010	Spare
1011	Spare
1100	Spare
1101	Spare
1110	Spare
1111	Spare

8.34 Bits 9 through 20 of the second type SSU (abbreviated routing information) contain the first three address signals. The address signals are coded as follows:

0000	Filler (no information)
0001	Digit 1
0010	Digit 2
0011	Digit 3
0100	Digit 4
0101	Digit 5
0110	Digit 6
0111	Digit 7
1000	Digit 8
1001	Digit 9
1010	Digit 0
1011	Operator code 11
1100	Operator code 12
1101	Spare
1111	ST (used on international calls to indicate end of digits)

8.35 The filler code 0000 is used to complete the signal information field of the last subsequent signal unit of the initial address message if needed. Special operator codes 11 and 12 are used in international applications only.

8.36 The third type of subsequent signal unit has bit 4 coded 0 (no information) and address signals in bits 5 through 20. This subsequent signal unit is used to carry the remaining digits of the called number.

Format of Miscellaneous Multiunit Messages

8.37 The miscellaneous multiunit message is a general class of message which has an initial signal unit that may contain, in the label field, a full label, a band number with other information, or special information. The messages presently included under this class are subsequent address messages (international transit traffic only), telephone signals that occur infrequently, multiunit management messages, and header messages. The heading code and initial signal unit type indicator combined are 1011. The message category is determined from bits 4 through 8 in the first subsequent signal unit. This indicator is used to designate the use of the multiunit message.

Bits 4 Through 8—Message Category

00000	Expansion (See message category extension bits 9 through 12.)
00001	Telephone signals that occur infrequently
00010	Spare
00011	Spare
00100	Spare
00101	Spare
00110	Spare
00111	Spare
01000	Management message (See 8.67.)
01001	Spare
01010	Spare
01011	Spare
01100	Spare
01101	Spare
01110	Spare
01111	Spare
1XXXX	Header message (See 8.74)

8.38 The format of telephone signals that occur infrequently is given in Fig. 12. Only one SSU is allowed so the length indicator is always 000.

8.39 The telephone signals that occur infrequently (message category 00001) are carried in bits 13 through 20 in the signal information field. Bits 9 through 12 are coded 0000. At present, only seven such signals are coded.

Bits 13 Through 20—Signal Information

0000/0001	Switching-Equipment-Congestion, international	(SEC)
0000/0010	Circuit-Groups-Congestion, international	(CGC)
0000/0011	National-Network-Congestion, non US	(NNC)
0000/0100	Forward transfer (ring-forward)	(FOT)
0000/0101	Vacant-National-Number	(VNN)
0000/0110	Line-Out-of-Service	(LOS)
0000/1000	Customer (subscriber) — transferred (changed number)	(SST)

8.40 The format of subsequent address messages uses a message category extension which includes a sequence number. Initially, only subsequent address messages use the message category extension although it is available for other uses. A 3-signal unit subsequent address message format is shown in Fig. 13.

```
                             TRUNK LABEL
ISU  1 0 1 / 1 / 0 0 0 / X X X X X X X X X / X X X X / X X X X X X X X

    HEADING  *     * *       BAND NUMBER        TRUNK          CHECK
                                                NUMBER

SSU  1 1 0 / 0 0 0 0 1 / X X X X X X X X X X X X X / X X X X X X X X

    HEADING  MESSAGE         SIGNAL INFORMATION           CHECK
             CATEGORY

  * = INITIAL SIGNAL UNIT TYPE INDICATOR

* * = LENGTH INDICATOR
```

Fig. 12—Format of a Telephone Signal in a 2-Unit Message

```
                                  TRUNK LABEL
        ISU  1 0 1 / 1 / 0 0 1 / X X X X X X X X X / X X X X / X X X X X X X X

            HEADING  *     * *      BAND NUMBER        TRUNK          CHECK
                                                       NUMBER

1ST  SSU  1 1 0 / 0 0 0 0 0 / X X X X / X X X X / X X X X / X X X X X X X X

        HEADING   MESSAGE       * * *     1ST        2ND              CHECK
                  CATEGORY               ADDRESS    ADDRESS
                                         SIGNAL     SIGNAL

2ND  SSU  1 1 0 / 0 / X X X X / X X X X / X X X X / X X X X / X X X X X X X X

        HEADING  †    3RD       4TH       5TH       6TH              CHECK
                     ADDRESS   ADDRESS   ADDRESS   ADDRESS
                     SIGNAL    SIGNAL    SIGNAL    SIGNAL

      * = INITIAL SIGNAL UNIT TYPE INDICATOR

    * * = LENGTH INDICATOR

  * * * = MESSAGE CATEGORY EXTENSION

      † = SPARE (CODED 0)
```

Fig. 13—Format of a Subsequent Address Message With Two Subsequent Signal Units

Note: The message category extension in the first SSU of a subsequent address message has bit 9 coded 0 and the sequence number going from 001 to 111 in bits 10 through 12.

8.41 The message category extension is in bits 9 through 12 of the first subsequent signal unit of a miscellaneous multiunit message when the message category is 00000. The extension is used for subsequent address messages at present.

Bits 9 Through 12—Message Category Extension

0000	Spare
0001	First subsequent address message
0010	Second subsequent address message
0011	Third subsequent address message
0100	Fourth subsequent address message
0101	Fifth subsequent address message
0110	Sixth subsequent address message
0111	Seventh subsequent address message
1000	Spare
1001	Spare
1010	Spare
1011	Spare
1100	Spare
1101	Spare
1110	Spare
1111	Spare

Example of an Initial Address Message

8.42 Since the majority of all the telephone signals has been presented, the following example of an address message is given to illustrate the format and coding of a typical intertoll call. As there is no relevant telephone signal information contained in the check field (bits 21 through 28) of the signal units, these fields are not shown.

8.43 ***National Intertoll Call***—An intertoll call from Boston to Holmdel which is routed over a trunk from Boston to Newark that has nonassociated CCIS signaling through one signal transfer point (intraregional call) follows.

Assumptions:

- Terrestrial facilities only
- Normal routing followed
- Dialed information: 201-949-5382
- Information transmitted: 949-5382
- Band number will change at the signal transfer point.

(1) Address message from Boston to STP:

```
A   B C      D        E
101/0/001/11001 1101/1010

    F   G   9     4   9
110/0/0001/1001/0100/1001

          5   3     8   2
110/0/0101/0011/1000/0010
```

A - Heading
B - ISU Indicator

C - Length Indicator
D - Band Number - 413

E - Trunk Number - 10
F - Route - Information Indicator
G - Abbreviated Route - Information

(2) Address message from STP to Newark—The band number is translated from 413 to 138. No other information changes.

```
101/0/001/01000 1010/1010
110/0/0001/1001/0100/1001
110/0/0101/0011/1000/0010
```

An example of an interregional 10-digit call from New York City to Los Angeles via San Bernardino (interregional call) follows.

Assumptions:

- Terrestrial facilities only
- Normal routing followed
- Dialed information: 213-957-8462
- Information transmitted: 213-957-8462
- Band number will change at both STPs.

(1) Address message from New York City to STP:

101/0/ 011/00000 1010/1100

A B C D Spare E F
110/1/0/0/0/00000/0000/0000
110/0/0000/0010/0001/0011
110/0/1001/0101/0111/1000
110/0/0100/0110/0010/0000

A - Expanded Routing Info

B - In Chain
C - No Satellite Trunk
D - This Link
E - Unknown Source
F - Ordinary Intertoll

(2) Address message from home STP to distant STP:

101/0/011/000000 111/1100
110/1/0/0/0/00000/0000/0000
110/0/0000/0010/0001/0011
110/0/1001/0101/0111/1000
110/0/0100/0110/0010/0000

(3) Address message from distant STP to San Bernardino:

101/0/011/000010110/1100
110/1/0/0/0/00000/0000/0000
110/0/0000/0010/0001/0011
110/0/1001/0101/0111/1000
110/0/0100/0110/0010/0000

8.44 ***Signaling-System-Control Signals***—The signaling-system-control signals are related to a signaling link and not to telephone signal information. They are necessary for the proper functioning of the signaling system. All system control signals are transferred as one-unit messages.

Acknowledgment Signal Unit (ACU)

8.45 The format of the ACU is shown in Fig. 14.

8.46 The ACU contains 11 acknowledgment indicators to acknowledge sequentially the corresponding 11 signal units of a block received. Each indicator will be coded in the following way:

0 No error detected
1 Error detected

8.47 Both the block being acknowledged and the block completed by the ACU are indicated by cyclic sequence numbers from the series 000, 001, 010, 011, 100, 101, 110, 111, 000, ...

```
0 1 1 / X X X X X X X X X X X / X X X / X X X / X X X X X X X X

 1-3            4-14              15-17    18-20       21-28
HEADING    ACKNOWLEDGEMENT          *       * *        CHECK
              INDICATORS

   * = SEQUENTIAL NUMBER OF BLOCK BEING ACKNOWLEDGED

 * * = SEQUENTIAL NUMBER OF BLOCK COMPLETED BY THIS ACU
```

Fig. 14—Format of an Acknowledgment Signal Unit

System Control Signal Units (SCU)

8.48 The synchronization signal unit (SYU) and the other system control signal units are grouped together under one heading (111) and signal information code (0111). The synchronization signal units and system control signal units under international control have bits 8 and 9 coded 01 and 00, respectively. Those under national control have bits 8 and 9 coded 11.

8.49 The format of the synchronization signal unit is shown in Fig. 15.

8.50 There are two versions of the SYU used. The odd synchronization unit has bit 16 coded 1. The even synchronization unit has bit 16 coded 0. The odd and even synchronization units are used in opposite directions of transmission on the signaling links. This allows immediate detection of accidental VFL loop-backs which would otherwise be difficult to detect.

8.51 *Codes for the SYU Parts*—This synchronization pattern is coded as 111/0111/0111000/X. The first part of the synchronization pattern consists of the heading and information fields which are coded 111 0111.

8.52 The sequence number may have any code of the 4-bit binary counting code 0000,0001,0010 up to 1010 inclusive. The remaining codes 1011 to 1111 are not assigned. The number chosen for a synchronization signal unit is determined by the position of that synchronization signal unit in the block of signal units. For example, if the SYU is the sixth signal unit, its sequence number would be 0110(6).

8.53 The format of other SCUs is shown in Fig. 16.

8.54 *Codes for the Parts of Other SCUs*—The heading and signal information fields are coded as 111 0111. This coding indicates that the signal unit is an SCU or an SYU or a type of signaling-network-management signal which requires no label. (See 8.61.)

```
1 1 1 / 0 1 1 1 / 0 1 1 1 0 0 0 1 / X / X X X X / X X X X X X X X

          1-15                       16    17-20        21-28
  SYNCHRONIZATION PATTERN             *     * *          CHECK

  *  = ODD/EVEN SYU INDICATION

* *  = SEQUENCE NUMBER OF SIGNAL UNIT IN THE BLOCK
```

Fig. 15—Format of the Synchronization Signal Unit

```
1 1 1 / 0 1 1 1 / X X X X X X X X X X X X X / X X X X X X X X

HEADING  SIGNAL          CONTROL SIGNALS            CHECK
         INFOR-
         MATION
```

Fig. 16—Format of Other System Control Units

Signaling System Control Signals

8.55 Those signals under national control are coded as follows:

Bits

8 through 9	11 (national control)		
10 through 12	001		
13 through 16	0001		
17 through 20	Signal codes for the control signals under national control		
	0000	Spare	
	0001	Manual-voice-frequency-link-transfer	(MVT)
	0010	Test-standby-voice-frequency link	(TSV)
	0011	Voice-frequency-link-test, passed	(VLP)
	0100	Voice-frequency-link-test, failed	(VLF)
	0101	Spare	
	0110	Spare	
	0111	Spare	
	1000	Spare	
	1001	Spare	
	1010	Spare	
	1011	Spare	
	1100	Spare	
	1101	Spare	
	1110	Spare	
	1111	Spare	

8.56 Those signals under international control but also used in the national network are coded as follows:

Bits

8 through 9	00 (International control)		
10 through 12	001		
13 through 16	0001		
17 through 20	0000	Spare	
	0001	Change-over	(COV)
	0010	Manual-Change-Over	(MCO)
	0011	Spare	
	0100	Standby-ready	(SRD)
	0101	Spare	
	0110	Load-transfer	(LTR)
	0111	Emergency-Load-Transfer	(ELT)
	1000	Spare	
	1001	Spare	
	1010	Manual-change-over acknow-ledgment	(MCA)
	1011	Spare	
	1100	Standby-Ready Acknowledg-ment	(SRA)
	1101	Spare	
	1110	Load-Transfer-Acknowledg-ment	(LTA)
	1111	Spare	

Management Signals

8.57 Management signals may include network-management signals, network-maintenance signals, and signaling-network-management signals, ie, signals concerned with the management of the signaling network or the trunk network. These signals may be transferred by means of one-unit messages or multiunit messages consisting of one or more signal units, respectively.

Single-Unit Management Signals

8.58 The format of the single-unit management signal is shown in Fig. 17.

All single-unit management signals have the heading code 111.

8.59 The signal information fields assigned for management signals bits 4 through 7 are:

0100	Network-management (reserved for international use)	(NMI)
0101	Signaling-network-management (reserved for international use)	(SMI)
1000	Network-management (national use DOC)	(NMN)
1001	Signaling-network-management (national use banded)	(SMN)
0111	+bits 8 and 9 = 10 signaling-network-management (non-banded)	

```
1 1 1 / X X X X / X X X X X X X X X / X X X X / X X X X X X X X

  1-3       4-7            8-16            17-20          21-28
HEADING   SIGNAL             *              * *           CHECK
          INFOR-
          MATION

   *  = BAND NUMBER, TERMINAL NUMBER, OR MISCELLANEOUS INFORMATION

  * * = MANAGEMENT INFORMATION
```

Fig. 17—Format of One-Unit Management Signals

8.60 Bits 8 through 16 will, in general, be used for band numbers but, in some cases, will have a terminal number or other information that is needed. For example, a link failure signal has a terminal number instead of a band number.

8.61 Those management signals that do not require either band or terminal numbers use a code similar to that of the signaling system control signal units and share the heading and signal information codes 111 0111. The difference occurs in bits 8 and 9 which are coded 10.

The signal information code for network-management signals for international use is 0100. At present, no signals are coded.

8.62 The signal information code for network-management signals for national use is 1000. For all signals coded at this time, bits 8 through 16 contain the band number portion of the label. The signals coded in the management information field bits 17 through 20 are Dynamic Overload Control (DOC) signals.

Bits 17 Through 20—Dynamic Overload Control Signals

0000	DOC-off	(DOC0)
0001	DOC-off-acknowledgment	(DOCA0)
0010	DOC-level-1	(DOC1)
0011	DOC-level-acknowledgment	(DOCA1)
0100	DOC-level-2	(DOC2)
0101	DOC-level-2-acknowledgment	(DOCA2)
0110	DOC-level-3	(DOC3)
0111	DOC-level-3-acknowledgment	(DOCA3)
1000	Spare	
1001	Spare	
1010	Spare	
1011	Spare	
1100	Spare	
1101	Spare	
1110	Spare	
1111	Spare	

8.63 The signal information code for signaling-network-management signals for international use is 0101. These network controls, however, are also used in the national CCIS network. Bits 8 through 16 contain the band number of the trunk label and bits 17 through 20 contain the management information. The signals coded in the management information field are as follows:

Bits 17 Through 20

0000	Spare	
0001	Spare	
0010	Spare	
0011	Spare	
0100	Spare	
0101	Transfer-prohibited	(TFP)
0110	Transfer-allowed	(TFA)
0111	Spare	
1000	Transfer-Allowed-Acknowledgment	(TAA)
1001	Spare	
1010	Spare	
1011	Spare	
1100	Spare	
1101	Spare	
1110	Spare	
1111	Spare	

8.64 The signal information code for signaling-network-management signals for national use is 1001. Bits 8 through 16 are used for either the band number portion of the trunk label, group 1, or the terminal number in a signal transfer point, group 2. The signals assigned are designated as to which group they belong. The signals coded in the management information field, bits 17 through 20, are as follows:

Bits 17 Through 20

0000	Spare	
0001	Spare	
0010	Request-particular-band-status-of-STP group 1	(RPB)
0011	Spare	
0100	Spare	
0101	Spare	
0110	Spare	
0111	Transfer-restricted, group 1	(TFR)
1000	Spare	
1001	Link-normal, group 2	(LKN)
1010	Link-failed, group 2	(LKF)
1011	Spare	
1100	Spare	
1101	Spare	
1110	Spare	
1111	Spare	

8.65 The signaling-network-management signals requiring neither band number nor terminal number have a signal information code of 0111 which is shared with signaling system control signals. At present, only signaling-network-management signals use this group of codes although eventually it is expected that network-management and network-maintenance signals will also use them. For example, broadcast signals are not expected to require band number or terminal number information.

8.66 The signal codes are as follows:

Bits

8 through 9	10		
10 through 12	001		
13 through 16	0001		
17 through 20	0000	Spare	
	0001	Spare	
	0010	Request-all-band-status-of-STP	(RAB)
	0011	Request-link-status-of-STP	(RLK)
	0100	End-of-status-update	(ESU)
	0101	Spare	
	0110	Spare	
	0111	Spare	
	1000	Spare	
	1001	Spare	
	1010	Spare	
	1011	Spare	
	1100	Spare	
	1101	Spare	
	1110	Spare	
	1111	Spare	

Multiunit Management Messages

8.67 The format of a multiunit management message is shown in Fig. 18.

The combined heading code and initial signal unit type code for the initial signal unit is 1011.

8.68 The multiunit management messages carry management information that, in most cases, applies to a band of labels. The bits normally used for trunk number in the initial signal unit, bits 17 through 20, are used to determine management message type. There may be messages defined at a later time that apply to all bands on a signaling link. Under such circumstances, the band number field may be used to expand the management message type or for signal information.

8.69 The management information fields in the subsequent signal units have a format defined by the management message type indicated in the ISU.

8.70 The signals included in this group are selectivity, for example, hard-to-reach (SHR) codes and out-of-chain-routing (OTO) turnoff signals. The selectivity messages are used to indicate difficulty of routing traffic to various destinations. The out-of-chain-routing-turnoff messages are used to notify an office sending out-of-chain calls to another office that no more out-of-chain calls to an NPA or office code should be routed to it for some time period.

Bits 17 through 20 in the ISU indicate the message type and have the following codes assigned:

Bits 17 Through 20—Message Type

0000	Selectivity, normal	(SLN)
0001	Selectivity, hard-to-reach	(SHR)

0010	Spare	
0011	Spare	
0100	Spare	
0101	Spare	
0110	Spare	
0111	Spare	
1000	Out-of-chain-routing-turnoff	(OTO)
1001	Spare	
1010	Spare	
1011	Spare	
1100	Spare	
1101	Spare	
1110	Spare	
1111	Spare	

8.71 The first subsequent signal unit has a heading code of 110, a message code of 01000, and management information in bits 9 through 20 defined according to message type. All other subsequent signal units have a heading code of 110 and management information in bits 4 through 20.

8.72 The codes for management information for both selectivity and out-of-chain-routing-turnoff messages in the first subsequent signal unit are as follows:

Bits 9 Through 10—Prefix Type

00	Country Code	(CC)
01	Numbering Plan Area	(NPA)
10	Office code	(OFC)
11	Spare	

Bits 11 through 20 in the first SSU are used for a binary representation of a 3-digit decimal number. Because 1000 codes are involved, a code table is not included.

8.73 The codes in all other subsequent signal units are as follows:

Bits 4 Through 7—Spare

Bits 8 Through 10—Prefix Types

000	Country Code	(CC)
001	Numbering Plan Area	(NPA)
010	Office code	(OFC)
011	Spare	
100	Spare	
101	NPA with previously listed CC*	
110	OFC with previously listed NPA*	
111	First three digits of line number with previously listed OFC	

```
        ISU  1 0 1 / 1 / X X X / X X X X X X X X X X / X X X X / X X X X X X X X

               HEADING  *    * *      BAND NUMBER        MANAGE-       CHECK
                                          OR              MENT
                                     MISCELLANEOUS       MESSAGE
                                      INFORMATION         TYPE

 1ST    SSU  1 1 0 / 0 1 0 0 0 / X X X X X X X X X X X X / X X X X X X X X

             HEADING   MESSAGE     MANAGEMENT INFORMATION         CHECK
                       CATEGORY

 2ND
  TO    SSU  1 1 0 / X X X X X X X X X X X X X X X X X / X X X X X X X X
 7TH
             HEADING       MANAGEMENT INFORMATION            CHECK

   *  = INITIAL SIGNAL UNIT TYPE INDICATOR

 * *  = LENGTH INDICATOR
```

Fig. 18—Format of Multiunit Management Messages With up to Seven Subsequent Signal Units

*These codes are used to prevent ambiguity. For example, an NPA may be transmitted with several office codes within the NPA in the following subsequent signal units or an NPA code may be given applying to all office codes in the area and nonrelated office codes in the following subsequent signal units.

Bits 11 through 20 in all of the subsequent signal units are used identically to bits 11 through 20 in the first subsequent signal unit, that is, for a binary representation of a 3-digit decimal number.

At present, only single-unit signaling-network-management signals are planned although future signals may require multiunit messages.

Header Message

8.74 A header signal unit prefixes messages carried between signal transfer point pairs within the same signaling region over "C" links. The header furnishes a means of making good a signal path under multiple failure conditions. The header message follows the general format of a miscellaneous multiunit message. The format of a header message is shown in Fig. 19.

8.75 The heading code of header signal units is 101 with an initial signal unit type indicator of 1 which makes it an ISU of a miscellaneous

```
         ISU  1 0 1 / 1 / X X X / X X X X X X X X X / X X X X / X X X X X X X X
                HEADING  *     * *      OUT TERMINAL         * * *        CHECK
                                        IDENTIFICATION

1ST  SSU  1 1 0 / 1 / X X X X X X X X X X X X X X X X / X X X X X X X X
            * * * *   †   SAME CODE AS LSU OR ISU OF             CHECK
                              PREFIXED MESSAGE

2ND  SSU  X X X X X X X X X X X X X X X X X X X X / X X X X X X X X
              SAME CODE AS 1ST SSU OF PREFIXED           CHECK
                           MESSAGE

NTH  SSU  X X X X X X X X X X X X X X X X X X X X / X X X X X X X X
             SAME CODE AS (N-1)TH SSU OF PREFIXED        CHECK
                           MESSAGE

         * = INITIAL SIGNAL UNIT TYPE INDICATOR

       * * = LENGTH INDICATOR

     * * * = FIRST FOUR BITS OF MESSAGE PREFIXED

   * * * * = SUBSEQUENT SIGNAL UNIT HEADING CODE

         † = MESSAGE CATEGORY
```

Fig. 19—Format of Messages With Header Signal Units

MUM. The length indicator is allowed to go to 111 maximum. The header message is the only message allowed to have eight subsequent signal units. All other multiunit messages are allowed a maximum of seven subsequent signal units.

The out-terminal identification is a number assigned to the terminal on the signaling link for which the message would normally be transmitted.

8.76 The first four bits from the prefixed message are in bits 17 through 20 of the header signal unit. This is required so that the subsequent signal unit heading code can be used in bits 1 through 3 of the lone signal unit or initiate signal unit of the message being prefixed and so an abbreviated message category indicator may be used.

8.77 The heading code of the lone signal unit or the initial signal unit of the message being prefixed is the subsequent signal unit heading code, 110, and the message category indicator in bit 4 is coded 1.

The codes for the rest of the message are identical to those for the message without a header.

Example of Messages With a Header Signal Unit

8.78 ***Lone Signal Unit Message With a Header Signal Unit***—An answer charge signal which would normally be sent out on terminal number 5 from STP0 is to be sent to its mate in the region, STP1, on the connecting CCIS link ("C" link). The message before modification is as follows:

```
     *        BAND 8   TRK1
010/1000/00000   1000/0001
```

*ANSWER, CHARGE (PRIORITY)

After the header is appended, the message is:

```
                    *       **
101/1/000/00000   0101/0101
110/1/000/00000   1000/0001
```

*OUT-TERMINAL#5
**FIRST 4 BITS OF MESSAGE PREFIXED

8.79 ***Initial Address Message With a Header Signal Unit***—The same signaling link as in the previous paragraph has an initial address message that requires a header. The message before modification is as follows:

```
                 BAND 138    TRK 10
101/0/001/01000       1010/1010
110/0/0001/1001/0100/1001
110/0/01011/0011/1000/0010
```

After the header is appended, the message becomes:

```
                    *       **
101/1/010/00000   0101/1010
110/1/001/01000   1010/1010
110/0/0001/1001/0100/1001
110/0/0101/0011/1000/0010
```

* OUT-TERMINAL #5
** FIRST 4 BITS OF MESSAGE PREFIXED

NOTES ON DISTANCE DIALING

SECTION 7

TRANSMISSION CONSIDERATIONS

CONTENTS PAGE

1. GENERAL

1.01 This section of the Notes on Distance Dialing presents transmission considerations bearing on operator assisted and direct distance dialed traffic. The first part of this section contains general information, an explanation of the organization of the remainder of this section, and general transmission considerations imposed by the distance dialing switching plan.

1.02 The transmission considerations of this section are presented in terms of:

(1) Performance objectives (long-range goals for transmission quality on an industry-wide basis)

(2) Circuit order tests (verifying that requirements are satisfied before initiating service)

(3) Maintenance requirements (reflecting desired transmission performance obtainable with existing equipment and operating procedures)

(4) Maintenance limits (indicating when transmission performance becomes unsatisfactory and maintenance action should be undertaken).

1.03 All these objectives, tests, requirements, and limits reflect an overall philosophy of a compromise between the customer's service needs, the customer's concept of the performance, and the economic aspects of achieving this performance through new designs or improved maintenance.

1.04 In general, improvements to the network are achieved through an evolutionary process. As such, objectives, requirements, etc, must be periodically reviewed and updated. In recent years, the review process for performance objectives has been achieved through computer simulation models which allow examination of the interrelationship between the various parameters. These simulation models are based on surveys of plant performance, data set evaluations, and subjective tests. The data set evaluations relate the effects of various parameters to error rates. Subjective tests relate the parameters to the customer's opinion of the quality of service.

1.05 In many cases, the customer's subjective opinion is measured on a scale of "excellent, good, fair, poor, and unsatisfactory" and estimates are obtained of the expected percentage of customers which would rate calls "good or better" (good and excellent) or "poor or worse" (poor and unsatisfactory) with certain network conditions. These estimates are referred to as "grade of service." In general, the subjective test results depend, to some extent, on the type of test, the particular set of subjects used, and other factors. Therefore, changes in grade of service with change in parameters using the same test results are more significant than the absolute value of grade of service.

1.06 In general, performance objectives are frequently long-range goals for performance. In contrast, circuit order test requirements and maintenance requirements are based on the performance obtainable with existing equipment and operating procedures. Circuit order requirements reflect the capabilities of the system if properly installed and adjusted. They also include parameter tests whose values will generally not vary over the lifetime of the trunk if the requirement is initially met. Maintenance requirements indicate when performance is unsatisfactory. They are established by considering their effect on quality of service and the maintenance effort in making a correction. In general, circuit order and maintenance requirements are stated in terms of limits which indicate when performance is unsatisfactory and corrective action should be undertaken.

1.07 The balance of this section presents the specific information about these transmission-affecting parameters divided between parameters primarily affecting voice transmission and those primarily affecting data transmission. By "primarily," it is meant that the parameter requirement is set by the needs of that service; however, each parameter generally affects both services. The parameter is first characterized by a description of its effects on transmission; then the control of that parameter is described. This includes applicable objectives, tests, requirements, and limits, each further subdivided where applicable into functions of the connecting parts of the transmission path and the characteristics of their physical makeup.

2. ECHO, SINGING, AND NEAR-SINGING

2.01 Echo is the energy which has been reflected in some manner from the primary speech path. This reflection can occur in the transmission path either at a 4-wire circuit to a 2-wire circuit junction or at an impedance irregularity on a 2-wire circuit. Figure 1 shows an example of how echo occurs on an end-to-end connection involving a 4-wire intertoll trunk (ITT) and a 2-wire toll-connecting trunk (TCT) at each end. The 4-wire trunk is connected to the 2-wire trunk by means of 4-wire terminating sets through the switches at each end. The impedance presented by the 2-wire trunk varies widely, being different for each connection. This causes energy to be reflected at the junction. The proportion of energy reflected depends on the impedance mismatch between the trunk impedance and the balancing network. It is measured in terms of Return Loss which can be expressed in dB by:

$$\text{Return Loss} = 20 \log_{10} \left| \frac{Z_N + Z_L}{Z_N - Z_L} \right| \text{dB}$$

2.02 For the case of impedance mismatch at the 4-wire to 2-wire junction, Z_N is the impedance of the compromise balancing network and Z_L is the impedance looking into the 2-wire trunk. Return loss is generally a function of frequency. Echo Return Loss (ERL) is defined as a weighted average of the return losses over the band of frequencies between 500 and 2500 Hz.

2.03 The reflected echo causes two types of phenomena, talker echo and near-singing. Talker echo occurs when the primary speech energy is reflected at the far end and returns to the talker along the talker echo signal path as indicated in Fig. 1. The talking customer thus hears his own voice delayed by the total delay of the echo path. If the reflected energy has sufficient amplitude and delay, it can be annoying and can interfere with the talker's normal speech process.

2.04 If talker echo is again reflected by the near-end impedance discontinuities, it is heard by the listener. It is frequently referred to as "near-singing distortion," as described next, for short delays and "listener echo" on longer connections. This type of echo is generally of concern on

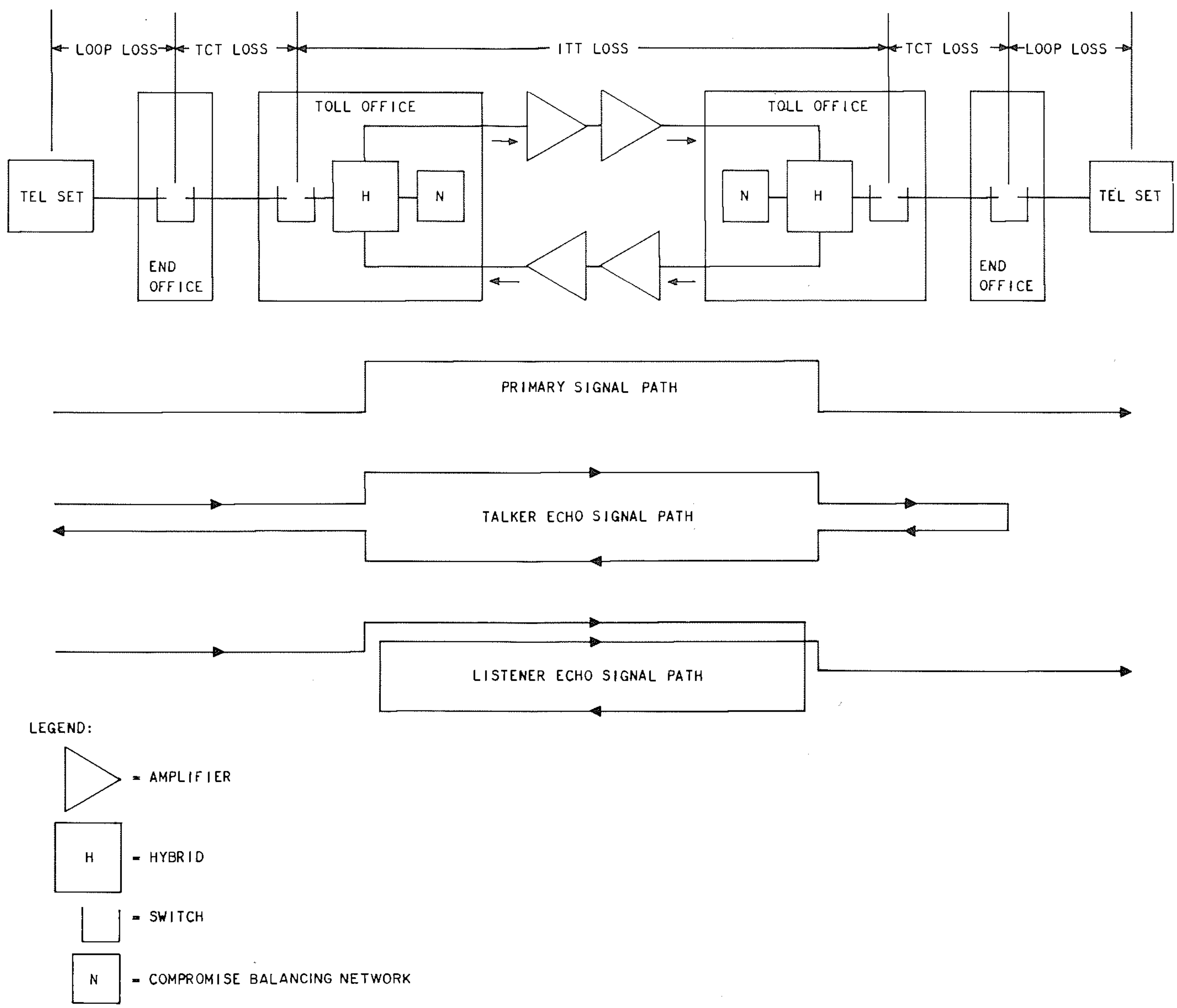


Fig. 1—Echo Path in a Telephone Connection

relatively short-length connections. On longer connections, methods to control talker echo will also control this echo.

2.05 The amount of annoyance caused by talker echo depends upon amplitude and delay of the echo signal. Figure 2 shows the latest talker echo subjective test results. The curves show a decrease in the percent good-or-better opinions with decrease in the acoustic talker echo path loss and/or increased echo path delay. The acoustic talker echo path loss includes the acoustic-to-electric transmit and electric-to-acoustic receive efficiencies of the telephone set, twice the electrical loss to the point of echo, and the echo return loss at the far end. For loops with a 500-type telephone set, the sum of the acoustic-to-electric transmit and receive efficiencies has a mean about 9 dB and standard deviation of 5 dB.

2.06 To control talker echo in the DDD network, three methods are used: (1) insertion of loss in the transmission path, (2) proper balance at impedance discontinuities, and (3) the application of echo suppressors. The use of each of these methods will be discussed in subsequent paragraphs.

2.07 Singing is caused by circulating energy in a transmission path. It occurs in the same manner as echo. Referring to Fig. 1, singing arises if the gains in line repeaters or carrier channels are high enough such that the energy returned to the hybrid via the "listener echo" path is greater than the original energy and the energy waves are in phase. Near-singing is the condition just before actual singing takes place. Low loss in a transmission path can produce the "near-singing" or "hollow" effect which is similar to talking into an empty barrel.

2.08 Singing and near-singing can be controlled by improving the return loss at the reflection points and providing some minimum amount of loss even when talker echo is not important. These measures are the same as used for talker echo except attention must be given to a wider bandwidth (200 to 3200 Hz). Normally, talker echo considerations are controlling in the frequencies between 500 and 2500 Hz. If singing occurs, it normally occurs at frequencies near the band edges (200 to 500 Hz or 2500 to 3200 Hz) where impedances are poorer. The singing objective is given in terms of singing margin defined as the amount of gain which, when added to a given connection, will just start it singing. The near-singing objective for the design of trunks is that the singing margin should be 10 dB or more in 95 percent of all cases.

3. LOSS

OPTIMAL LOSS

3.01 Loss is introduced into the transmission path in telephone connections primarily to control echo and near-singing. This loss appears once in the primary speech path and twice in the talker echo and near-singing path. The loss attenuates the reflected speech energy and, therefore, reduces its annoyance when it arrives at the talking customer. As indicated in Fig. 2, the amount of loss needed to achieve a given echo grade of service increases with increased delay. However, the loss also attenuates the primary speech signal. The subjective effect of the loss in the primary speech signal path depends on the amount of noise on the circuit. The effect is measured by loss-noise subjective tests. The good-or-better results from a recent test are plotted in Fig. 3. The results indicate that, for low values of noise, the percentage of calls rated good or better is controlled primarily by loss but, for noise values more typical of toll calls, both loss and noise affect the rating.

3.02 Actually, a customer's opinion of a call is based on a joint assessment of these effects since both effects are experienced during portions of the conversation. This joint assessment is measured through the loss-noise-echo grade of service. Quantitatively, the good-or-better value of this grade of service will be slightly lower than the value of either good-or-better loss-noise grade of service or talker echo grade of service which is individually lowest. This effect can be seen by examination of Fig. 4. Plotted in this figure is an estimate of the customers who would rate a call good or better in terms of the acoustic loss of an end-to-end connection of about 1300 airline miles. Also plotted are the individual loss-noise grade of service and echo grade of service. At low values of loss, the value of the loss-noise-echo grade of service is determined by the echo grade of service. As the loss is increased, it follows the improvement in the value of the echo grade of service until the echo value exceeds the loss-noise grade of service. For loss values higher than this value, the loss-noise-echo grade of service follows the loss-noise grade of service.

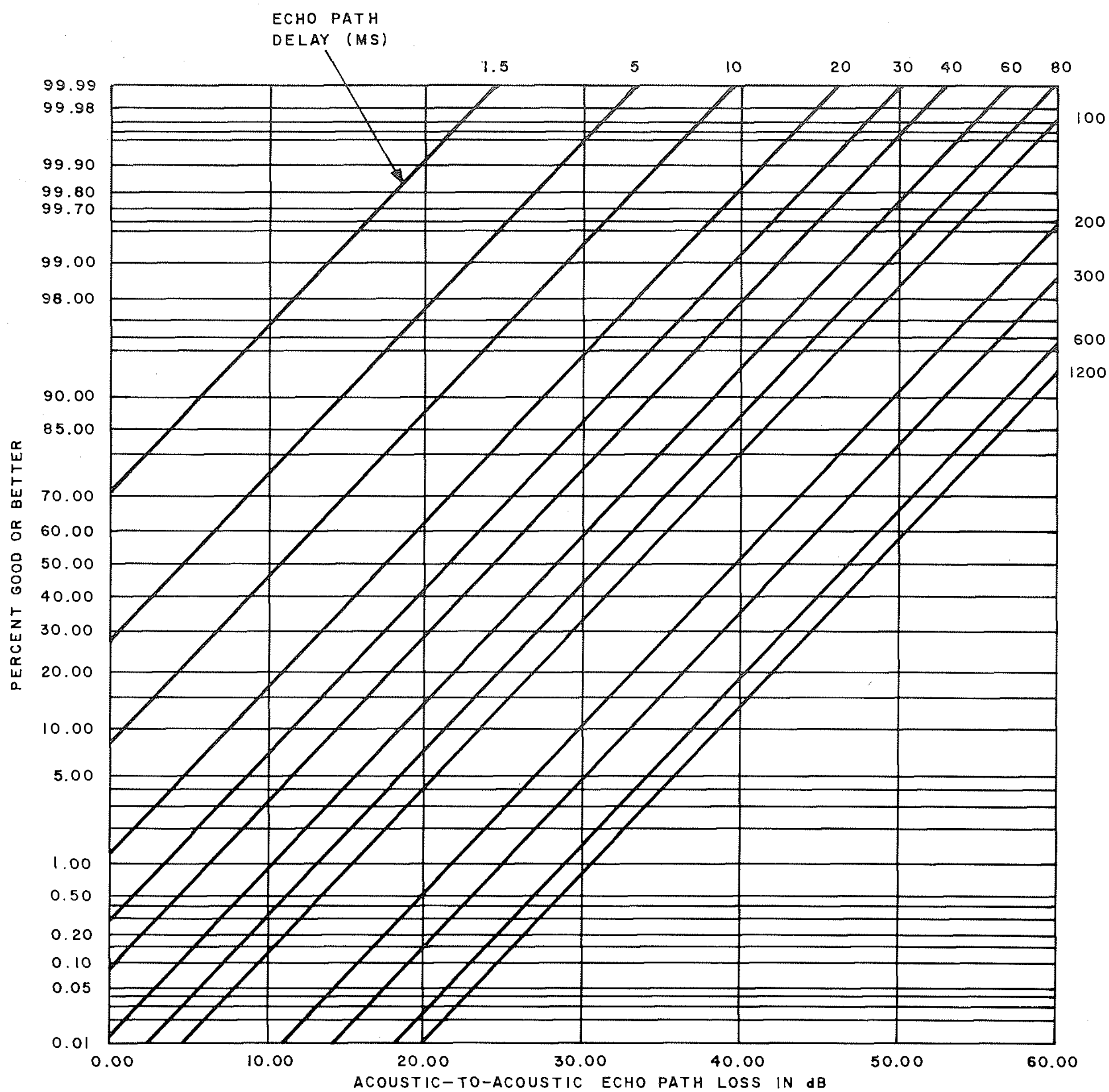


Fig. 2—Echo Grade of Service—Percent Good or Better

3.03 The good-or-better loss-noise-echo grade of service as a function of loss increases to some maximum value and then decreases. The value of loss at which the good-or-better loss-noise-echo grade of service is the maximum is defined as the optimal loss. The optimal loss can be determined for any given connection. Its value depends on the noise and delay associated with that length connection.

3.04 Ideally, a loss plan should provide a value of connection loss which is close to the optimal value for all length connections. At the same time, a loss plan must be able to be easily implemented and administered. In general, these constraints mean that the actual loss can only approximate the optimal loss. Small deviations from the optimal value can occur with insignificant changes in loss-noise-echo grade of service. In

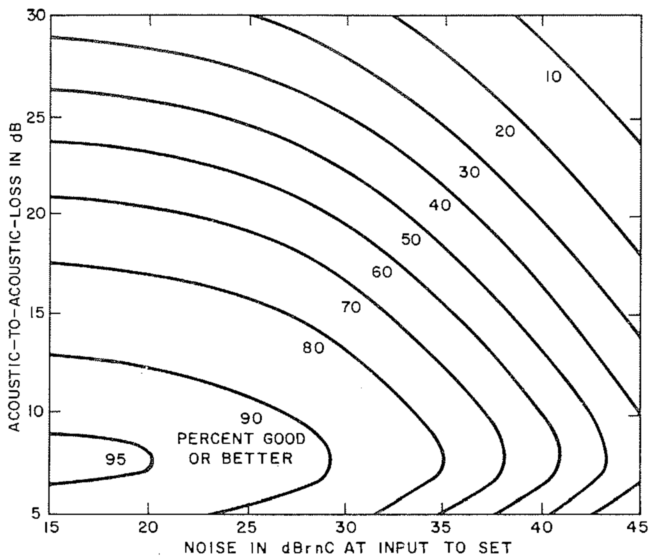


Fig. 3—Loss-Noise Grade of Service

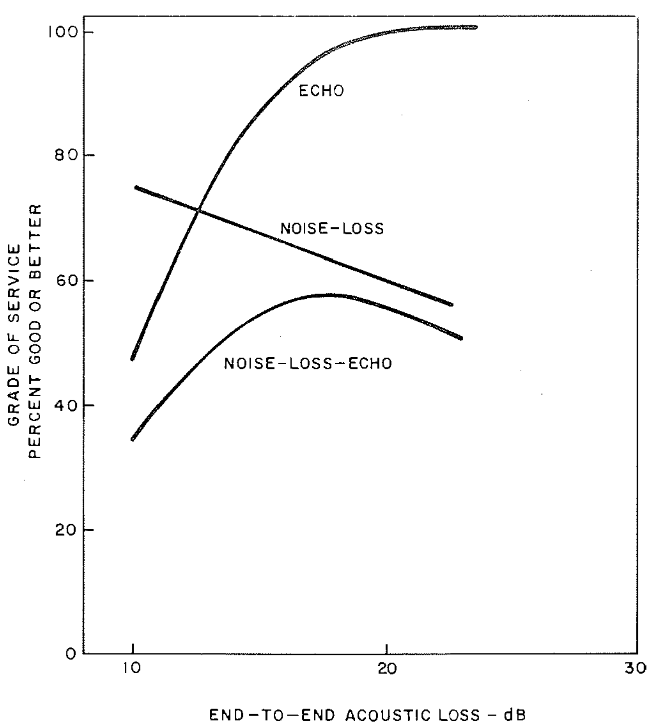


Fig. 4—Optimum Loss (1270 Airline Mile Connection)

some cases, slightly better echo grade of service is obtained with some decrease in loss-noise grade of service or the opposite.

3.05 In order to provide loss close to the optimal values on all connections, there are currently two loss plans for the DDD network. The first is for connections carried over analog facilities and switched at voice frequencies. Conceptually, this is representative of the network as it exists today. The second plan is for connections carried on digital facilities and digitally switched without multiplexers to decode the signal. This type of connection is not possible today but will become prevalent with the introduction of digital switching systems like No. 4 ESS. Although stated as two plans, the loss plans are compatible; connections can be established involving portions of both networks with quite satisfactory performance. The remaining parts of this section will derive the trunk loss objectives for the two plans.

3.06 The basic loss design objectives are specified in terms of the Inserted Connection Loss (ICL). ICL is the 1000-Hz* loss of the trunk when switched into an actual operating connection. It is the sum of all gains and losses from the originating outgoing switch appearance to the terminating outgoing switch appearance to which the trunk is connected with the trunk terminated in nominal impedance of the office of 600 or 900 ohms.

*This is the nominal test frequency. Currently, there is a long-term program to change 1000 Hz to 1004 Hz to avoid slow gain variations caused by beating of the 1000-Hz tone with the 8-kHz sampling of digital channel banks.

3.07 Related to the ICL is the Expected Measured Loss (EML). EML is the 1000-Hz loss that one would expect to measure between two readily accessible trunk test points corresponding to the ICL specification calculated with the proper terminating impedances at the test points. EML includes switching (or cord circuit) loss, test pad losses when specified in the measuring circuit, and connection losses to the 1000-Hz generator and detector.

3.08 Actual Measured Loss (AML) is the actual measured 1000-Hz loss between the same two access points for which EML was computed.

VIA NET LOSS PLAN

3.09 The Bell System standard loss plan for the analog network is the Via Net Loss (VNL) plan. It was derived in the early 1950s with the aim of assigning the lowest possible loss commensurate with satisfactory talker echo performance. A recent study has compared the connection loss obtained with VNL plan with that obtained through optimal loss considerations. This comparison is shown in Fig. 5. The study indicated that the VNL plan provides slightly too much loss for short connections but about optimal loss for long connections. Although the VNL plan provides more loss than optimum for short connections, the difference is not sufficiently great to have any appreciable effect on grade of service. Since the VNL plan is nearly optimum, it has been retained for use in the analog network.

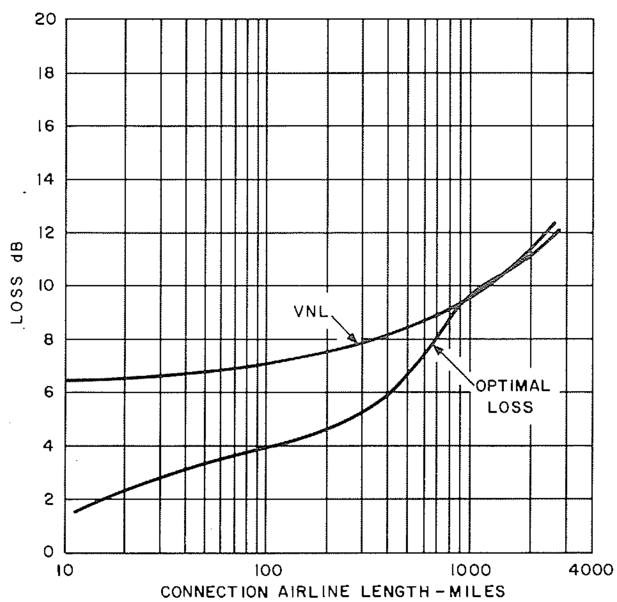


Fig. 5—Optimal Loss Compared With VNL

3.10 The VNL plan was developed using the available echo tolerance curves, the number of trunks in a connection, the deviation in trunk losses from design values, and the expected echo return loss at the far-end Class 5 office. Using these factors, curves of the required connection loss (Class 5 to Class 5 office) as a function of delay and number of trunks were derived as plotted on Fig. 6.

3.11 The VNL allocation plan was developed using linear approximations to these curves. The approximation for a single trunk connection, also plotted in Fig. 6, was derived by assigning more loss at short delays to prevent near-singing and allowing a maximum loss of about 9 dB which was judged to occur at approximately 45 milliseconds round trip delay; connections requiring greater loss would be equipped with echo suppressors. The approximations for more than one trunk were derived by adding 0.4 dB for each additional trunk to the loss required for a single trunk connection. This additional 0.4 dB per trunk compensates for the increased loss variability with the increased number of trunks. The linear approximate curves are given by the equation:

Class 5 to Class 5 Loss (dB) = 4.0 + 0.4 × (number of trunks) + 0.1 × (echo path delay, milliseconds)

3.12 Since the time of the development of this formula, new methods of measuring end-to-end connection loss have assigned switching and battery supply losses at Class 5 offices to this loss. This leads to a corrected required loss formula of:

Class 5 to Class 5 Loss (dB) = 5.0 + 0.4 × (number of trunks) + 0.1 × (echo path delay, milliseconds)

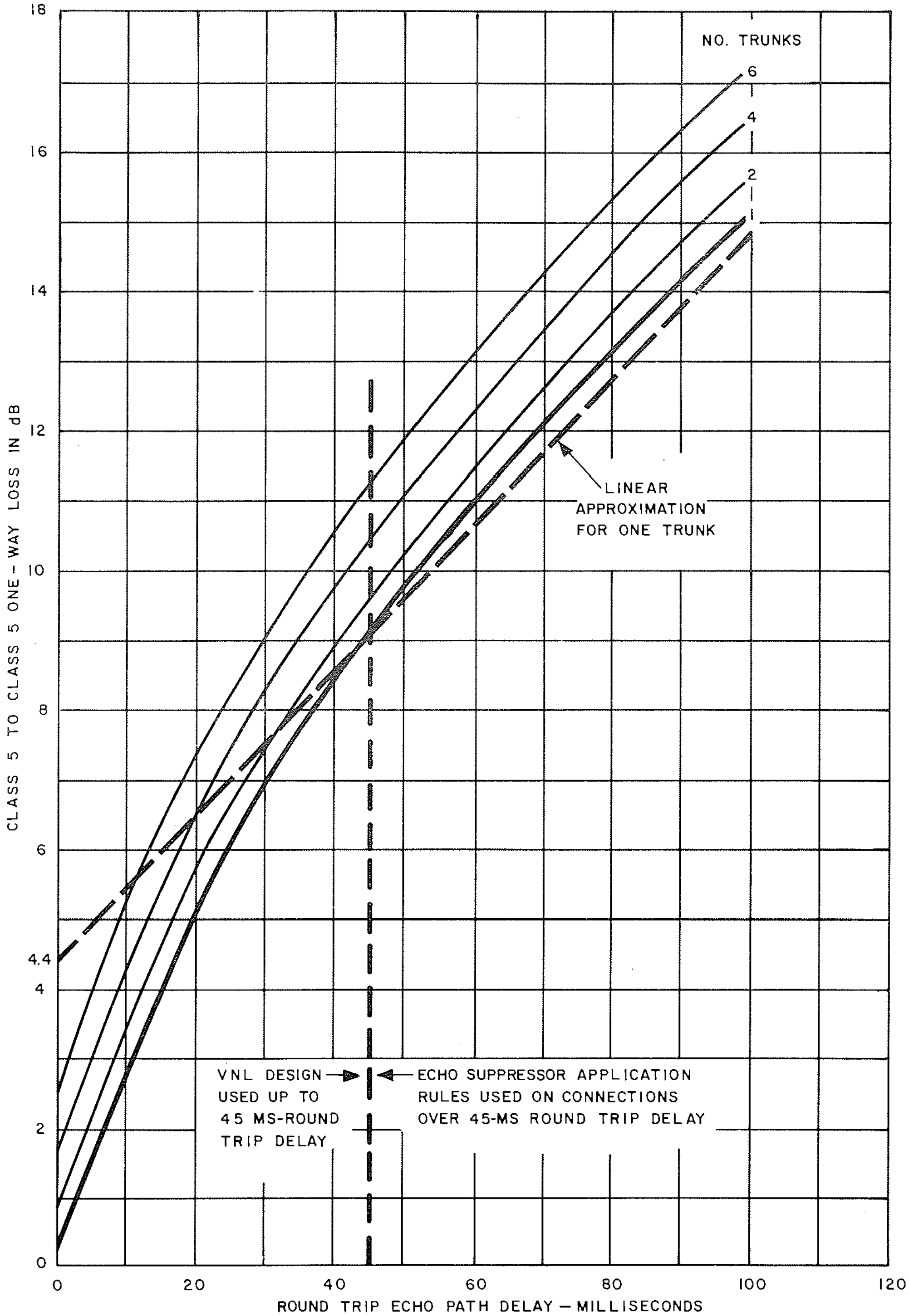
3.13 The trunk plan was developed to insure that this required connection loss is achieved on all length connections. The procedure was to assign half of the constant 5-dB loss to each toll-connecting trunk and to assign the remainder to all trunks, including toll-connecting trunks, in proportion to the echo path delay of each trunk. This remainder is called Via Net Loss (VNL) which is defined as the loss value in dB assigned to a trunk to compensate for its added propagation delay, terminal delay, and loss variability.

Class 5 to Class 5 Loss = (ΣVNL + 5) dB where for each trunk VNL = [0.1 × (echo path delay) + 0.4] dB

3.14 Since the echo path delay of a trunk is related to its length, the above equation is most easily used when given in terms of length and a Via Net Loss Factor (VNLF) as:

$$\text{VNL} = [\text{VNLF (one-way distance)} + 0.4]\ \text{dB}$$
$$\text{where VNLF} = \frac{2 \times 0.10}{\text{velocity of propagation}}$$

3.15 The factor "2" appears in this derivation because the factor 0.1 is the one-way incremental loss in dB per unit delay while the



NOTE:
THESE CURVES ASSUME CONTROL OF ALL INTERMEDIATE REFLECTIONS WITHIN THE CONNECTION (THROUGH 4-WIRE CIRCUITS AND 4-WIRE SWITCHING OR THEIR EQUIVALENTS IN 2-WIRE TOLL OFFICES MEETING THROUGH AND TERMINAL BALANCE OBJECTIVES FOR VNL OPERATION).

Fig. 6—Relationship Between Overall Connection Loss and Echo Path Delay (Class 5 to Class 5 Office)

echo path delay is round trip. The velocity of propagation used in the above equation must allow for the delay in an average number of terminals, repeaters, and intermediate modulation equipments as well as the velocity of propagation of the carrier, radio, or voice-frequency facilities. The accepted values for the via net loss factors of typical facilities are given in Table 1. Although there has been some decrease in the delay of carrier systems since the VNL factors were established, the difference is not great enough to warrant a change in the factor and in the required loss.

3.16 Although the VNL formula is a continuous function of distance, it has been found desirable administratively to use a step approximation to this formula for trunks on carrier facilities. It was decided to have the first step be 0.5 dB and each step thereafter increase by 0.3 dB with the step values agreeing with the formula at the midpoint of the interval. (See Table 2.)

ANALOG TRUNK LOSS OBJECTIVES

3.17 This segment states the loss objectives for the classes of analog trunks within toll and metropolitan DDD networks. (Trunks using digital facilities with digital channel banks at both ends are classified as analog trunks.) Trunks associated with operator services are covered later. Trunks serving multiple functions should meet the loss objective for each function and have facilities designed according to the highest class. For convenience, Table 3 summarizes all of the loss objectives.

Toll Network-Intertoll Trunks (ITT)

3.18 An intertoll trunk connects a toll switching office to another Class 1 through Class 4 office. Its traffic classification can be common final, full group, high usage, and individual final. Due to balance requirements, the trunk must be 4-wire using physical facilities or carrier. Use of long physical facilities is not recommended. Loss design is ICL = VNL dB.

3.19 The loss of carrier trunks is rounded to the nearest 0.3-dB step. Since most intertoll trunks operate on carrier and are tested with a 2-dB test pad (TP2) at each end, Table 2 has been provided as a convenient reference for these conditions. An additional length category was added with the recent change in the echo suppressor application distance from 1565 to 1850 miles for high-usage intertoll trunks.

TABLE 1

VIA NET LOSS FACTORS

TYPE OF FACILITY	dB PER MILE	
	2-WIRE CIRCUITS	4-WIRE CIRCUITS
Carrier (all types, including microwave radio)		0.0015
Exchange cable, H88, or other VF loaded and nonloaded	0.04	0.017

TABLE 2

ICL AND EML VALUES FOR INTERTOLL

TRUNKS OPERATING ON ALL CARRIER FACILITIES

TRUNK LENGTH MILES	ICL = VNL dB (0.0015 X AVG LENGTH + 0.4 dB)	EML = TP2 + ICL + TP2 (NOTE 1) dB
0 — 165	0.5	4.5
166 — 365	0.8	4.8
366 — 565	1.1	5.1
566 — 765	1.4	5.4
766 — 965	1.7	5.7
966 — 1165	2.0	6.0
1166 — 1365	2.3	6.3
1366 — 1565	2.6	6.6
1566 — 1850	2.9	6.9
Any length with echo suppressor (Note 2)	0.0	4.0

Notes:

1. EML values listed are for analog offices having 2-dB pads in the measuring facilities at each end. For digital offices using 3-dB pads, the loss values are 5 or 6 dB greater than ICL. [See digital loss objectives (3.35).]

2. In 4-wire toll offices employing 7-dB "A" pads on intertoll trunks, the additional loss of 1.8 dB for 1A-type echo suppressor plus office cabling and equipment losses greater than about 0.3 dB may be too high to permit the trunk to operate at 0.0 dB. In such cases, the ICL should be 0.5 dB and the EML 4.5 dB. However, newer echo suppressors will allow the 0.0 dB objective to be met in all cases.

Toll-Connecting Trunks

3.20 A toll-connecting trunk interconnects an end office (Class 5) to a higher ranking office. They include trunks classified as DDD access, operator office, recording completing, traffic service position, toll completing, toll completing and toll switch combined, and toll switch. The loss design objective is ICL = 2.5 + VNL dB.

An alternative design objective is allowed for trunks less than 200 miles which constitutes most toll-connecting trunks.

TCT LOSS:

Trunk Without Gain*	Min 2.0 dB	Max. 4.0 dB
With Gain or Carrier	3.0 dB	

*Trunks without gain are those provided on metallic facilities without repeaters or amplifiers. The minimum and maximum values given for a particular type of trunk indicate the range in design loss for that type of trunk. Trunks provided on carrier facilities should all be designed to one loss value as indicated. In all cases, however, maintenance variations will cause actual loss measured to deviate from the design value.

TABLE 3

LOSS DESIGN OBJECTIVES OF THE DDD NETWORK

DDD NETWORK		TRUNK		EQUIVALENT	ICL (dB)	MAXIMUM ICL (dB)	ECHO SUPP MILES	REMARKS
ANALOG TRUNK		TCT			2.5 + VNL			
		ITT	HU		VNL	2.9	1850	With Echo Supp; ICL = 0 dB.
			Final		VNL	1.4		
		EOT: Class 5 — Class 5			6.0 + VNL	8.9	No Echo Suppressors	(1) Trunks without gain <200 miles ICL: Min 0.0 dB Max. 5.0 dB (2) Trunks with gain <200 miles ICL = 3.0 dB.
		Class 5 — Higher Class			2.5 + VNL		1850	(1) Trunks without gain <200 miles ICL: Min 2.0 dB Max. 4.0 dB (2) Trunks with gain ICL = 3.0 dB (3) With Echo Supp; ICL = 3.0 dB.
DIGITAL TRUNK		TCT			3.0			
		ITT			0.0		1850	
		Class 5 — Higher Class			3.0		1850	Trunks <200 miles may have ICL = 3.0 dB. With Echo Supp; ICL = 3.0 dB.
DIGITAL AND ANALOG COMBINATION TRUNK		TCT			3.0			
		ITT			1.0		1850	
OPERATOR SERVICE	Manual Switchboard	Class 5 — Switchboard		TCT	2.5 + VNL	4.0		
		Secondary ITT			0.0	0.5		
	TSPS	RTA to TSPS Base Unit		ITT	0.0			See Fig. 10.
	NO. 5 ACD (See Fig. 11)	Local DA: Class 5 — ACD		Tandem Trunk	3.0			
		Class 5 — Concentrator		Tandem Trunk	3.0			
		Concentrator — ACD		Intertandem Trunk	0.5			
		Intra-NPA DA: Tandem Office — ACD		Intertandem Trunk	0.5			
		Toll — DA Class 3 — ACD		ITT	VNL	0.8		
	AIS and No. 5 ACD Intercept (See Fig. 11.)	Class 5 — ACD		AIS Trunk	3.0			
		Class 5 — Concentrator		AIS Trunk	3.0			
		Concentrator — ACD or AIS		ITT	0.0			

Notes:

1. VNL = VNLFX (Avg Length) + 0.4 dB.
2. VNLF can be found in Table 1.
3. Loss requirement for ITT on carrier facility can be found in Table 2.

3.21 Intertoll trunks in 4-wire switching systems generally have additional gain available which, if added to a connection, makes it possible to increase the loss of toll-connecting trunks by an amount equal to the available gain. This involves gain transfer across the switch and is referred to as High Loss Design for toll-connecting trunks. Switching pads ("A" pads) are included in the intertoll trunks and the loss of toll-connecting trunks is increased by an amount equal to the value of the "A" pad in the intertoll trunk. When the intertoll trunk is switched to the high-loss trunk, the machine switches out the "A" pad. This effectively transfers available gain from the intertoll trunk to the toll-connecting trunk. Steps must be taken to insure that high-loss designed trunks are never switched to other high-loss trunks. Moreover, if the "A" pad is switched out inadvertently on a trunk that is not high loss, the trunk may sing. Administrative difficulties and availability of lower cost gain devices make this approach less desirable for new switching centers.

End Office Toll Trunk

3.22 An end office toll trunk connects an end office to a higher ranking office or another Class 5 office in a different toll area. End office toll trunks carry high-usage traffic and are designed to the total loss which would have been assigned to the connection of toll-connecting and intertoll trunks which they replace. The loss design objectives are:

Class 5 to Class 5

ICL = VNL + 6.0 dB — Max. 8.9 dB

Class 5 to Higher Class

ICL = VNL + 2.5 dB

The design objective for Class 5 to Class 5 trunks provides about the same loss as that which would occur on an end-to-end connection switched through the network. Direct application of VNL design formula would allow 1 dB less loss. The higher value was recommended in order to avoid the use of echo suppressors on these trunks. Trunks longer than 1850 route miles should be designed to the maximum loss of 8.9 dB.

3.23 For trunks greater than 200 miles, the trunk must be 4-wire end to end and be derived on carrier facilities with perhaps short 4-wire metallic extensions. Trunks less than 200 miles may contain 2-wire junctions and sections of 2-wire facilities. Trunks under 200 miles may be designed like local or toll-connecting trunks.

Trunks Without Gain <200 Miles		
Class 5 to Class 5	Min 0 dB	Max. 5.0 dB
Class 5 to Higher Class	Min 2 dB	Max. 4.0 dB
Trunks With Gain or Carrier < 200 Miles		
Class 5 to Class 5	3.0 dB	
Class 5 to Higher Class	3.0 dB	

Metropolitan Network—Intertandem Trunks

3.24 An intertandem trunk connects two sector tandem offices or a sector tandem office to a high-volume (directional) tandem or toll center. An intertandem trunk must always be provided on 4-wire transmission facilities and use intertoll-type relay equipment. The loss design objectives for intertandem trunks are:

Sector Tandem Office to Sector Tandem or High-Volume Tandem

ICL = 1.5 dB

Sector Tandem Office to Toll Center meeting toll balance requirements

ICL = 0.5 dB

Tandem Trunks

3.25 A tandem trunk interconnects an end office and a sector or high-volume tandem office. Tandem trunks may be final groups to a serving tandem office or high-usage groups to a sector tandem office in other local exchange areas. Tandem trunks are equivalent to toll-connecting trunks and, in general, they are designed like TCTs. The loss design objectives are:

Without Gain	Min 0 dB	Max. 4.0 dB
With Gain or Carrier	3 dB	

End Office Direct Trunks

3.26 An end office direct trunk connects an end office to an end office in the same toll area. The loss design objectives for end office direct trunks are:

Without Gain	Min 0 dB	Max. 5 dB
With Gain or Carrier	3 dB preferable 5 dB acceptable	

End office direct trunks longer than 200 route miles should be designed according to rules for end office toll trunks.

SWITCHED DIGITAL NETWORK LOSS DESIGN—DDD

3.27 Economic studies of digital switching systems indicate that considerable economic advantage can be achieved by direct digital switching of bits coming from digital transmission systems without decoding them into voiceband analog form. By using long-haul and short-haul digital facilities, it is possible to have a Switched Digital Network (SDN) in which the voice signal is digitally encoded and decoded at the Class 5 office only and the bit stream is switched at higher ranking digital offices. Such a network will be quite different from the present DDD network which requires all messages to be demodulated to voiceband analog form at each switching system.

3.28 The VNL design plan discussed previously is not well suited for the switched digital network due to the fact that the VNL plan requires loss to be inserted in each trunk. This would require either that the digital signal be decoded to an analog signal, loss inserted and the signal recoded, or that the encoded signal level be changed by some digital processing technique so that, when it is decoded, a lower signal level will be obtained. Either of these techniques would add cost and introduce transmission impairments.

3.29 The switching of digits without processing at higher class offices requires that end-to-end connections on purely digital facilities have the required loss for control of talker echo inserted in the toll-connecting trunks. Since it is impractical to insert different losses on end-to-end connections having different mileages, a fixed amount of loss has been selected for all connections. This fixed loss value was determined such that a reasonable compromise was provided between the desirability of lower loss for shorter connections and the need for higher loss for control of talker echo on longer connections.

3.30 A fixed loss design is feasible for the digital network but impractical for the analog network because of the different delay and noise characteristics. Connection delay in the digital network is the sum of the propagation delay, the delay of the digital terminals at the Class 5 offices, and the delay through the switching machines. The delay of digital terminals and switching systems is analogous to the component of delay introduced by multiplex terminals in each trunk of the analog network; however, the amount of delay will be considerably less. The noise on a digital facility depends on the number of encoding and decodings and not on length. For the all digital network with only one encoder and decoder, the noise is less in comparison to the analog network and has a constant value for all length connections. Also a higher usage of digital toll-connecting trunks is anticipated with the result that the return loss at the Class 4 office will be an average of approximately 22 dB.

3.31 Because of these factors, as shown in Fig. 7, the range of the optimal loss is less between long connections and short connections in comparison to that of the analog network. This makes the compromise between low-loss values and high-loss values more appropriate.

3.32 A loss of 6 dB for all length connections was selected as the best compromise. In comparison with VNL design with the analog network, this plan has better loss-noise grade of

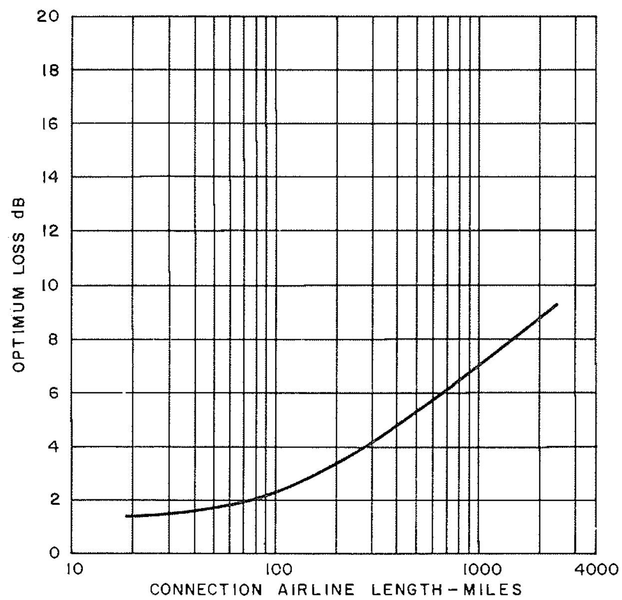


Fig. 7—Switched Digital Network Optimum Loss

service for all length connections but particularly for longer connections due to the reduced noise. There is, however, some small decrease in echo performance. This small decrease is more than compensated by the increase in loss-noise grade of service.

3.33 The 6-dB end-to-end connection loss must be achieved by inserting loss in either the transmit or receive direction of the toll-connecting trunks before the digital encoder or after the digital decoder. This loss is allocated equally (3 dB) to each toll-connecting trunk based on the need for approximately the same connection loss when digital trunks are connected in tandem with analog trunks and for maintenance considerations. The maintenance considerations are that:

(1) The measured loss, including test pads (EML), should be the same in each direction of transmission.

(2) Test tone levels should correspond to standard levels at the input and output of carrier systems.

(3) Standard loop-around tests for digital carrier systems should be preserved.

(4) The transmission level point (TLP) of existing offices should remain at 0 TLP for local and −2 TLP for toll offices.

3.34 Although the toll-connecting trunk is required to have 3 dB of loss, there is no loss adjustment at the end of a trunk connected to the digital office by a digital interface. Since the outgoing switch of an end office is defined as a 0 TLP, the necessary loss can only be achieved within the above constraints by having the end of the trunk be at an effective −3 TLP. Actually, this transmission level point does not exist in the normal sense of a definable analog signal since a signal at the digital end of a trunk exists only as a bit stream within the office. The level only exists when the bits are decoded into an analog signal. This occurs at the voice-frequency interface. Thus, the voice-frequency interface used for trunk testing is defined as a −3 TLP rather than the standard −2 TLP used with analog offices. This definition leads to the level plan for toll-connecting trunks connected to a digital office as shown in Fig. 8A and digital intertoll trunks as shown in Fig. 8B.

DIGITAL TRUNK LOSS OBJECTIVES

3.35 Since digital trunks are always derived on carrier facilities, the transmission distinction between toll and metropolitan trunks no longer occurs. Intertandem and tandem trunks should be designed as intertoll and toll-connecting trunks. These objectives are summarized in Table 3.

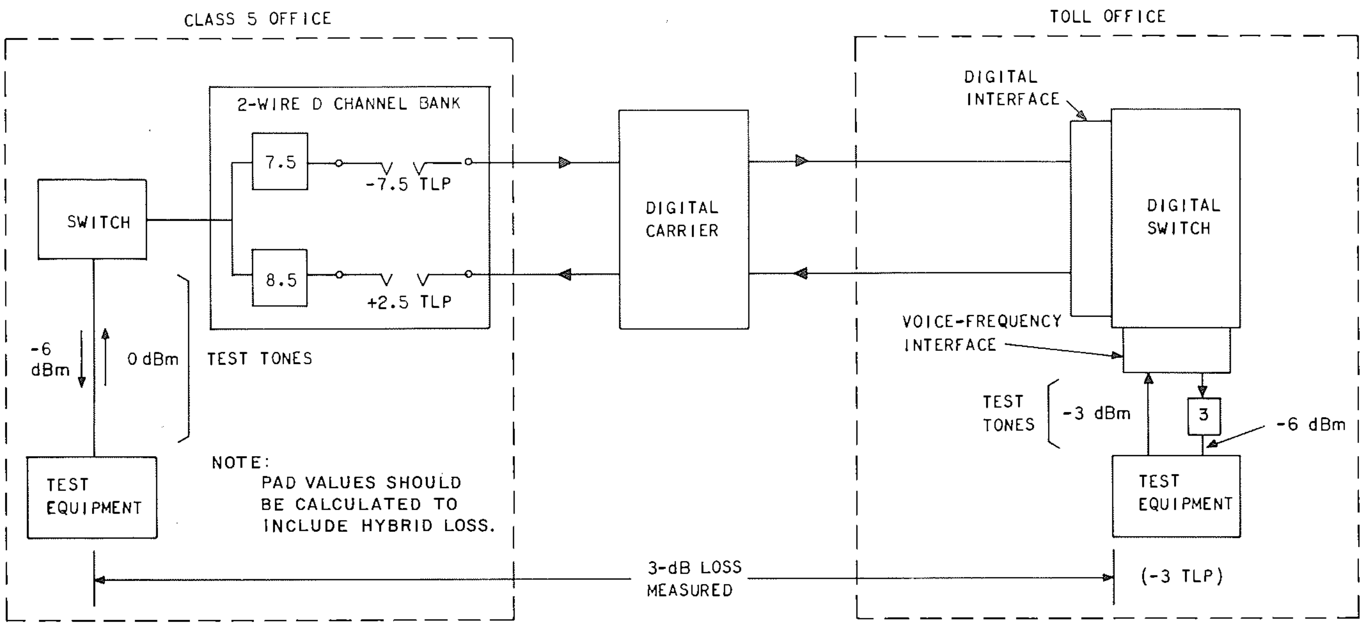
Intertoll Trunks (ITT)

3.36 Intertoll trunks in the switched digital network are those which use digital facilities and terminate on digital switching systems at both ends without decoding. Trunks with one end terminated on an analog switching system are classified as combination trunks whose design is given later. Trunks using analog facilities are designed according to the analog loss plan. The loss on intertoll trunks between digital switches is by definition ICL = 0 dB.

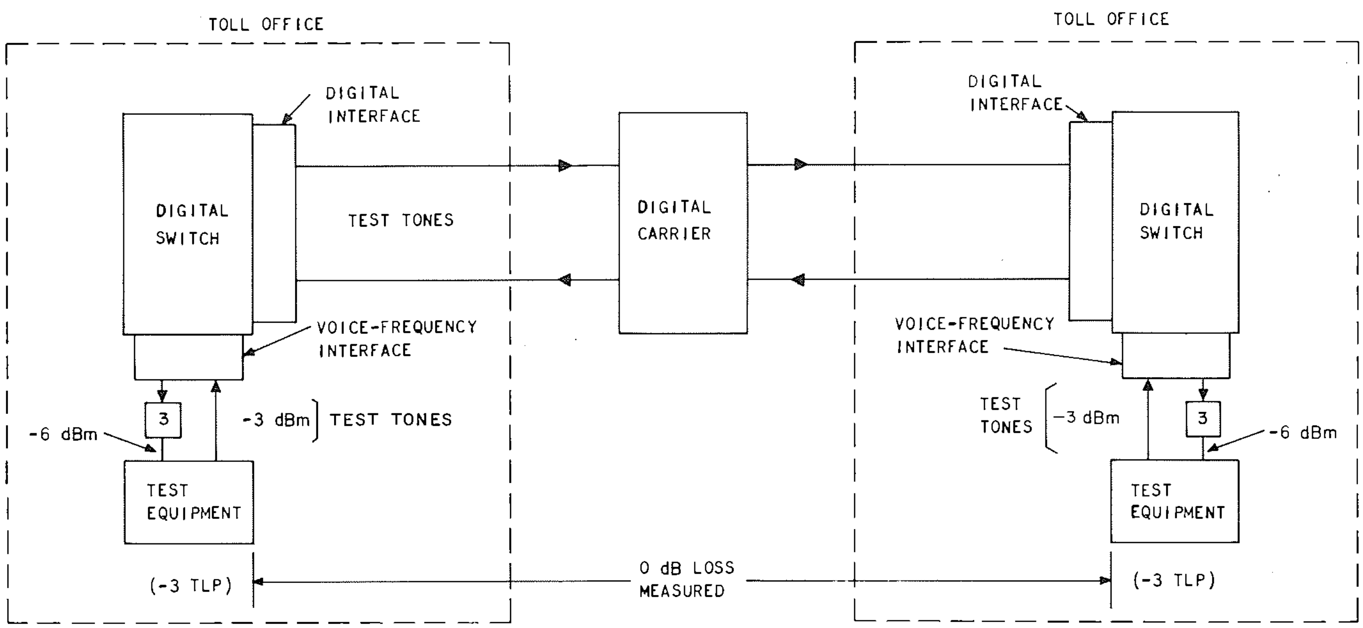
Toll-Connecting Trunks

3.37 Toll-connecting trunks on digital facilities which terminate at the Class 5 office and on digital switching systems at Class 4 or higher offices without decoding are designed to ICL = 3 dB.

All other trunks are designed according to the analog network toll-connecting trunk loss design.



A. PROVISION OF 3-dB TOLL-CONNECTING TRUNKS



B. PROVISION OF 0-dB INTERTOLL TRUNKS

Fig. 8—Provisions of Toll-Connecting and Intertoll Trunks

End Office Toll Trunk

3.38 End office toll trunks, considered part of the digital network, are those using digital facilities without any intermediate decoding or encoding and terminating on one end in a digital higher class office without decoding. All others are considered to be analog trunks. The loss objectives are:

Class 5 to Higher Class ICL = 3 dB

MIXED ANALOG-DIGITAL NETWORK

3.39 For sound technological and economic reasons, the analog and digital networks are being designed to different loss and level plans. Yet, in many instances, a connection will be established over portions of both networks. Therefore, a mixed analog-digital network will exist and the compatibility of the two different level and loss plans is an important consideration in maintaining the integrity of the DDD network. Specifically, the following situations involving the interface of the VNL plan and the SDN loss plan may occur:

(1) Trunks on digital facilities may terminate on a digital interface of a switching system at one end and channel banks associated with an analog switching system at the other end. These trunks are defined as combination trunks.

(2) Trunks on analog or digital facilities may terminate on the voice-frequency interface of the digital switching system. These trunks are defined as analog trunks.

3.40 The definition of the voice-frequency interface of a digital switching machine as a −3 TLP causes a trunk using digital facilities from an analog toll office to a digital toll office to have a loss of 1 dB. This occurs because of the level differences between the two offices as shown in Fig. 9. This 1-dB minimum loss could have been avoided by having the digital office at a −2 TLP but the Class 5 offices would have to be at a +1 TLP to meet the maintenance considerations. This would mean that all Class 5 offices throughout the network would probably have to be changed from their normal 0 TLP which is economically undesirable.

3.41 The loss of 1 dB on these combination trunks is about the same loss as required by the VNL design plan for a 500-mile trunk. Thus, this loss is higher than that normally used for trunks of less than this distance and lower for trunks longer than 500 miles. A computer simulation study showed that connections having 1-dB combination trunks had better loss-noise grade of service and

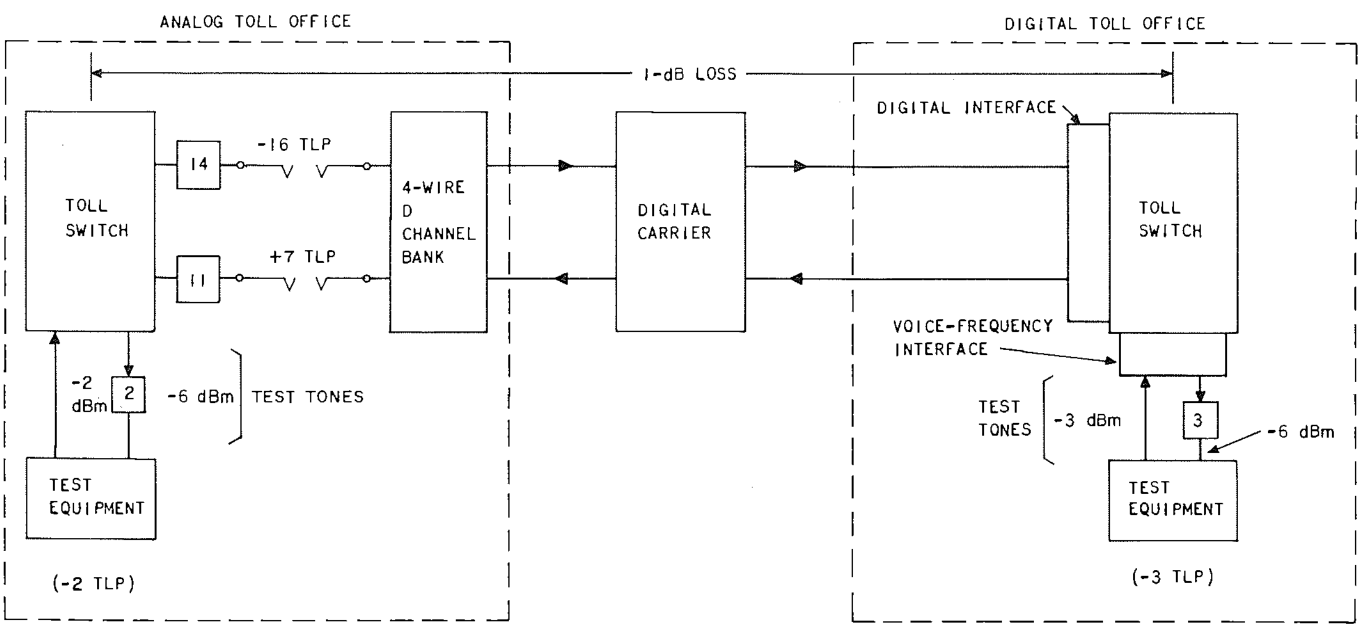


Fig. 9—Provision of Intertoll Combination Trunks (1 dB Only)

echo grade of service than connections with analog trunks of VNL design. This improvement is caused by the decreased noise and delay of the digital facilities. However, connections involving analog intertoll trunks designed to a fixed loss of 1 dB would have poorer loss-noise and echo grade of service than VNL design. Therefore, analog intertoll trunks in the mixed network are designed according to the VNL plan as in the normal analog network.

LOSS DESIGN—OPERATOR SERVICE

3.42 The Bell System provides operator service to handle two major classes of customer assistance.

(1) Traffic Service—On such operator-handled calls as coin, credit card, person-to-person, etc

(2) Number Service—Such as local and toll directory assistance (DA), intercept service, etc.

3.43 Both types of service were traditionally handled manually by operators at a switchboard. Recent trends in operator service have been to centralize the operators at a position remote from the customer. The centralization of operator service is made possible by such operator service systems as the Automatic Intercept System (AIS), designed to automate traffic intercept in metropolitan areas, the No. 5 Crossbar Automatic Call Distributing (No. 5 ACD) system, capable in some instances of centralizing the directory assistance traffic for an entire Numbering Plan Area (NPA), and the Traffic Service Position System (TSPS) which handles the traffic service requirements of a large toll office.

3.44 The transmission performance objectives for customer calls established by operator services should be the same as for DDD connections. For traffic service type calls, the transmission performance between the operator and the calling customer should be equivalent to a short DDD call. The performance between the operator and the called customer should be about the same as that the customer will have once the call is established. Likewise, the objectives for number services is to have local number service be equivalent to a short toll call and toll service be equivalent to a normal call to the same area. The loss design objectives are formulated based on these objectives.

Manual Operator Switchboard

3.45 Manual operator switchboards have been traditionally located near the associated toll office. Operator service is generally established by trunks from the Class 5 office to the manual operator switchboard. Such trunks are basically toll-connecting trunks; thus, their loss should be designed accordingly. The toll-connecting trunks that belong to this category include: operator office trunk, recording completing trunk, toll completing-toll switching combined trunk, and toll switching trunk.

3.46 The transmission links between a manual operator switchboard and its associated toll office are called secondary intertoll trunks which are separately identified here because they are extra trunks in the DDD hierarchical plan. Secondary intertoll trunks should be designed with an ICL objective of 0 dB with a maximum allowed loss of 0.5 dB. They are normally intrabuilding trunks but may be developed over T-carrier or voice-frequency cable with circuit mileage limitation of 50 miles per trunk for T-carrier and 9 miles for 22H88 cable facilities.

Traffic Service Position Systems

3.47 Figure 10 shows the DDD facilities associated with a typical Traffic Service Position System (TSPS) No. 1 and with a remote accessed TSPS established via a Remote Trunking Arrangement (RTA). A customer requiring traffic service dials up to the serving toll office on a TCT dedicated to the TSPS or through the RTA connected through an equivalent intertoll trunk to the TSPS. The TSPS connection is bridged onto the TCT near the toll office end for a nonremote access operation and a common transmission level point (-2 TLP) is shared between the associated Class 4 office and TSPS as indicated in this figure. The ICL objectives for TSPS together with its RTA are also summarized in Table 3.

Automatic Call Distributing and Intercept Systems

3.48 Referring to Fig. 11, the No. 5 Automatic Call Distributing (ACD) system network is basically similar to the regular message network. For example, toll directory assistance is configured like the toll network and local and intra-NPA directory assistance like the metropolitan network.

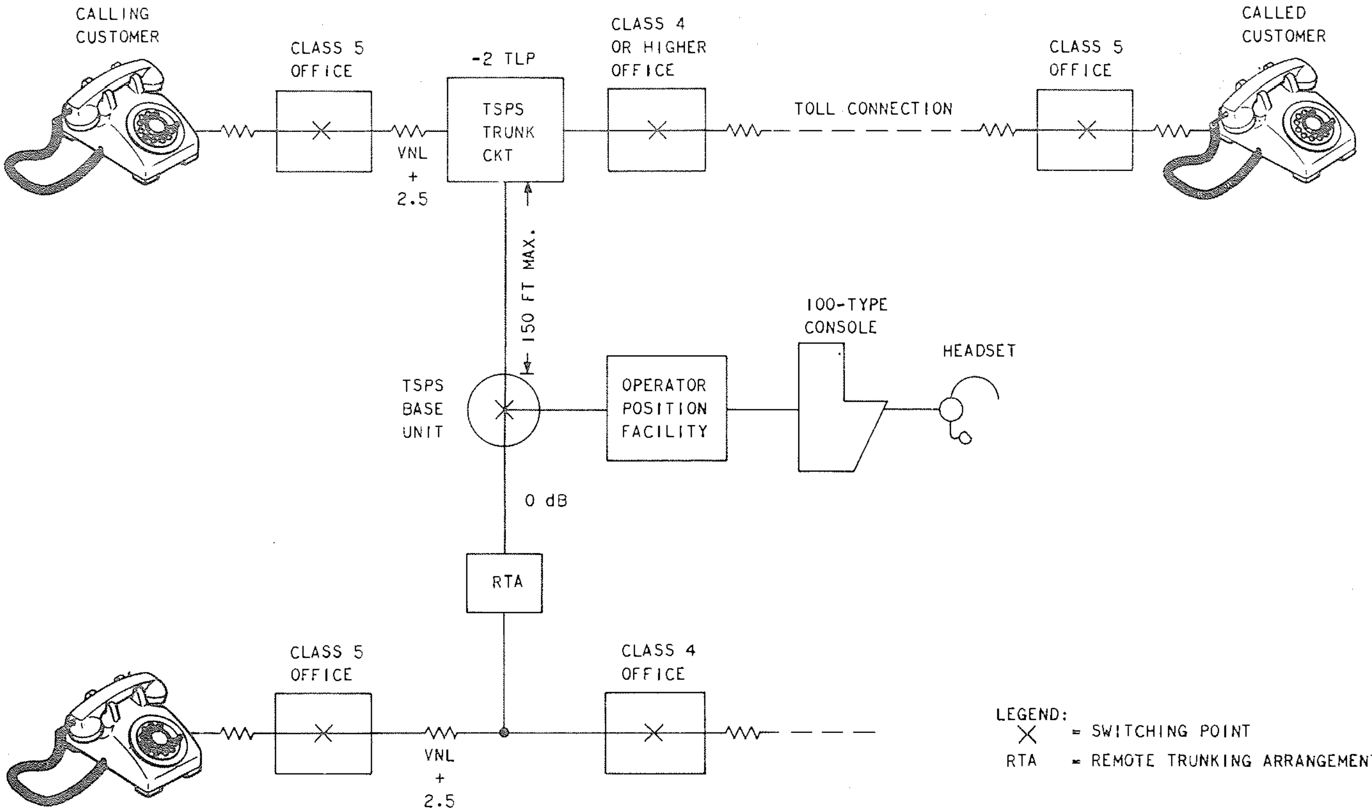


Fig. 10—TSPS and Remote Accessed TSPS

The system is configured so that the No. 5 ACD functions as a Class 4 office or sector tandem office. Insertion loss objectives for the ACD network are indicated for each type of transmission link in Fig. 11.

3.49 The No. 5 ACD transmission plan can, in principle, be adapted for an AIS with the ACD replaced by an AIS in Fig. 11. Trunks between end offices and intermediate concentrators are equivalent to Tandem Trunks (TT) for directory assistance links and should have an ICL objective of 3 dB while, for the intercept link, such trunks are defined as AIS type with the same 3-dB ICL objective. The loss design objectives are summarized in Table 3 in terms of end points of each type of transmission link and their equivalent message network trunks.

TRUNK LOSS MAINTENANCE OBJECTIVES

3.50 Losses of trunks must be kept close to their assigned loss objectives (EML) in order that the network will provide satisfactory performance. To achieve this, limits are stated for allowable deviation from assigned loss at initial lineup. In addition, periodic loss measurements should be made and corrective action taken if the values exceed certain prescribed limits. The effectiveness of these procedures is evaluated by the Trunk Transmission Maintenance Index.

3.51 Before trunks are placed in service, loss pads are adjusted so that the 1000-Hz tone at the transmission level points is within ± 0.13 dB of the desired level. The end-to-end trunk loss is required to be within ± 0.5 dB of expected measured loss although for nonrepeatered voice-frequency trunks and certain complex facility makeups ± 1.0 dB is allowed.

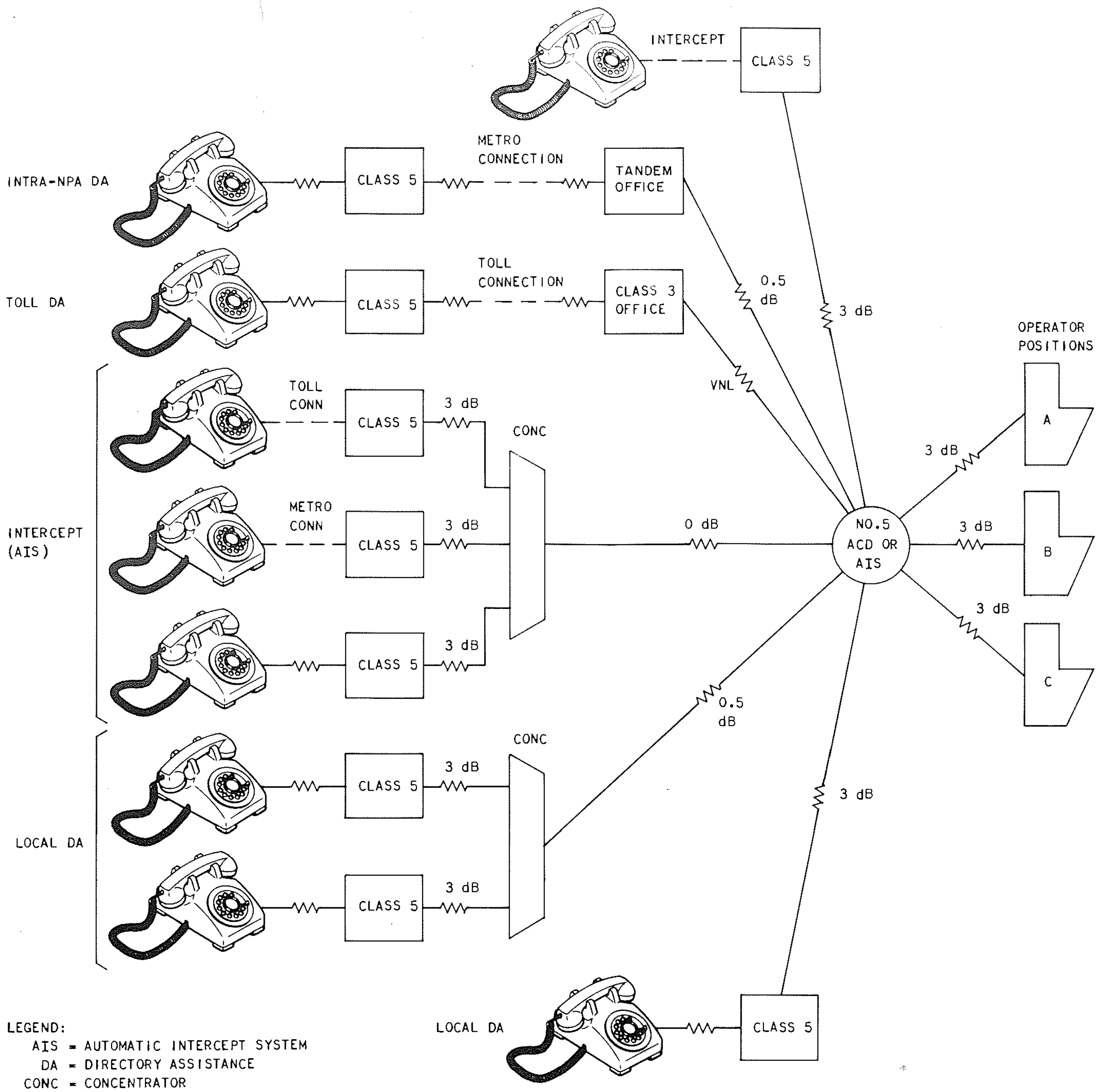


Fig. 11—Loss Plan for No. 5 Automatic Call Distributor

3.52 In order to insure that the loss remains at the expected measured loss value with time, routine loss measurements are made according to the intervals given below with more frequent measurements being recommended when automatic measuring equipment is used:

RECOMMENDED FREQUENCY OF OVERALL 1000-HZ

LOSS MEASUREMENTS ON MESSAGE TRUNKS

TRUNKS CONTAINING CARRIER CHANNELS OF THE FOLLOWING TYPES ONLY

L, R with supergroup and group regulation N2, N3, T1, T2	Weekly
Trunks containing carrier channels of all other types	Daily
Trunks containing only VF repeaters	Semimonthly
Nonrepeatered voice-frequency trunks	Monthly

3.53 The results of these measurements are used in the quarterly Trunk Transmission Maintenance Index. To obtain a high index, the deviations from expected measured loss in an office should be normally distributed by having no more than 30-percent deviations greater than ± 0.7 dB and no more than 4.5 percent greater than ± 1.7 dB. Trunks with deviations exceeding 3.7 dB must be removed from service until necessary corrective action is completed.

3.54 In order to meet the objectives of the index plan, it is also necessary to take corrective action on trunks with deviations which are less than 3.7 dB. The deviation value at which corrective actions should be taken is left to the individual offices.

LOOP LOSS DESIGN

3.55 The loop between the customer's telephone and the local central office is always the first and the last part of any telephone connection. Satisfactory transmission design of this loop is as important to the toll switching plan as is the design of intertoll and toll-connecting trunks.

3.56 The design of customer loops is done today according to the "resistance design plan" or the "unigauge plan." Resistance design has been in standard use for about 20 years while the unigauge plan is a fairly new plan for customer loop design. A detailed knowledge of the transmission art is not required by the loop designer in either of the plans.

3.57 Resistance design is based upon establishing a resistance limit and applying the following rules for controlling the transmission loss:

(1) Maximum conductor loop resistance of 1300 ohms (central office range permitting).

(2) Load all loops over 18 kft.

(3) Limit bridged tap on nonloaded loops to 6 kft or less.

(4) Limit end section plus bridged tap on loaded loops to 15 kft or less.

(5) Use only 500-type sets (or equivalent) beyond 10 kft.

(6) Design load spacing deviations normally within ± 120 feet.

(7) No bridged tap between load points.

(8) No loaded bridged tap.

3.58 Application of the above resistance design rules permits a reasonable distribution of transmission loss and results in satisfactory transmission for all customers.

3.59 The resistance design plan is conceptually easy to administer and has generally taken care of growth requirements in a timely efficient manner with relatively few complaints from customers. In actual practice, however, administrative and engineering factors tend to make it difficult to obtain the optimum network as envisioned in the plan.

3.60 Some of the outside factors that affect the resistance design plan are: limitations on choice of cable sizes (manufacturer's pairs-per-sheath standards), difficulty of accurately forecasting growth in a specific cable gauge, inflexibility of composite gauge cables, and physical limitations on the number of cables that can be placed on a pole line or in a conduit. In addition to these factors, the use of four cable gauges in the resistance design plan has led to growth problems such as congested conduit runs, complication of cable networks that need to be kept adaptable to service changes, and the use of ever-increasing amounts of copper.

3.61 The unigauge plan for designing customer loops was introduced in an attempt to solve some of the above problems. The rules for application of unigauge are simpler than for resistance design and are as follows:

(1) Serve all customers within 30 kft of the central office with 26-gauge cable.

(2) Serve most of the remaining customers with a plan as extended unigauge using a combination of 26- and 22-gauge cable.

(3) Load at 15 kft, and at 6-kft intervals beyond, only those loops which are over 24 kft in length.

3.62 The unigauge plan employs relatively inexpensive devices to provide voice-frequency gain and range extension. Range extenders are inserted in the switching system to increase the operating range of local switching equipment from 1300 ohms to 2500 ohms. With this approach, the ratio of lines to range extenders is about four or five to one.

3.63 Unigauge is currently available for common control local switching systems. No effort is being made to adapt panel or step-by-step offices to unigauge.

4. BALANCE

4.01 Echo can occur at any 4-wire to 2-wire junction or 2-wire impedance irregularity. The amount of echo returned is a function of the mismatch between the impedance at those points. Balance procedures are used to control the amount of mismatch as a fundamental means of controlling echo.

4.02 The transmission design plans assume that the predominant echo signal occurs at the impedance mismatch of the toll-connecting trunk and the customer loop. This source is predominately controlled by proper design of the loops. All other reflections would further degrade expected talker echo performance or near-singing conditions. These reflections can and must be controlled. The procedures for the control of echo are called through and terminal balance.

4.03 Since the same techniques are used for controlling the two phenomena, that is, balancing the impedance mismatch at various trunking junctions, current balance objectives include requirements for Echo Return Loss (ERL) and Singing Return Loss (SRL).

(1) ERL is the average of return losses over the echo range (500 to 2500 Hz) as weighted by the return loss measuring set or its equivalent.

(2) SRL is the average return loss in the singing bands (200 to 500 Hz and 2500 to 3200 Hz) as measured with the return loss measuring set or equivalent.

THROUGH BALANCE

4.04 Intertoll trunk transmission facilities are designed on a 4-wire basis which prevents intermediate echoes. However, many of the switching systems used for the interconnection of intertoll trunks are 2-wire and, therefore, require hybrids to effect the necessary 4-wire to 2-wire conversions. The amount of echo returned at these conversions depends on the impedance on the 2-wire side of the intertoll terminating set. This impedance primarily depends on the amount of office cabling from this set through the switch to the outgoing terminating set. The overall procedure for controlling the impedance is called through balance. In general, the purpose is to make the impedance of all the possible paths through the switching system be very nearly the same.

4.05 The transmission elements involved in through balance are shown schematically in Fig. 12. The impedance of the office cabling can be thought of as a series resistance and a shunt capacitance. The procedure is to match each of these components. Two approaches are currently used. In older type switching systems, bridging capacitance (Drop Build-Out, DBO) is used on shorter paths to make them capacitively equivalent to the longest path plus growth factor. The Network Build-Out (NBO) capacitance of all trunks is set to the capacitance of this longest path. The resistance component is controlled by requiring the 2-wire, cross-office resistance to be less than 65 ohms in a 900-ohm switch and 45 ohms in a 600-ohm switch. In electronic analog switching systems, DBO capacitors are not used and the resistance (NBOR) and capacitance (NBOC) of each network are adjusted using a nominal test connection. The length variability is controlled by insuring that the 50 percent of the paths from the center of switch to a hybrid are less than 1000 feet and the longest path is less than 1200 feet.

4.06 The through balance objectives at a 2-wire switching point are:

THROUGH BALANCE OBJECTIVES	50 PERCENT INTERTOLL TRUNKS EQUAL OR EXCEED	MINIMUM	TURNDOWN LIMITS
Echo Return Loss (ERL)	27 dB	21 dB	18 dB
Singing Return Loss (SRL)	20 dB	14 dB	11 dB

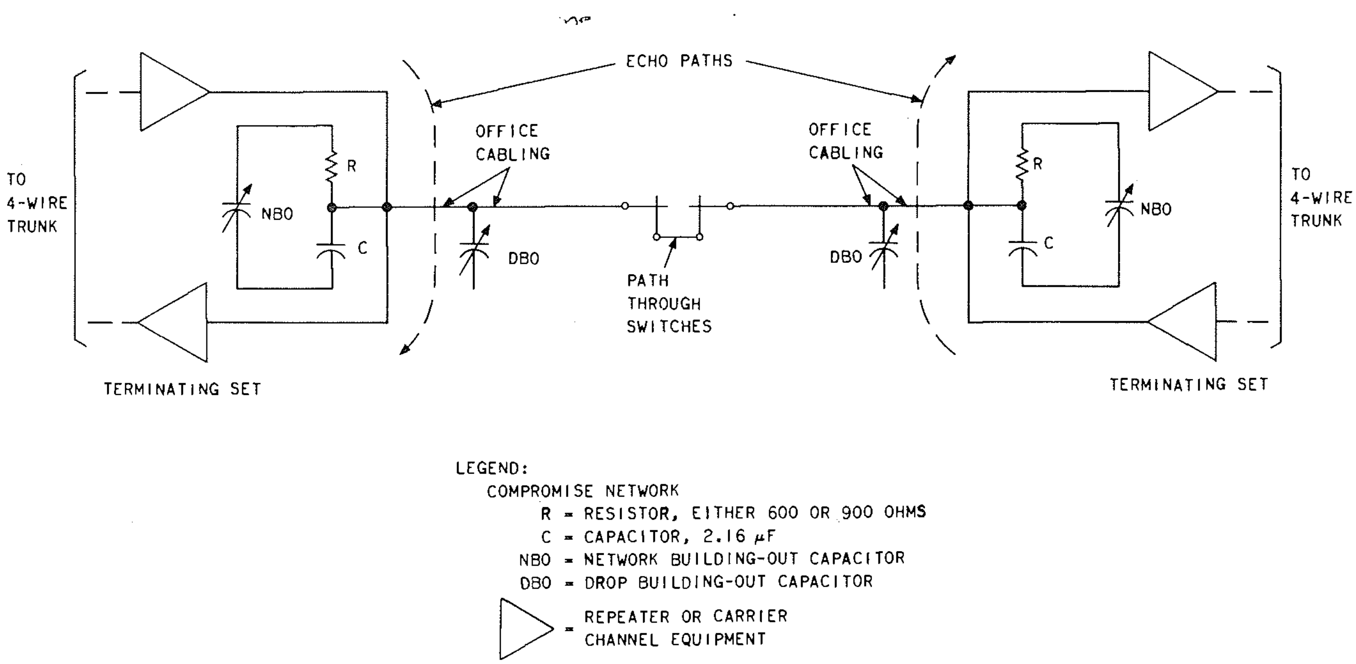


Fig. 12—Switching of 4-Wire Trunks at a 2-Wire Switching Office

4.07 To meet these balance requirements, an office must have at least 50 percent of all trunks meeting or exceeding the 50-percent requirement and no more than 2 percent below the appropriate minimum requirements for ERL and SRL. For initial installation of a trunk, no trunk below minimum should be turned up for service. On subsequent testing, any trunk measuring below the turndown limit should be removed from service.

TERMINAL BALANCE

4.08 When an intertoll trunk is connected to a toll-connecting trunk at a Class 4 or higher ranking office, adequate balance of transmission facilities is required. The procedure is called terminal balance and is required in all toll offices having trunks to or from a Class 5 office.

4.09 Return loss associated with terminal balance is measured at the toll office with the toll-connecting trunk terminated in 900 ohms in series with 2.16 microfarad (μf) at the Class 5 office. It thus includes the effect of all impedance irregularities up to and within the Class 5 office. With reference to Fig. 13, if the trunk facility is derived on carrier, the return loss depends primarily on the impedance of the originating hybrid and office equipment. For a 2-wire metallic facility, the return loss includes as well the effects of cable irregularities.

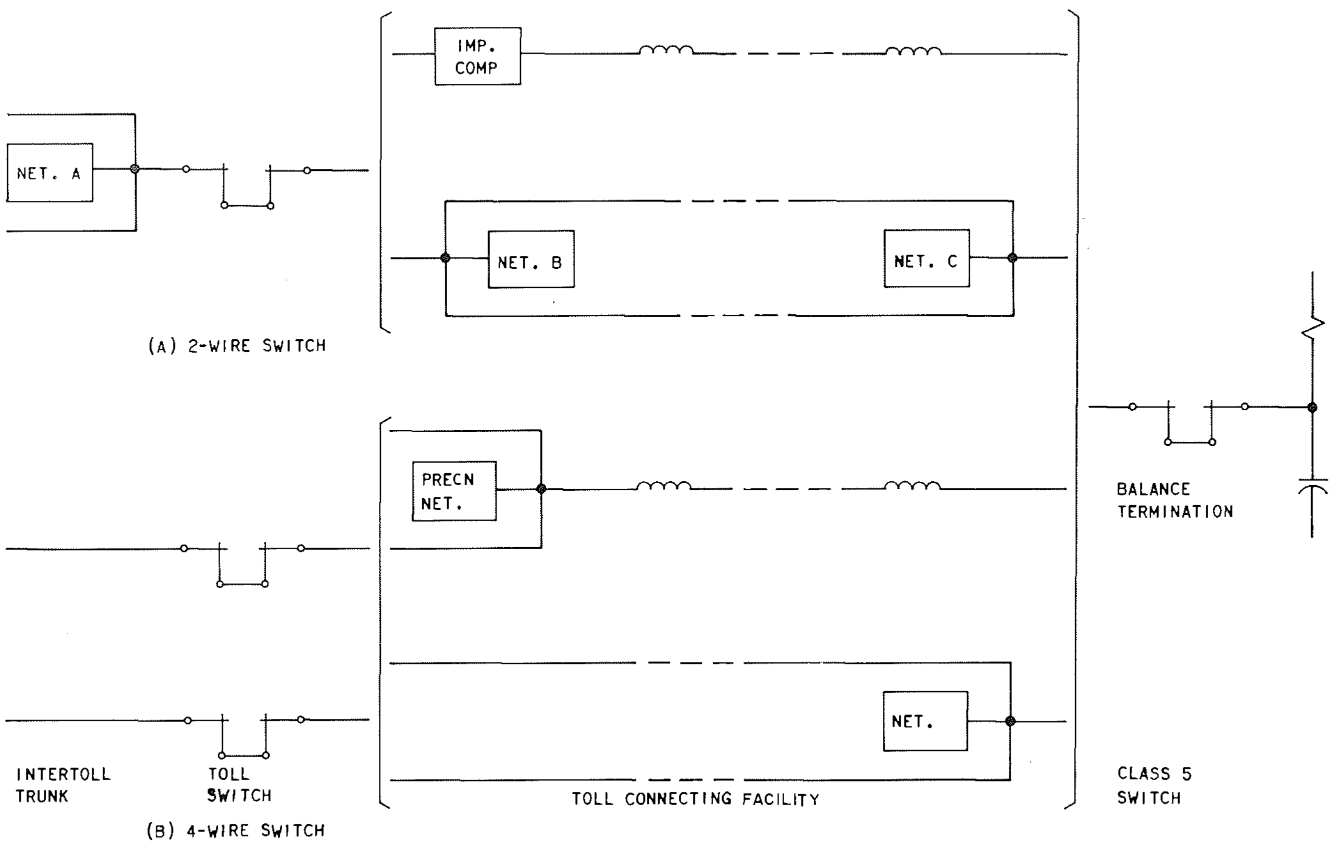


Fig. 13—Terminal Balance Arrangements

4.10 The return loss values obtained for terminal balance are highly dependent on proper design and installation of the toll-connecting trunk. This includes the use of pads in short trunks, impedance compensators on loaded trunks, and gain devices located at Class 5 offices.

4.11 The recent study which reaffirmed the use of VNL design also indicated that considerable echo improvement would be realized if the terminal balance requirements could be tightened. Thus, a long-term terminal balance objective was established for all toll-connecting trunks of:

50 Percent 22 dB echo return loss, 15 dB singing return loss
Minimum 16 dB echo return loss, 11 dB singing return loss

This should be viewed as a long-term goal. New designs of individual pieces of equipment should meet even higher values so that this goal may be reached on the overall trunk.

4.12 These requirements have been adopted as the terminal balance requirements for all types of toll-connecting trunks connected to a digital switching system. This higher return loss requirement is needed because the Switched Digital Network plan (3.27) uses less loss for control of talker echo. The requirements for the SDN are given in Table 4.

4.13 Present toll-connecting trunks in the analog network should meet the requirements in Table 4. To meet these balance requirements, an office must have at least 50 percent of all trunks in each trunk category meeting or exceeding the 50-percent requirement and no more than 2 percent below the appropriate minimum requirements for ERL and SRL. For initial installation of a trunk, no trunk below minimum should be turned up for service. On subsequent testing, any trunk measuring below the turndown limit should be removed from service.

BALANCE MAINTENANCE OBJECTIVES

4.14 In order to effectively control reflections of echo at any intermediate impedance mismatch in the network, echo return loss and singing return loss of an office must be maintained close to the through and terminal balance objectives. To achieve this, the limits for ERL and SRL are used for both the initial balance requirement and subsequent maintenance requirement.

4.15 Every office which has met initial balance requirements should be surveyed at one- or 2-year intervals. Sampling surveys are used to determine whether office balance is maintained in a satisfactory status. The survey procedures involve ERL and SRL measurements on samples of trunks chosen from a stratified random sample. The results of the measurements should have more than half of the measurements greater than the 50-percent requirement and no more than 2 percent below the minimum in each through and terminal balance category. The results constitute the balance component of the Bell System Trunk Transmission Maintenance Index.

TABLE 4

TERMINAL BALANCE REQUIREMENTS

TYPE OF FACILITY	ERL IN dB					SP/SRL IN dB				
	50% >		MINIMUM		TURNDOWN LIMIT	50% >		MINIMUM		TURNDOWN LIMIT
	ANALOG	SDN	ANALOG	SDN		ANALOG	SDN	ANALOG	SDN	
2-wire facilities (interbuilding)	18	22	13	16	10.5	10	15	6	11	4
2-wire facilities with 2-dB pad (intrabuilding)	22	22	18	18	10.5	14	15	10	11	4
4-wire facilities (See Note.)	22	22	16	16	10.5	15	15	11	11	4

Note: For 4-wire facilities equipped with E-type signaling units which have built-in 4-wire terminating sets, the interbuilding 2-wire requirement is used.

5. ECHO SUPPRESSOR APPLICATION RULES

5.01 As indicated previously, insertion of loss into trunks is one of the methods used to control talker echo in the DDD network. However, the loss causes some degradation of loss-noise grade of service. The amount of degradation can be reduced by introducing echo suppressors since trunks with echo suppressors are designed with zero loss. However, an echo suppressor adds cost and complexity and there is a potential risk that an echo suppressor might not be installed properly or maintained properly. In such a case, the degradation from the echo suppressor could be much greater than that caused by added amount of loss. In general, an echo suppressor should be applied at a trunk length where the improvement in grade of service outweighs their inherent risks. In order to avoid more than one echo suppressor in a connection, echo suppressors should only be applied to interregional high-usage trunks and to final trunks connecting Regional Centers.

END OFFICE TOLL TRUNKS

5.02 End office toll trunks from Class 5 to Class 4 or higher offices should use echo suppressors and be designed to 3 dB if the mileage of such trunks is greater than 1850 miles. However, trunks between Class 5 offices do not need echo suppressors regardless of their length. The maximum loss of 8.9 dB provides sufficient echo protection for all length trunks.

DIGITAL NETWORK

5.03 Present studies indicate that echo suppressors should be applied on high-usage intertoll trunks longer than 1850 miles. However, this value may be changed if, as anticipated, the performance of a digital echo suppressor is improved and its cost substantially reduced over the present analog version.

6. NOISE AND CROSSTALK

6.01 Noise in speech transmission is, in the most general sense, any unwanted signal present in a communication channel other than the desired speech signal. The unwanted signals referred to as message circuit noise may be either noise originating from various components of the transmission path or the interference produced by one transmission channel being coupled to another. Regardless of their nature and origin, these unwanted signals can be annoying to the telephone user. Because of this annoyance, noise should be controlled to limits judged to be acceptable.

6.02 One type of interference that is treated separately is intelligible crosstalk. Intelligible crosstalk is particularly objectionable because it violates the privacy of the telephone user.

MESSAGE CIRCUIT NOISE

6.03 Message circuit noise is a weighted average of the noise within a voice circuit as measured by the 3-type noise measuring set equipped with a frequency weighting called "C-message weighting." Figure 14 shows this weighting and the international standard "psophometric" frequency weighting. Measurements are expressed in decibels above reference noise (dBrn) with the reference for the 3-type noise measuring set being that a 1000-Hz tone at a power of −90 dBm will give a 0-dBrn reading. The notation dBrnC is used when readings are made using C-message weighting. White noise from 0 to 3 kHz of 0-dBm total power is equal to 88 dBrnC.

6.04 The Bell System customer-to-customer message circuit noise objectives are based on noise subjective tests and system-wide noise survey results. These objectives have recently been confirmed using the loss-noise subjective tests. Figure 15 shows the Bell System message circuit noise objective. These customer-to-customer objectives are then allocated to various parts of a connection. On subscriber loops, a limit of 20 dBrnC is specified as not to be exceeded. For carrier facilities, the objectives are specified as a function of trunk length as shown in Fig. 16. In general, the long-haul objectives are about 3 dB tighter than those used prior to the early 1960s. The change was instituted to improve the performance of longer calls. The grade of service on these calls is primarily affected by the noise contributed by the long-haul transmission facility.

6.05 Noise (thermal or interference) is primarily controlled by design. This includes the design limits on applied channel load of individual transmission systems and in the layout and construction of associated outside plant. Noise control in carrier, repeatered voice, and radio systems requires care in locating repeaters and terminals, provision of suppression devices to nullify

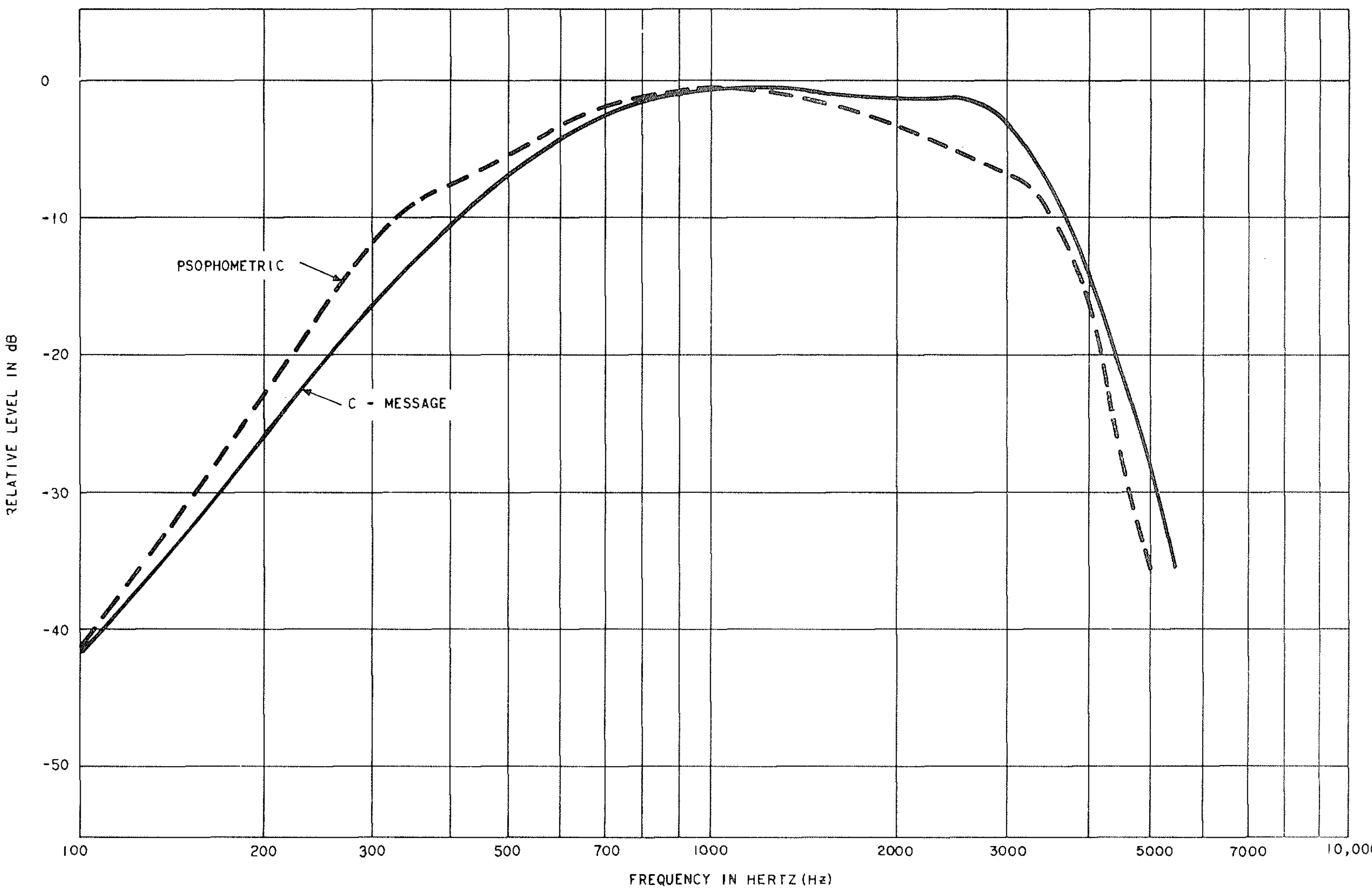


Fig. 14—Comparison Between Psophometric and C-Message Weighting

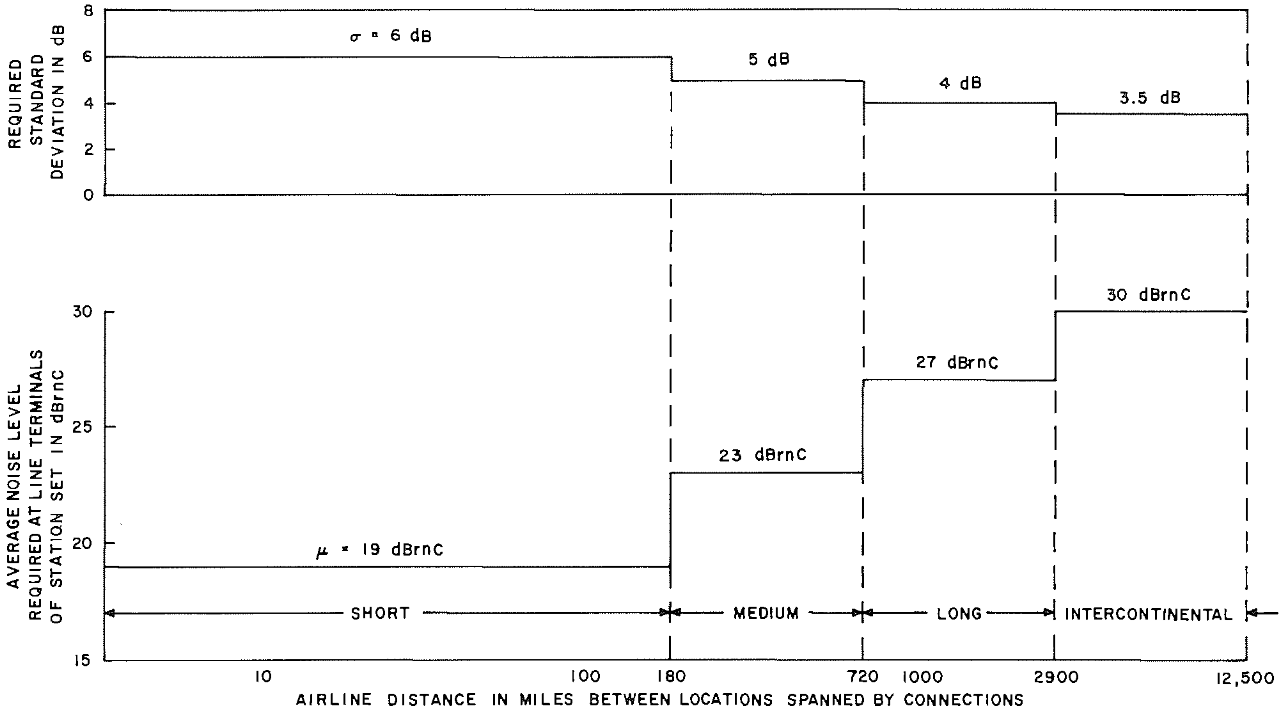


Fig. 15—Bell System Message Circuit Noise Objectives for Customer-to-Customer Connections

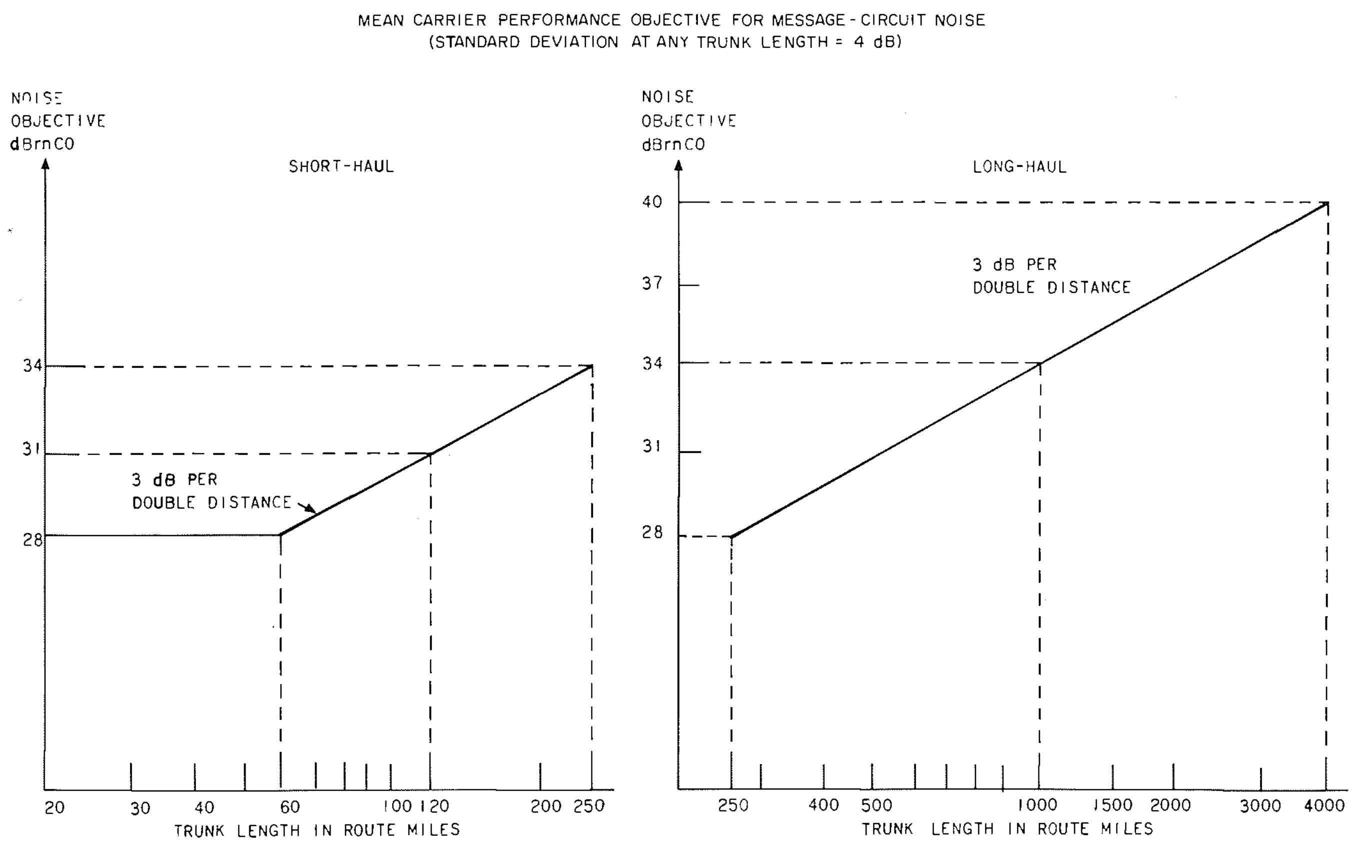


Fig. 16—Trunk Message Circuit Noise Performance Objectives

disturbances, and coordination not only with other telephone systems but with also power company and radio services. In voice-frequency cables and subscriber loops, it is also necessary to use cables that are well balanced and to employ sound splicing practices. In open wire, both voice frequency and carrier, it is necessary to employ transposition layouts adequate for the frequencies employed and to maintain adequate clearances with power lines.

6.06 Once a system is installed, the noise must be kept within well-defined maintenance limits. The Bell System message circuit noise maintenance requirements are stated in terms of a maintenance limit and an immediate action limit. A maintenance limit specifies the deviation beyond which maintenance action should be initiated. An immediate action limit specifies the deviation beyond which a circuit should be removed from service immediately. Figure 17 shows the action recommended in relation to measured noise on subscriber loops. The noise limits for trunks are given in terms of mileage categories as shown in Fig. 18 and 19. The limits given in Fig. 18 are used when the noise measuring set is connected through a 2-dB test pad (TP2) or equivalent. When the noise measuring set is not connected through test pads, the limits given in Fig. 19 are used. Consequently, the values of the limits given in Fig. 19 are 2 dB higher than those given in Fig. 18.

6.07 Noise generated in the serving central office is largely attributable to cross-office noise. Cross-office noise is the net sum of all noise sources on a connection between any two line appearances. Excessive battery noise and corrosion or maladjustment of switching equipments are some of the potential sources of cross-office noise. The nature of the noise sources is such that excessive noise occurs on random connections rather than on all connections. If these random occurrences of excessive noise become too frequent, the noise performance at the average station terminal may become unsatisfactory. The noise in serving central office, therefore, must be kept within well-defined limits through adequate equipment maintenance.

6.08 The cross-office noise test consists of steady state noise measurements and average peak noise measurements. The steady state measurements are made by reading the position where the needle of a 3-type noise measuring set rests most of the time. The average peak measurements are made by observing the 3-type noise measuring set and mentally averaging the peak swing of the needle over a few minutes.

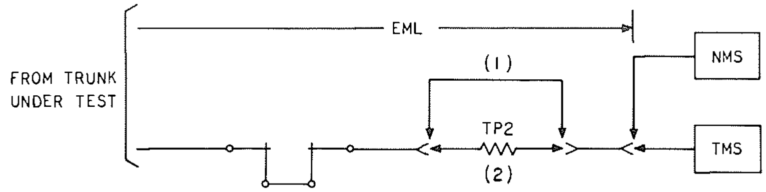
6.09 The condition of the office is judged by making measurements on 20 randomly selected cross-office connections. An office is considered satisfactory if none of the measurements of both types exceeds the lower limits shown in Table 5. An office is considered unsatisfactory if four or more measurements of either type exceed the lower limits or if any single measurement of either type exceeds the upper limits. When an office is judged to be unsatisfactory, corrective action must be taken.

6.10 If one, two, or three measurements of both types exceed the lower limits but not the upper limits, the condition of the office is considered to be doubtful. In such cases, another 20 connections must be tested to improve the sample accuracy.

NMS READING (dBrnC)	LEVEL OF SIGNIFICANCE	ACTION RECOMMENDED	
		SHORT LOOPS	LONG LOOPS (>30 KFT)
20 or Less	Objective for All Loops	Further Analysis Not Necessary	
21 to 30	Loop Noise Marginal as 30 dBrnC Approached	Further Analysis and Investigation	Review to Assure Design and Construction Best Possible
Greater than 30	Unacceptable	Immediate Investigation	Further Analysis and Investigation

Fig. 17—Loop Noise Objectives and Requirements

NOISE MEASURED AT ALL TESTING LOCATIONS
WHERE: (1) NO TEST PAD IS INCLUDED IN THE EML
(2) A 2-dB TEST PAD (TP 2), OR EQUIVALENT (NOTE 1) IS INCLUDED IN THE EML AND BOTH LOSS AND NOISE ARE MEASURED THROUGH THE TEST PAD
SKETCH ILLUSTRATING ABOVE CONDITIONS:



LIMITS SHOWN IN dBrnC (C-MESSAGE WEIGHTING) AT POINT OF MEASURE. NO CORRECTIONS REQUIRED

TRUNK ASSIGNED TO:	Limit	VOICE FREQUENCY	CARRIER ONLY OR MIXED FACILITIES - MILES: 0 TO 15	16 TO 50	51 TO 100	101 TO 200	201 TO 400	401 TO 1000	1001 TO 1500	1501 TO 2500	2501 TO 4000
NONCOMPANDORED	B	36	36	36	36	36	40	40	40	44	46
NONCOMPANDORED	A	20	28	28	29	31	33	35	36	39	41
COMPANDORED	B	SEE NOTE 2	30	30	30	30	34	34	34	40	40
COMPANDORED	A	SEE NOTE 2	23	23	24	26	28	30	31	34	36

B - IMMEDIATE ACTION LIMIT
A - CIRCUIT ORDER AND MAINTENANCE LIMIT

NOTES:
1. EQUIVALENT MEANS, FOR EXAMPLE, AT A 17C TESTBOARD EQUIPPED WITH TP9 OR TH9 WHERE A 7-dB "A" PAD IS SWITCHED OUT OF THE TRUNK UNDER TEST DURING TRANSMISSION LOSS AND NOISE MEASUREMENT.
2. VOICE-FREQUENCY TRUNKS ARE RARELY COMPANDORED; THEREFORE, COMPANDORED NOISE LIMITS DO NOT APPLY.

Fig. 18—Noise Limits for Message Trunks

The limits given in the table are then applied to all 40 measurements. This procedure is repeated until the test results are conclusive that the office is either in satisfactory or unsatisfactory conditions.

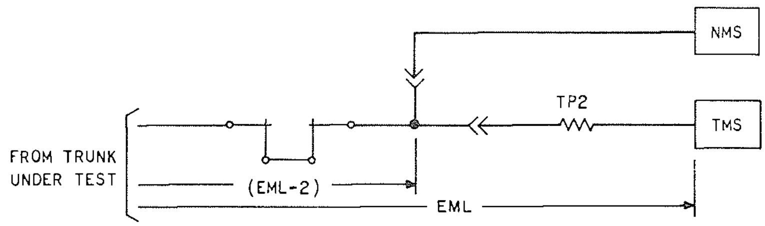
INTELLIGIBLE CROSSTALK

6.11 Intelligible crosstalk is the speech signal transferred from one voice channel to another which is sufficiently understandable under pertinent circuit and room noise conditions that meaningful information can be obtained. Reception of intelligible crosstalk not only causes a certain amount of annoyance but also violates the privacy of some other customer. It could also cause doubts in the customer's mind as to the privacy of his own conversation.

6.12 Intelligible crosstalk can occur as interchannel interference with a transmission system or between systems which are physically isolated. There are three basic causes of crosstalk: (1) nonlinearities within a frequency division multiplex system, (2) time slot interchange in a time division multiplex system, and (3) electrical coupling between various transmission media.

6.13 Whether a telephone user will actually receive intelligible crosstalk or not is a probabilistic event. The probability of a user hearing intelligible crosstalk expressed in percent is called the crosstalk index. The Bell System objectives for intelligible crosstalk specify that a crosstalk index of 1 should not be exceeded on intertoll trunks and crosstalk index of 0.5 should not be exceeded on toll-connecting trunks.

NOISE MEASURED AT TESTBOARDS
WHERE A 2-dB TEST PAD (TP2) IS INCLUDED IN THE EML FOR LOSS MEASUREMENTS
BUT IS NOT USED FOR NOISE MEASUREMENTS
SKETCH ILLUSTRATING ABOVE CONDITIONS:



LIMITS SHOWN IN dBrnC (C-MESSAGE WEIGHTING) AT POINT OF MEASUREMENT. NO CORRECTIONS REQUIRED

	TRUNK ASSIGNED TO:									
	VOICE FREQUENCY	CARRIER ONLY OR MIXED FACILITIES - MILES								
		0 TO 15	16 TO 50	51 TO 100	101 TO 200	201 TO 400	401 TO 1000	1001 TO 1500	1501 TO 2500	2501 TO 4000
NONCOMPANDORED	38 / 22	38 / 30	38 / 30	38 / 31	38 / 33	42 / 35	42 / 37	42 / 38	46 / 41	48 / 43
COMPANDORED	SEE NOTE	32 / 25	32 / 25	32 / 26	32 / 28	36 / 30	36 / 32	36 / 33	42 / 36	42 / 38

B / A:
B - IMMEDIATE ACTION LIMIT
A - CIRCUIT ORDER AND MAINTENANCE LIMIT

NOTE:
VOICE-FREQUENCY TRUNKS ARE RARELY COMPANDORED; THEREFORE, COMPANDORED NOISE LIMITS DO NOT APPLY.

Fig. 19—Alternative Noise Limits for Message Trunks

TABLE 5

CENTRAL OFFICE NOISE REQUIREMENTS

OFFICE TYPE	STEADY STATE NOISE (dBrnC)		AVERAGE PEAK NOISE (dBrnC) (METER DAMPED)	
	LOWER LIMIT	UPPER LIMIT	LOWER LIMIT	UPPER LIMIT
Panel	24	28	32	36
All Other	18	22	26	30

6.14 The probability of hearing intelligible crosstalk depends on traffic usage, speech volumes, coupling losses, and listener ability to hear low-level signals in the presence of noise. In general, crosstalk is controlled by initial design of the system. It should not be excessive except if a large amount of gain is applied on cable systems or unusually low-cable coupling loss occurs between pairs. It also can occur if single-frequency, high-level tones or concentrated energy signals are applied to a frequency division multiplex system. (See part 7.)

7. LOAD AND OVERLOAD

7.01 The power level of a signal, load, applied to a channel is one of the factors which affects the noise performance of carrier systems. In frequency division multiplex systems, the noise is normally the sum of thermal noise and intermodulation noise. The intermodulation noise consists of intermodulation products of components of the signal which are generated by nonlinear characteristics of the system. The thermal noise does not normally vary with applied signal level. However, intermodulation products, usually caused by second- and third-order nonlinearities, increase, respectively, at rates of 2 and 3 dB for each dB by which the signal is increased. Therefore, the change in total noise power with change in signal level depends upon the relative amount of thermal noise and intermodulation noise.

7.02 A value of −16 dBm0 for the average long-term input power per voiceband channel has been established as a long-range Bell System objective for a domestic multichannel system. This value is to be used as the value for signal power in the design of new systems.

7.03 Station equipment may cause a degradation in the service provided to other customers if its signal power is excessive. In order to avoid such service degradation, it is necessary that station equipment conform with the average long-term power requirement of −16 dBm0 per channel. In applying this long-term average power requirement to station equipment, it is possible to permit somewhat higher power on a given channel during active periods to compensate for the idle periods between calls. It has been established that the signal power during an actual call should not exceed −13 dBm0 averaged over any 3-second interval. Since toll switching offices operate at −2 dB transmission level point and are separated from the serving central offices by toll-connecting trunks which have an average loss of approximately 3 dB, it follows that the average signal power during a call should not exceed −12 dBm at the serving central office.

7.04 Test tones used for short-term tests are treated as an exception and are allowed to be at 0 dBm0. Tones for long-term tests are operated at −10 dBm0. New automatic testing systems, however, are being designed for −16 dBm0 test tone levels.

7.05 The overload limit is the signal level at which the nearly linear performance of the system is no longer linear enough for satisfactory performance. The overload limit is usually expressed in terms of the RMS power of a single-frequency tone whose peak amplitude is just on the threshold of being clipped by an ideal peak clipper. When overload occurs, the signal is clipped causing distortion and noise.

7.06 The overload limit objectives are based on the grade of service obtained by combining the estimates of customer reaction to clipped speech with the probability that the peak speech level will exceed a given overload limit. In general, the Bell System overload limit objective for analog intertoll and toll-connecting trunks is that a 5 dBm0 tone would be just on the threshold of being clipped.

7.07 In pulse code modulation systems, interference signals, which are normally at a low level, can be enhanced due to the sudden jumps at quantizing points. The amount of enhancement is reduced with reduced step size. Since the number of steps is fixed for a coder, a smaller step size results in a smaller overload limit. Therefore, the overload limit objectives for pulse code modulation channel banks are established based on a compromise between the enhancement of low-level interference signals and the service degradation due to overload. A value of 3 dBm0 has been established as the overload limit objective for pulse code modulation channel banks.

8. SLOPE-FREQUENCY RESPONSE

8.01 The loss of a channel is measured at three different frequencies*: 400 Hz, 1000 Hz, and 2800 Hz. The loss of 1000 Hz is then compared to the loss at 2800 Hz and that at 400 Hz. These differential losses are referred to as the slope at 2800 Hz or 400 Hz. These two slopes are a measure of the frequency response of the channel under test. Higher loss at 2800 Hz or 400 Hz in comparison to loss at 1000 Hz results in positive slope value. Slope tests are made using an oscillator and a level measuring device.

*The actual frequencies used are being changed to 4 Hz higher than these nominal values to avoid measurement difficulties with digital carrier systems as indicated in the footnote to 3.06.

8.02 Slope affects both voice and data transmission. Measurements at 400 Hz are made primarily to assure voice-frequency transmission quality including margin against low-frequency singing; slope at 400 Hz has relatively little effect on data transmission. Data receivers become more susceptible to noise and intersymbol interference with increased high-frequency slope. Most data receivers can tolerate up to +15 dB of slope at 2800 Hz. At about this value, they begin to make errors even in the absence of noise.

8.03 The slope of a channel is determined primarily by the characteristics of the filters used in carrier system channel banks. Nonloaded cable, trunk circuits, terminating sets, and office cabling also contribute.

The slope is, for the most part, under the control of the equipment design engineer although the layout engineer can exert some control by choosing loaded cable and using short cable runs within an office. Aging vacuum tubes in older carrier terminals may also contribute to slope problems.

8.04 Of the 15 dB of allowable slope at 2800 Hz for a data connection, local loops are allotted 3 dB of slope* leaving 9 dB for all the trunks and switching equipment between Class 5 offices. Slope limits on trunks vary according to the capabilities of the type of carrier system or, for metallic facilities, according to the use of repeaters. A typical trunk on carrier facility has a 2800-Hz slope requirement of no more than −1 to +2 dB (other carrier facilities have more or less stringent slope requirements); nonrepeatered cable is set at a slope of −2.5 to +3 dB and repeatered cable −1 to +4.5 dB.

*The slope requirement on loops is applicable to Type II or Type III data circuits only. Type I data (data speeds of 300 baud or less) requires no loop conditioning.

9. IMPULSE NOISE

9.01 Impulse noise is defined as any excursion of the noise waveform on a channel which exceeds a specified threshold. Impulse noise is evaluated on channels by counting the number of excursions during a predetermined time interval. In order to avoid counting the excursions of thermal noise, the minimum threshold is set 12 to 18 dB above the RMS value of the noise. Impulse noise level is emended to be that threshold at which the average counting rate is equal to one per minute.

9.02 Impulse noise counters, the measuring instruments, may use either electromechanical or electronic counters. In either case, the maximum counting rate is controlled to be seven per second in some sets.

9.03 Impulse noise causes errors in data transmission whenever the noise peaks reach a level 3 to 12 dB below the RMS data signal level depending upon the type of modulation used by the data modems, the speed of transmission in bits per second, and the magnitudes of other transmission impairments on the channel. Bell System impulse noise objectives are established to maintain the impulse noise level 5 to 6 dB below the RMS data signal level on 80 to 90 percent of connections. Control is exercised through engineering rules and limits on measured impulse noise levels.

9.04 Since most impulse noise originates as transients from the operation of relays and other switching equipment, engineering rules and mitigative measures are aimed at shielding low-level carrier signals from the radiation associated with these transients. Carrier-only sheaths, separate carrier entrance cables, shielded cross-connect cabinets, longitudinal suppression coils, midspan amplifiers, short spans between repeaters, line build-out networks on the inputs to repeaters instead of the outputs, and contact arc suppression networks are some of the techniques used.

SAMPLING TECHNIQUES APPLIED TO TRUNK GROUPS

9.05 Because impulse noise is sporadic in occurrence, relatively long time periods are required for its measurement. If a single channel is being measured, a 15-minute time period is required. Time can be saved in the evaluation of complete trunk groups between common end points by using sampling techniques and a shorter measurement period, 5 minutes. This is permissible because trunks in a common route are assumed to share a similar impulse noise environment. The requirement on a trunk group is that no more than 50 percent of measurements should display an impulse noise level in excess of a specified value. This is determined by adjusting the impulse counter threshold to the specified level and noting whether the count at the end of 5 minutes is five or less (acceptable) or six or more (unacceptable).

9.06 The basic procedure for evaluation of impulse noise on trunks and facilities is known as sequential sampling. In general, the procedure is to look at the cumulative value of some parameter after each test or measurement is completed. On the basis of the cumulant, a decision is made among three possible choices.

(1) Accept the lot under test.

(2) Reject the lot.

(3) Make another test.

9.07 This method of testing has the advantage of requiring a minimum of measurements if the population under test meets or fails the acceptance criterion by a considerable margin. Thus, a very good system would be accepted, or a very poor system rejected, after a relatively small number of measurements. However, systems which are borderline may require a relatively large number of tests. The object is to decide whether 50 percent of the trunks under test meet the objectives of no more than five counts in 5 minutes at the specified test level.

9.08 At the end of each 5-minute test, a 0 is scored if the number of counts recorded is five or less; a 1 is scored if the count is six or more. In fact, any measurement may be terminated whenever the count exceeds five. At least four trunks must be measured and then the total number of 1s and 0s is compared with the values given in Table 6 and one of the decisions given above is made. The minimum total of 1s or 0s which must be observed in order to accept or reject the trunk group is a function of the trunk group size and the total number of measurements made.

9.09 Two kinds of errors can be made. These are accepting a system that is actually bad or rejecting a system that is actually good. It is, of course, highly desirable to minimize the probability of either kind of error. These probabilities can be made arbitrarily small but at the expense of additional testing. A judgment must be made. In the procedure established here, the choice has been made at 0.1 or 10 percent. Once the choice has been made, the procedure described determines an upper bound on the number of tests (or the sample size) required. As stated above, however, the testing may terminate before the maximum sample size is achieved. Such a termination in no way affects the error probability; it simply means that the performance of the system being tested is somewhat better (or worse) than the objective.

9.10 A sample work sheet for impulse noise testing is shown in Table 7. Column 1 is simply a count of the trunks measured. Column 2, Remarks, notes whether or not the trunk is a compandored facility. (Compandored analog trunks must be measured using a holding tone.) Column 3 records the impulse counter threshold setting. Column 4 is taken from Table 6. Columns 5 and 6 record the cumulative number of 1s and 0s as the test progresses. As soon as the cumulative count of either 1s or 0s exceeds the corresponding decision number, the test terminates. In the example, the test ended after seven measurements because, at that point, the total number of 0s was five which is more than the four in the decision number column.

9.11 In the example given previously (Table 7), the trunk group passed after seven tests as indicated by the fact that five zeroes have been tallied by that time and the maximum for decision is four. Note that if trunks 2 and 5 and two others with a one score had been measured first, the test would have shown the trunk group to be bad, an erroneous conclusion. The chances of such an error occurring are 10 percent or less and then only when the impulse noise level on the trunk group is very close to the objective value. If the actual threshold for the group is at least 2.5 dB from the objective, either below or above, the chance of such an error is less than 1 percent. Objectives for carrier and VF trunks are given in Table 8.

SAMPLING FOR SWITCHING SYSTEMS

9.12 The following describes a sampling plan and method for measuring impulse noise in a central office. The office is defined as all of the equipment and cable that is required to complete a connection from one termination on the MDF to a second termination on the MDF. For ease of administration, a single office is defined to include only those MDF terminations assigned to a single exchange number even though more than one such number may exist for a given switching system.

TABLE 6

DECISION NUMBER OF 0s OR 1s

(FOR VARIOUS TRUNK GROUP SIZES)

CUMULATIVE NUMBER OF TRUNKS TESTED	SIZE OF TRUNK GROUP 5-12	13-18	19-24	25-30	31-43	44 UP
4	3	3	3	3	3	3
5	3	4	4	4	4	4
6	4	4	4	4	4	4
7	4	5	5	5	5	5
8	5	5	5	5	6	6
9	5	6	6	6	6	6
10	6	6	6	6	7	7
11	6	7	7	7	7	7
12	6	7	7	7	8	8
13		7	8	8	8	8
14		8	8	9	9	9
15		8	9	9	9	9
16		9	9	10	10	10
17		9	10	10	10	10
18		9	10	11	11	11
19			10	11	11	11
20			11	12	12	12
21			11	12	13	13
22			12	12	13	13
23			12	13	14	14
24				13	14	14
25				14	14	14
26				14	15	15
27				15	15	15
28				15	16	16
29				15	16	16
30				15	17	17
31					17	17
32					18	18
33					18	18
34					19	19
35					19	19
36					20	20
37					20	20
38					20	20
39					21	21
40					21	21
41					21	21
42					21	21
43					21	21
44						26
45						26
46						26
47						26
48						26
49						26
50						26

Note: Accept group if 0s exceed decision number. Reject group if 1s exceed decision number. Accept if equal 0s and 1s after maximum tests.

TABLE 7

SAMPLE TEST SHEET FOR GROUP OF UP TO 12 TRUNKS

CUMULATIVE NUMBER OF TRUNKS MEASURED	REMARKS	TEST LEVEL	DECISION NUMBER OF 0s OR 1s	CUMULATIVE 0s	CUMULATIVE 1s
1	COMPANDORED	66 dBrnC	—	1	
2	COMPANDORED	66 dBrnC	—		1
3	COMPANDORED	66 dBrnC	—	2	
4	NON-COMP-(VF)	54 dBrnC	3	3	1
5	NON-COMP-(VF)	54 dBrnC	3		
6	NON-COMP-(VF)	54 dBrnC	4	4	
7	COMPANDORED	66 dBrnC	4	5	
8			5		
9			5		
10			6		
11			6		
12			6		
				↑ Accept if 0s exceed decision no.	↑ Reject if 1s exceed decision no.
				Accept if equal 0s and 1s after maximum no. of tests	

9.13 Since there is an extremely large number of possible paths that may be taken for a connection between two arbitrary MDF terminations and there are N(N-1) possible pairs of MDF terminations, where N is the total number of such terminations, a sampling plan is required to select paths for measurement as one step in evaluating the noise encountered on connections through an office.

9.14 When selecting a test sample, all of the lines and numbers selected in an office must be in the same switching system and not, for example, from a number on a panel MDF to a number on a crossbar MDF in the same building. Where there is more than one crossbar marker group in the same building, consider each marker group a separate entity. Select spare terminations in each marker group. The lines selected must be in different originating subgroups. This precludes identical paths through the originating switching system on two test calls in the same sample. In panel and step offices, call numbers selected for noise measurement must be in different hundred groupings. In small offices where there are a limited number of subgroups or in crowded offices with few spares, the same subgroup may be used more than once.

TABLE 8

IMPULSE NOISE MAINTENANCE LIMITS FOR TRUNKS

TRUNK LENGTH (MILES)	VF FACILITIES	COMPANDORED CARRIER AND MIXED COMPANDORED AND NONCOMPANDORED CARRIER FACILITIES	NONCOMPANDORED* CARRIER FACILITIES
0 — 60	54 dBrnC0	66 dBrnC0	58 dBrnC0
60 — 125	54 dBrnC0	66 dBrnC0	58 dBrnC0
125 — 250	54 dBrnC0	66 dBrnC0	59 dBrnC0
250 — 500	54 dBrnC0	66 dBrnC0	59 dBrnC0
500 — 1000		66 dBrnC0	59 dBrnC0
1000 — 2000		66 dBrnC0	61 dBrnC0
over 2000		66 dBrnC0	64 dBrnC0

*Digital carrier systems are considered to be noncompandored.

Note: Compandored carrier must be measured using a holding tone at −13 dBm0 and a C-notch filter in the test set.

9.15 Assign line numbers to 20 of the selected spare terminations and break the 20 into two sets of ten each with two remaining spares. Place calls consecutively from one of the two remaining spares chosen to each of the ten terminations in set 1; then place calls from the other remaining test termination to each termination in set 2. On each call, measure impulse noise; if the count at the end of 5 minutes is five or less, a zero is recorded for that measurement; otherwise, a 1 is recorded. Twenty measurements (ten in each of the groups) are made. The office is acceptable from an impulse noise standpoint if no more than six 1s are accumulated in either of the two groups of ten measurements. This criterion assures that 50 percent of calls through the office will have five counts or less in 5 minutes with 90-percent confidence.

9.16 Since it is proposed that an office be evaluated only following a specific noise complaint which is traced to that office, the measurement results should be forwarded to an appropriate evaluation group for follow-up action.

9.17 Impulse noise problems in other than step-by-step offices will probably require engineering assistance for mitigative measures. In step offices, cleaning and adjusting the switches according to standard practices usually result in improved performance. Objectives for impulse noise in offices are given below:

TYPE OF OFFICE	NO MORE THAN FIVE COUNTS IN 5 MINUTES ON 50 PERCENT OF TEST CALLS AT A LEVEL OF:
Panel	No objective (do not use for data transmission)
SXS	59 dBrnC
Crossbar	54 dBrnC
ESS	47 dBrnC

10. OTHER PARAMETERS AFFECTING DATA TRANSMISSION

ENVELOPE DELAY

10.01 Envelope delay is defined as the derivative with respect to frequency of the phase characteristic of the channel. Measuring this derivative is impractical, so it is approximated by a difference measurement. There are numerous envelope delay measuring sets in use employing various frequency widths for this difference measurement. The Bell System standard is 166-2/3 Hz. In test results, these differences show up as varying resolution of ripples in the envelope delay characteristic. The narrower widths yield higher resolution but reduced accuracy.

10.02 The frequency of minimum envelope delay in telecommunication channels is usually in the vicinity of 1800 Hz. Therefore, envelope delay measurements are usually normalized to zero at 1800 Hz. Departure from zero at other frequencies is referred to as envelope delay distortion. Envelope delay distortion gives rise to intersymbol interference in data transmission which causes errors and increased sensitivity to background noise.

10.03 In the DDD network, envelope delay is controlled in the design of channel bank filters and other apparatus. In addition, some engineering rules are applied in the circuit layout process to minimize the effects of envelope delay distortion. For example, DDD trunks frequently avoid the use of channels 1 and 12 in a group when group connectors are used in the facility makeup. These channels are reserved for such things as voice-only private lines. Thus, the added envelope delay distortion on edge channels is avoided.

10.04 There are no maintenance limits for envelope delay distortion* on the DDD network but the Bell System is currently exploring the use of peak-to-average (P/AR) measuring apparatus in order to increase control of this impairment in the field.

*Except for loops with Type II and Type III data where they are engineered to have no more than 100 microseconds of envelope delay distortion between 1000 and 2400 Hz.

PHASE JITTER

10.05 Phase jitter is defined as unwanted angular modulation of a transmitted signal. Its most commonly observed property is that it perturbs the zero crossings of a signal. Since noise also perturbs the zero crossings of a signal, it usually causes readings on a phase jitter measuring set even though no incidental modulation may be present. At this time, there are no commercially available test sets which can guard against this type of erroneous reading although there is at least one in experimental development.

10.06 Phase jitter impairs data transmission by reducing data receiver margin to other impairments. Phase jitter is controlled by the design of transmission equipment. Although specific sources of it, such as primary carrier frequency supplies, have been located in the field, the corrective techniques applied have amounted to design changes in specific equipment. The end-to-end objective for phase jitter is no more than 10 degrees peak to peak. Individual carrier terminals are allotted 1.3 degrees.

NONLINEAR DISTORTION

10.07 Nonlinear elements in transmission equipment give rise to an impairment which can be referred to as harmonic distortion, intermodulation distortion, or, more generally, nonlinear distortion.

10.08 Nonlinear distortion can be broadly defined as the generation of signal components from the transmitted signal that add to the transmitted signal usually in an undesired manner. The nonlinear distortion of concern here is that within an individual voice channel. It should not be confused with the intermodulation noise caused by nonlinearities in the multiplex equipment and line amplifiers of a frequency division multiplex system. Although these nonlinearities can contribute to the nonlinear distortion at voice frequencies, their contribution is usually negligible.

10.09 Nonlinear distortion is commonly measured and identified by the effect it has on certain signals. For example, if the signal is a tone having frequency "A", the nonlinear distortion appears as harmonics of the input; that is, it appears as tones at 2A, 3A, and so on. Since most of the distortion product energy usually occurs as the second and third harmonics, distortion is often quantified by measuring the power of each of these harmonics and is called second and third harmonic distortion. If the amount of nonlinear distortion is measured by the power sum of all the harmonics, the result is called total harmonic distortion. These distortion powers are not meaningful unless the power of the wanted signal (the fundamental) is known, so measurements are usually referred to the power of the fundamental and termed second, third, or total harmonic distortion.

10.10 Currently, there are two methods of measuring nonlinear distortion on voiceband channels. The single-tone measurement is made by transmitting, at data level, −13 dBm0, a tone at 704 Hz and measuring the received tone and the second (1408 Hz) and third (2112 Hz) harmonics with a frequency selective voltmeter. R2 and R3 are the ratio in dB of the received fundamental to the received second and third harmonic, respectively.

10.11 The 4-tone method uses two sets of tones. One set consists of tones at 856 and 863 Hz (a 7-Hz spacing). A second set uses frequencies of 1374 and 1385 Hz (an 11-Hz spacing). The frequency spacing within each set of tones is not critical but should be different for each set. Let these four tones be called A_1, A_2, B_1, and B_2. The second-order products (A+B) fall at A_1+B_1, A_1+B_2, A_2+B_1, and A_2+B_2. If the spacing between A_1 and A_2 is the same as that between B_1 and B_2, then $A_1+B_2 = A_2+B_1$ and these two components will add on a voltage basis and give an erroneous reading.

10.12 The third-order products (2B−A) fall at $2B_1-A_1$, $2B_1-A_2$, $2B_2-A_1$, $2B_2-A_2$, $B_1+B_2-A_1$, and $B_1+B_2-A_2$. The receiver uses 50-Hz wide filters to select the A+B, B−A, and 2B−A products. R2 is the ratio of received composite fundamentals to the power average of the A+B and B−A products. R3 is the ratio of received composite fundamentals to the 2B−A products. For this test, the four equal level tones are transmitted at a total composite power equal to the data level −13 dBm0.

10.13 When measuring large values of R2 and R3, the noise in the channel may add to the readings and give an erroneous result. To guard against this, after each measurement of R2 or R3, one set of tones is removed from the line and the power in the second set is increased by 3 dB. The increase in power maintains the same composite level on the line to operate compandors and encoders in about the same manner as the full 4-tone signal. Since the products measured for R2 and R3 are now removed from the line, the noise in the receiver filter slots may now be measured to see if it contributed significantly to the original readings; appropriate corrections may be made if necessary using Fig. 20.

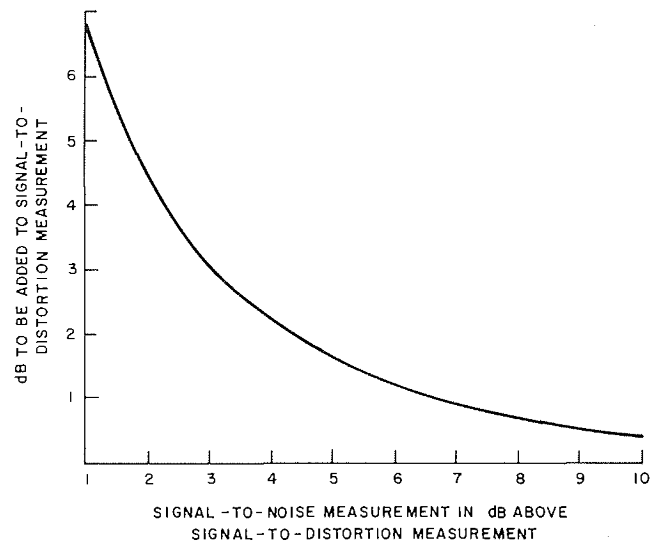


Fig. 20—Diagram of an Exponential Curve

10.14 The single-tone method, not recommended for future use in the Bell System, is the simplest to apply and, when measuring large values of R2 and R3, this method will be the least affected by background noise because very narrow filters can be used to select the tones out of the noise. However, a single-tone measurement may be strongly biased by frequency-dependent nonlinearities. The tone may be in a peak or a valley of the curve relating distortion to frequency and thus yield a biased answer. Further, the amplitude density of a single sinusoid is very unlike that of a data signal and the test tone will not operate compandors and encoders in a manner similar to a data signal.

10.15 The 4-tone test signal has an amplitude density function quite similar to that of a data signal and is preferred. However, because of the relatively wide (50 Hz) passband of the receiver filters, the 4-tone method is most affected by circuit noise.

10.16 The intermodulation products arising from nonlinear distortion add to the wanted signal and interfere with it much as noise does. The intermodulation products are more damaging than noise, however, and the ratio of fundamental to second- or third-order products must be in the range of 25 to 38 dB, depending upon the type of data transmission, for satisfactory operation.

10.17 Nonlinear distortion is controlled primarily in the design of equipment. However, such things as aging vacuum tubes in older equipment and poor alignment of D1 channel banks can cause this distortion to increase over its design limits. The overall customer-to-customer long-term objective for nonlinear distortion is given below:

Method of Measurement:	1 Tone	4 Tone
R2	32 dB	32 dB
R3	37 dB	35 dB

C-NOTCHED NOISE

10.18 For voice transmission, the noise that is heard during the quiet intervals of speech is most important and this is what the standard message circuit noise measurement evaluates. For data transmission, the noise on the channel during active transmission and corresponding signal-to-noise ratio is what is important. In systems using compandors or quantizers, the noise increases during active transmission. In order to measure this noise, a tone, at data level (−13 dBm0), must be transmitted from the far end of the channel under test and then filtered out ahead of the noise measuring set. The filter used to remove the tone is a narrow notch filter centered at the frequency of the tone, hence, the name C-notched noise. This type of measurement is also referred to as noise with tone. Test equipment is now available which uses 1004 Hz as the tone for this measurement.

10.19 Noise, of course, can cause errors in data transmission and a signal to C-notched noise ratio of at least 24 dB should be maintained for satisfactory performance. Noise is controlled in the design of transmission equipment, in the engineering of transmission systems, by such things as repeater spacing, and in the maintenance of these systems. Most of the techniques used to improve message circuit noise will also improve C-notched noise.

FREQUENCY SHIFT

10.20 When a tone experiences a change in frequency as it is transmitted over a channel, the channel is said to have frequency shift or offset. Frequency shift can be measured by using frequency counters at both ends of a channel. When the input frequency differs from the output frequency, the difference is the frequency shift on the channel.

10.21 In modern telecommunication equipment, the frequency shift, if any at all, is usually negligible on the order of 1 Hz or less. Some older carrier systems, such as C, J, and H, may have substantial amounts of offset; 15 to 20 Hz is not uncommon.

10.22 Frequency shift is important in systems which use narrowband receiving filters such as telegraph multiplexers and remote meter reading equipment. When systems using these types of transmission experience frequency shift, the received signals fall outside the bandwidth of the filters. Frequency shift can occur on facilities which use single sideband suppressed carrier transmission. In the Bell System, frequency shift is controlled by means of the frequency synchronization network. The overall objective for frequency shift is ±5 Hz.

GAIN AND PHASE TRANSIENTS

10.23 Gain and phase changes that occur very rapidly may be encountered on telecommunications channels. Some of the more common causes of these phenomena are automatic switching to standby facilities or carrier supplies, patching out working facilities to perform routine maintenance, fades or path changes in microwave facilities, and noise transients coupled into carrier frequency sources. The channel gain and phase (or frequency) shift may return to its original value in a short time or remain at the new values indefinitely.

10.24 Gain changes are typically detected by changes in an Automatic Gain Control (AGC) circuit and phase changes by means of phase locked loop. In order to provide protection against the test set detectors falsely operating on peaks of uncorrelated noise (impulse noise), a guard interval of 4 milliseconds is designed into the gain or phase peak indicating instrument. Unfortunately, such a guard interval will also effectively mask out true phase hits shorter than 4 milliseconds that are not also accompanied by a peak amplitude excursion. The risk is considered justified at this time when the known relative frequencies of phase jumps are compared with those for impulse noise.

10.25 Instruments used to measure gain and phase hits, as the rapid gain and phase changes are usually called, do so by monitoring the magnitude and phase of sinusoidal tone. Hits are recorded and accumulated on counters with adjustable threshold levels. Gain hit counters typically accumulate events exceeding thresholds of 2, 3, 4, and 6 dB although they do not distinguish an increase from a decrease of magnitude. Similarly, phase hit counters accumulate changes at thresholds from 5 to 45 degrees in 5-degree steps. They respond to any hits equal to or in excess of the selected threshold. A switch which removes the impulse noise blanking feature under the user's discretion may be desirable when impulsive phase hit activity is suspected. As with the impulse noise counters, a controlled maximum counting rate of 6.7 counts per second should be built into the counters in order to obtain consistent readings with sets of different manufacture.

10.26 Gain hits begin to cause errors in high-speed data transmission when their magnitude is on the order of 2 to 3 dB. Phase hits begin to cause errors when the magnitude is about 20 to 25 degrees. The end-to-end objective for gain hits is no more than eight in 15 minutes larger than 3 dB and no more than eight phase hits in 15 minutes at a threshold of 20 degrees. Individual trunks are allotted two hits of each type in 15 minutes. Dropout is defined as a decrease in level greater than or equal to 12 dB lasting at least 10 milliseconds.

AMPLITUDE MODULATION

10.27 This parameter is currently under investigation. It is known to cause errors in high-speed data transmission at levels of about 10 percent and greater. Very little is known about the occurrence of this impairment in the network.

NOTES ON DISTANCE DIALING

SECTION 8

MAINTENANCE REQUIREMENTS

CONTENTS PAGE

1. GENERAL

1.01 The requirements of an overall maintenance plan are based on an ever expanding network with decreasing operator interaction in the placement of calls. To assure the customer of continued high quality service, a maintenance program must adapt to the changing network needs coincident with more efficient use of the telephone plant.

1.02 For distance dialing, the test equipment, methods, and organization of the maintenance job must continue to improve in order to maintain the precision and stability required of the network of interconnecting switching systems. Trouble detection is more difficult with direct (customer) distance dialing because operators can no longer supervise connections. Employment of automatic alternate routing adds to the difficulty of identifying trunks in trouble. Accordingly, maintenance methods and facilities based on requirements for automatic switching have to be provided, rather than attempting to use older techniques based on manual switching, inasmuch as most of the trouble indicators under manual switching no longer exist.

1.03 With automatic switching, poor maintenance at one office can result not only in excessive trouble at that office but also in adverse reaction elsewhere in the switching network. It is essential that each company have a well-organized maintenance plan at all locations. Intercompany cooperation should be maintained between all operating companies of the North American Integrated Network for the coordination and exchange of maintenance information and results. Maintenance plans should clearly define the responsibility among forces, departments, and telephone companies along with organized procedures for reporting and analyzing trouble to insure prompt action.

1.04 Evolutionary development of maintenance procedures will continue as experience is gained in the network and new switching techniques and methods are adopted. The trend has been toward:

(1) Reduction in manual effort due to the use of more reliable components and optimized equipment design and the provision of automatic testing devices and self-alarming arrangements which will automatically indicate troubles in the switching and transmission network.

(2) Rapid and efficient trouble reporting and analysis procedures. Maintenance arrangements must be provided to permit quick responses to trouble reports whether the report is from an operator or an automatic testing system.

(3) Electronic switching which allows expanded real-time analysis of trouble conditions.

1.05 This section will discuss testing and maintenance facilities as well as information applying their use in various types of offices. Since, with few exceptions, Sectional and Regional Centers are Bell operated, the discussion in this section is confined to other class office functions, namely:

(1) Class 3 (Primary Center)

(2) Class 4 (Toll Center or Toll Point)

(3) Class 5 (End Office).

Classification, rank, and homing arrangements for the various offices are discussed in Section 3.

2. MAINTENANCE FACILITIES

2.01 Maintenance or testing facilities, such as testboards, test desks, and test lines, are used to facilitate the location of trouble on toll and local circuits and to expedite the restoration of service. Older design testing equipment, still in use but rated Manufacturer Discontinued, will not be described here. Only the more common facilities currently in general use will be considered. Chart 1 indicates the facility requirements by class of office. Actual conditions in any location are, of course, the final criteria for selecting facilities.

TESTBOARDS

2.02 Primary testboard positions are used to terminate toll line cable and open wire pairs. The primary jacks, usually of the 4-jack per circuit type, permit ready access to line conductors to facilitate testing them and determining the type and location of any existing trouble. These jacks also permit patching toll terminating equipment. The test equipment consists of test and talk cords, test battery, voltmeter, and Wheatstone Bridge.

2.03 Secondary testboard positions are used for monitoring, talking, and signaling on circuits as desired and for patching or making operating tests on drop circuits and ringer equipment. The facilities consist of test multiples with or without patching jack bays. The test multiple is usually a single appearance of two jacks per trunk. One jack is a multiple of the switch appearance (and/or multiple of the switchboard) which permits making overall tests including monitoring and tests toward the line or carrier facilities. The other jack is provided to make the trunk test busy to the near-end switching system. (It may still be accessed from the distant end of a 2-way circuit.) Modern arrangements provide the capabilities on a "dialed up" basis using test connector switches, or the switching machine itself, to provide maintenance access to the trunks.

PATCHING BAYS

2.04 Patching jack bays may have four, five, six, or seven jack circuits. These jacks provide means to:

(1) Test and patch the transmission path between the 4-wire terminating set and the other terminal equipment (repeater, signaling equipment, carrier, etc). Also, transmission path troubles can be sectionalized; the drop circuit can be patched to the transmission path of any trunk.

(2) Test and patch the signaling and dialing path (E&M leads) between the signaling equipment and the trunk relay equipment. By means of these jacks, signaling troubles can be sectionalized.

(3) Patch dc supervisory signaling leads between trunk relay equipment and signaling equipment (usually designated as A and B or A and D leads) when required. Generally, direct cabling is used and patching facilities for these leads are not required.

2.05 For those switching systems in which the test multiple is cut off on an inward or through call, a single monitoring jack, a multiple of the drop patching jack, should be installed in the same general location as the multiple test jacks. The trend has been toward the elimination of these bays as more efficient packaging arrangements are developed.

2.06 Voice-frequency (VF) patch bays provide a patching junction and test point between carrier terminals and voice-frequency terminal equipment. (If the carrier system includes E&M lead signaling, it is advantageous to provide jacks for these signaling leads.) Also, line facilities can be patched through to any other line using proper pads. In some arrangements, switched maintenance access is provided at the VF patch point.

MISCELLANEOUS TESTING FACILITIES

2.07 Listed below are other common testing facilities:

(1) Testing Jacks—Associated with E&M signaling systems.

(a) Composite Line Jacks—Used to obtain 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 and Test Points—For testing SF and CX equipment units; associated with individual equipment.

(2) Pulse Repeating Test Set—For pulsing over E&M leads and measuring pulsing speed and percent break.

(3) Pulse Generating and Measuring Test Set—For pulsing over E&M leads and associated carrier signaling paths as well as measuring pulsing speed and percent break characteristics.

(4) Switchboard Cord and Position Maintenance Test Facilities and related test lines from the terminal and switching rooms as required.

(5) Centralized Test and Make-Busy Jacks—For trunk maintenance as required.

(6) Switching Equipment Maintenance Test Sets—In accordance with the type of switching system employed. Bell System common control 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 arrangements.

(7) Sender Test Facilities—Used where senders are involved.

(8) Transmission Test Equipment

(9) Carrier Testing Facilities—To test the various types of carrier units that may be involved. Carrier Group Alarms (CGAs) are provided as an aid to carrier system maintenance which release all connections on a faulty system, make the carrier channels busy at the offices that select the channels, and provide associated alarm signals in the maintenance area. (Refer to Section 5.)

TEST LINES

2.08 Test lines are part of the basic maintenance pattern in the distance dialing plan for the maintenance of trunks. Test line and test termination are terms sometimes used interchangeably to name testing equipment, facilities, circuits, or testing communication channels. These include simple passive terminations and relatively complex testing circuits capable of applying marginal signaling tests and transmission tests and of recognizing and replying to specific signals received.

2.09 In general, test lines that send tones provide a 300-millisecond quiet period to permit the SF signaling units to change supervisory state. (Refer to Section 5.) Some Class 5 offices must furnish continuously repeated supervisory cycles consisting of an off-hook interval followed by an on-hook supervisory interval in order to release the test line.

The stated frequencies of test line tones are nominal in the case of older design test lines due to the inherent instability of the vacuum tube circuits. New test line designs provide an additional 4 Hz above the desired frequency to avoid the modulation byproducts (beating problem) which may be produced in PCM type carrier.

2.10 ***Balance (100 Type)***—Is recommended for industry-wide use to facilitate connection to a termination for balance and noise testing. See Fig. 1. The requirements for this termination are as follows:

(1) Provides off-hook supervision to calling end as long as trunks are held by calling end. A 5-second milliwatt tone is provided before the balance mode on the newer version of the 100-type test line. This allows one-way loss and noise measurements to be made with one dial-up.

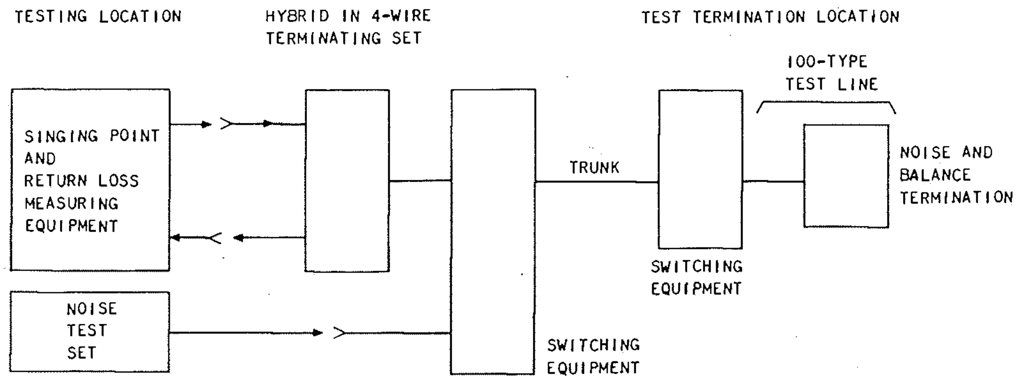


Fig. 1—100-Type Test Line

(2) Provides a termination (600 or 900 ohms plus a capacitance) which simulates the nominal office impedance.

2.11 *Communications (101 Type)*—Provides a communication and test line into a testboard or test position which can be reached over any trunk incoming to the switching system served by that test position. See Fig. 2. It is used for reporting trouble, making transmission tests, etc.

2.12 *Milliwatt (102 Type)*—Provides connection to a 1000-Hz testing power source for one-way transmission measurements. See Fig. 3. In 2-train No. 4 type crossbar offices, code 102 has been assigned to the intertoll train. This was done to guarantee that an incoming trunk will satisfactorily complete calls over both the intertoll and toll-completing trains. The features of this termination are as follows:

(1) Some early types provide continuous tone through a sequence consisting of a 9-second off-hook signal, during which 1000-Hz test power is applied, followed by a 1-second on-hook interval with no test power.

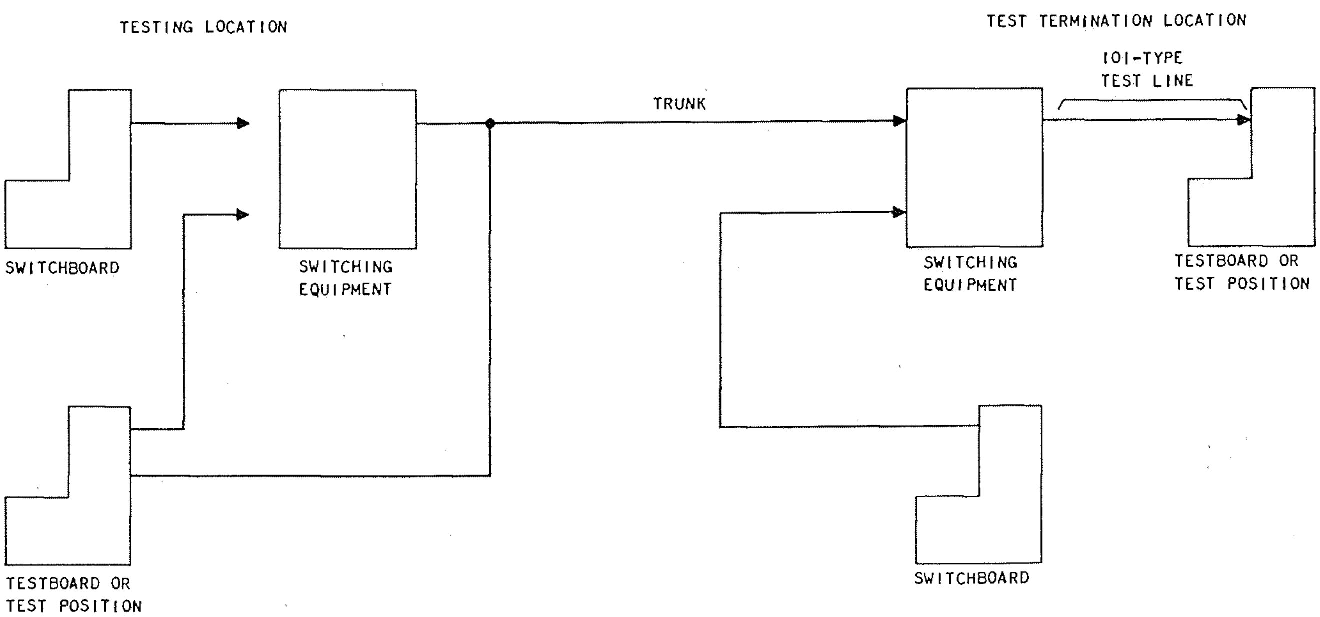


Fig. 2—Arrangement for 101-Type Test Line

(2) Other types provide a 9-second off-hook signal with test power followed by a steady on-hook signal without test power until released.

(3) Provides an idle circuit termination during the on-hook condition.

(4) Furnishes the necessary pad switching signals and test power level for intertoll trunks terminated on No. 4 type systems. In offices using fixed 2-dB pads (TP-2), the test pads are included in the test line to reduce the testing power to the proper level at the switches.

2.13 ***Signal-Supervisory (103 Type)***—Provides a connection to a supervisory and signaling test circuit for overall testing of these features on intertoll trunks, equipped with ring forward (rering) features, which can be reached by an automatic trunk test frame or by dialing manually. See Fig. 4.

(1) On seizure, the test trunk returns an off-hook signal.

(2) On receipt of a ring forward (rering) signal, the test trunk returns an on-hook signal.

(3) On the receipt of a second ring forward (rering) signal, the test trunk returns a 120-IPM flash.

2.14 ***Transmission Measuring and Noise Checking (104 Type)***—Provides a test termination for 2-way transmission testing and one-way noise checking. See Fig. 5. This termination can be used to test trunks from offices equipped with either the Automatic Transmission Test and Control Circuit or the Automatic Transmission Measuring System (ATMS) associated with automatic trunk test frames. It may also be used for manual "one-person," 2-way transmission measurements from a testboard or a maintenance center. The features of the 104-type test termination are:

(1) Provides test pads as required by the office in which it is located.

(2) Provides off-hook supervision.

(3) Measures the 1000-Hz loss of the trunk from originating end to far end.

(4) Adjusts a transmitting pad to equal the trunk loss measured in (3). If this loss exceeds 10 dB, the transmitting pad value is

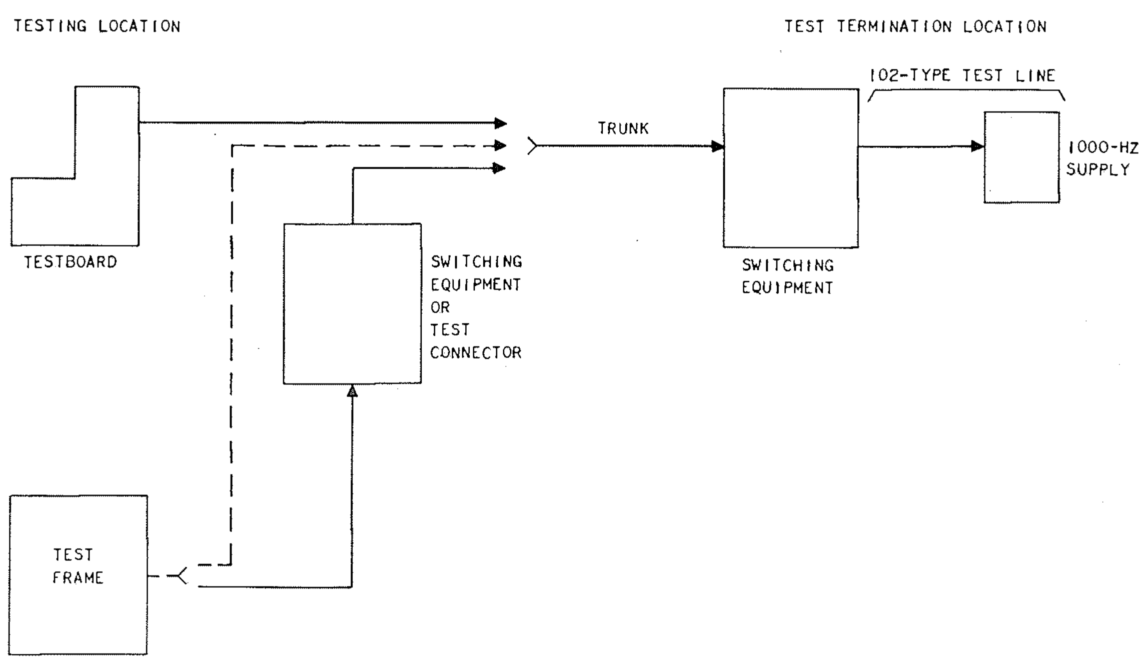


Fig. 3—Arrangement for 102-Type Test Line

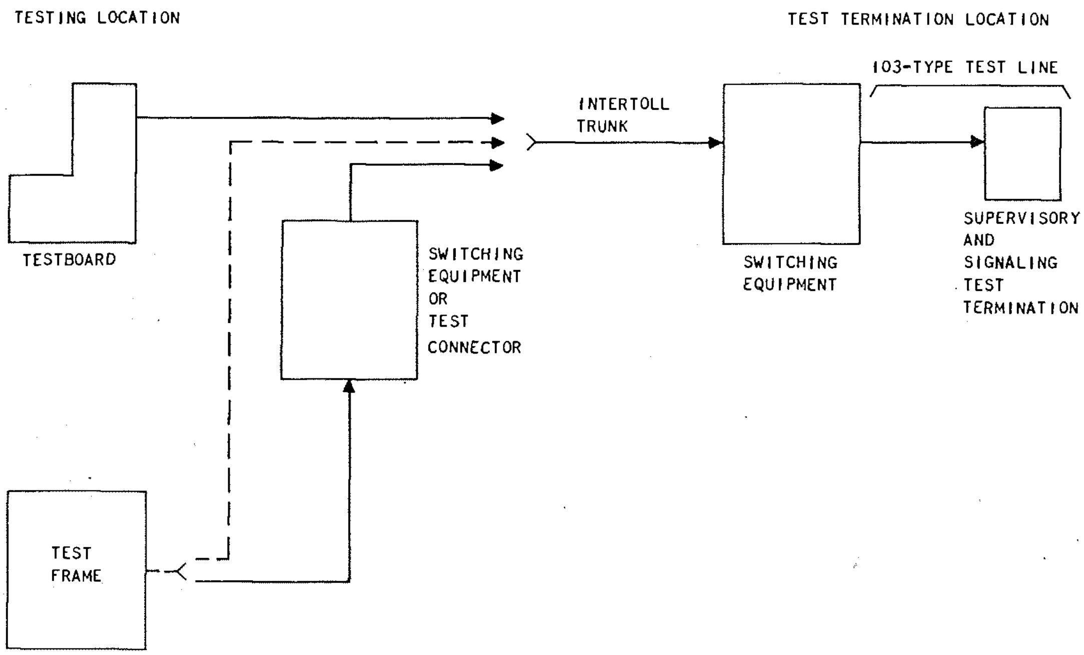


Fig. 4—Arrangement for 103-Type Test Line

reduced by 10 dB and a subsequent "wink" signal indicates this fact to the originating end.

(5) Makes a recheck of the trunk loss. By means of a local loop, checks to see if the pads have been properly adjusted. In case of failure in either of these checks, a repetition of the measurement is requested.

(6) Applies 1000-Hz test power directly to the trunk to permit a receiving measurement at the originating end.

(7) After a timed interval, sends 1000-Hz test power through the transmitting pad adjusted in (4) preceded by a "wink" signal if it has been reduced by 10 dB. This provides information on the loss in this pad to the originating end.

2.15 ***Automatic Transmission Measuring Test Line (105 Type)***—Provides access to a responder at the far end and permits automatic 2-way transmission loss and noise measurements to be made on trunks from the near-end office when it is equipped with a suitable test frame and an ATMS director or a Remote Office Test Line and responder. See Fig. 6. The responder is not readily adaptable to manual tests unless the near-end office is equipped with a compatible test unit such as the ATMS director or a Remote Office Test Line and responder unit equipped with an interrogator.

2.16 ***Data Transmission Test Line (107 Type)***—Provides connection to a signal source which provides test signals for one-way testing of data and voice transmission parameters. See Fig. 7. The test line provides a peak-to-average ratio (P/AR) signal, gain-slope frequencies, and quiet termination and allows measurement of return loss, frequency shift, phase jitter, C-notched noise, impulse noise, gain hits, phase hits, and dropouts.

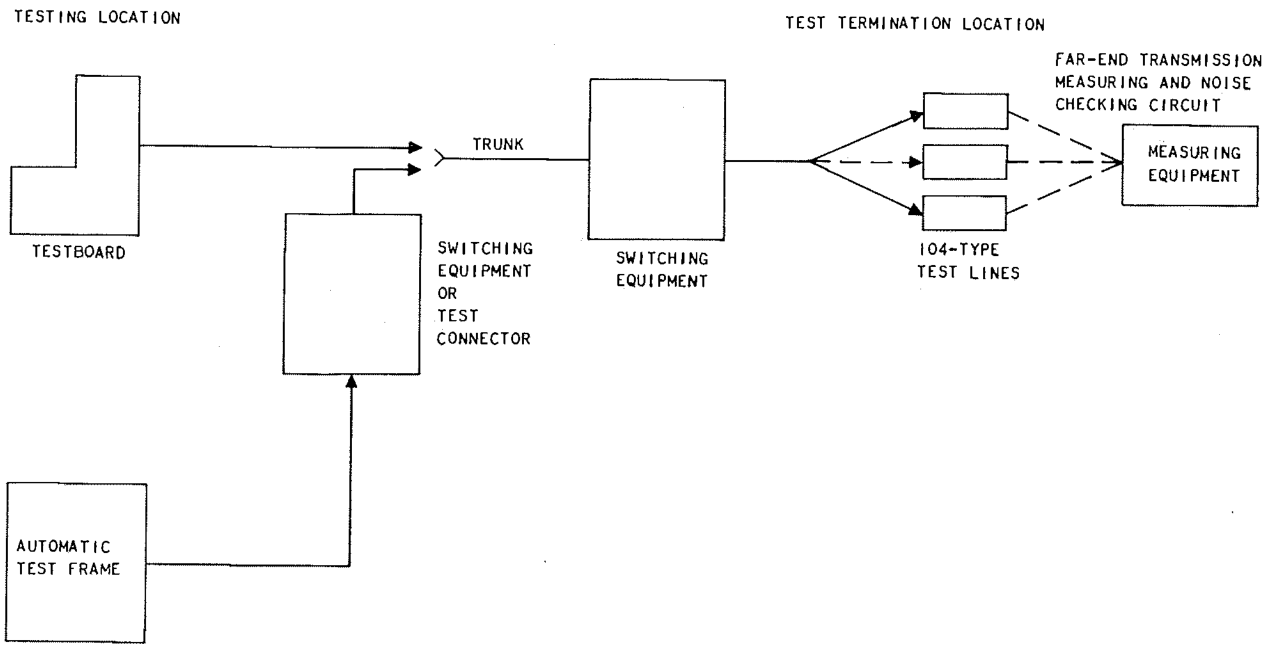


Fig. 5—Arrangement for 104-Type Test Line

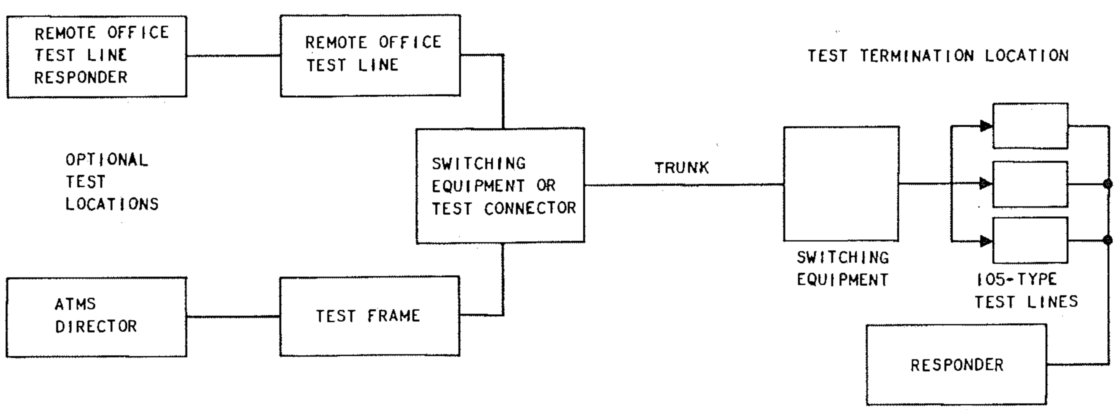


Fig. 6—Arrangement for 105-Type Test Line

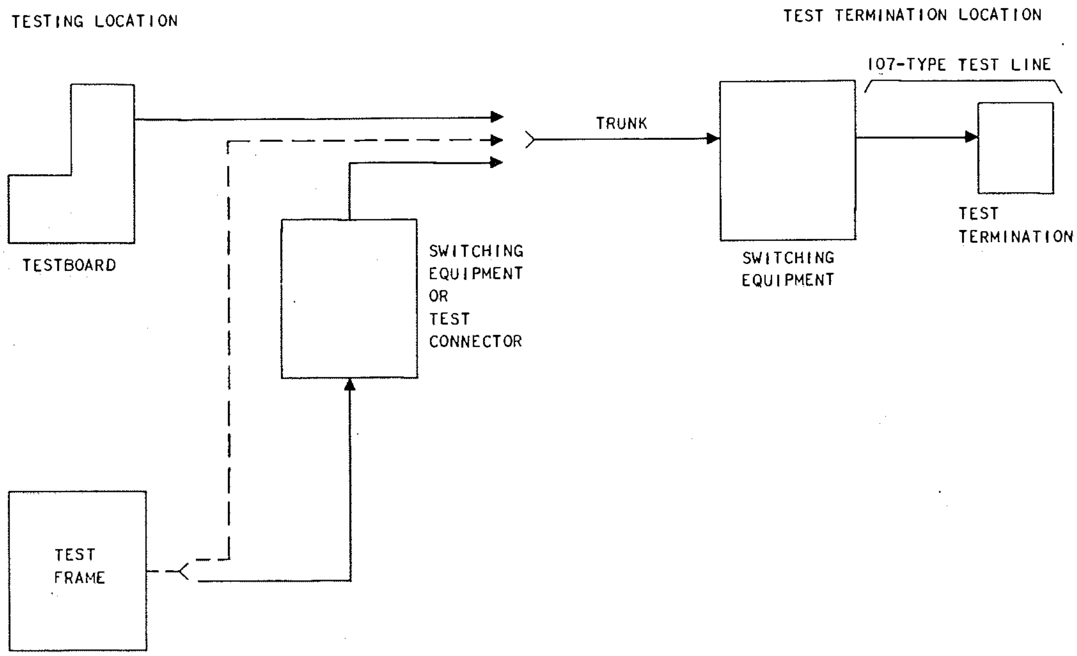
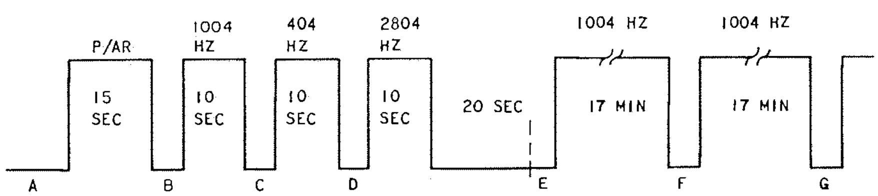


Fig. 7—Arrangement for 107-Type Test Line

Upon seizure, the test line proceeds through the sequence of tones shown in the following illustration:



A - 200 MILLISECONDS OFF-HOOK (QUIET TRANSMISSION)
B, C, D - 1 SECOND OFF-HOOK (QUIET TRANSMISSION)
E, F, G - 3 SECONDS ON-HOOK FOLLOWED BY 300 MILLISECONDS OFF-HOOK

2.17 The P/AR (peak-to-average ratio) signal, which has a spectrum similar to many high-speed data sets, permits a rapid check of the quality of a facility for data transmission. The P/AR signal is particularly sensitive to envelope delay distortion. The three gain-slope frequencies, 1004 Hz, 404 Hz, and 2804 Hz, at −16 dBm permit measurement of the facility frequency characteristic. The 20-second quiet termination permits measurement of background noise or provides a proper termination for return loss measurements. The 17-minute, 1004-Hz, −16 dBm tone permits measurement of frequency shift, phase jitter, C-notched noise, impulse noise, gain hits, phase hits, and dropouts. The 3-second on-hooks permit dropping facilities with joint hold.

2.18 ***Echo Suppression Loop-Around Test Line (108 Type)***—Provides far-end loop-around terminations to which a near-end echo suppression measuring set is connected. See Fig. 8. The loop-around unit steers the first near-end test call to the test port termination; the second near-end test call connects to the auxiliary port termination.

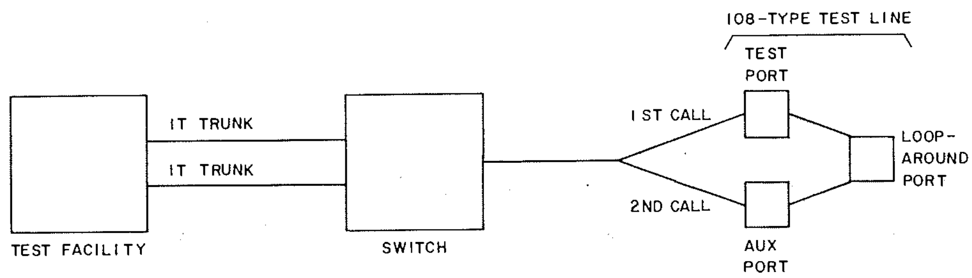


Fig. 8—Arrangement for 108-Type Test Line

The echo suppressor associated with the second call is disabled. The echo suppression measuring set is then used to make echo suppression tests on the test port trunk.

2.19 *Code 161*—Code 161 has been assigned in most Bell System toll switching offices to reach a communication line terminated at a trouble-reporting location. This code is used by operators to report troubles encountered on trunks. See Fig. 9.

2.20 *Code 958*—Code 958 has been assigned throughout the Bell System for the present as a communication trunk for receiving incoming calls to the switching system maintenance center for purposes of obtaining assistance in clearing intersystem trouble. See Fig. 10. Equipment trouble in a remote office may impair calls between two offices. When there are indications of intersystem trouble, tracing and clearing may be expedited by the use of this line for communication between the two maintenance centers involved.

Additional Test Lines for Testing Toll-Connecting Trunks

2.21 Test lines similar to those described previously are reached by dialing a customer-type telephone number when testing toward a Class 5 office or by dialing an arbitrary 3-, 4-, or 7-digit number when testing toward a toll office. In addition to the features described in preceding paragraphs, test lines in Class 5 offices are arranged to trip machine ringing.

2.22 The loop-around test line in a Class 5 office enables one person in a toll office to make

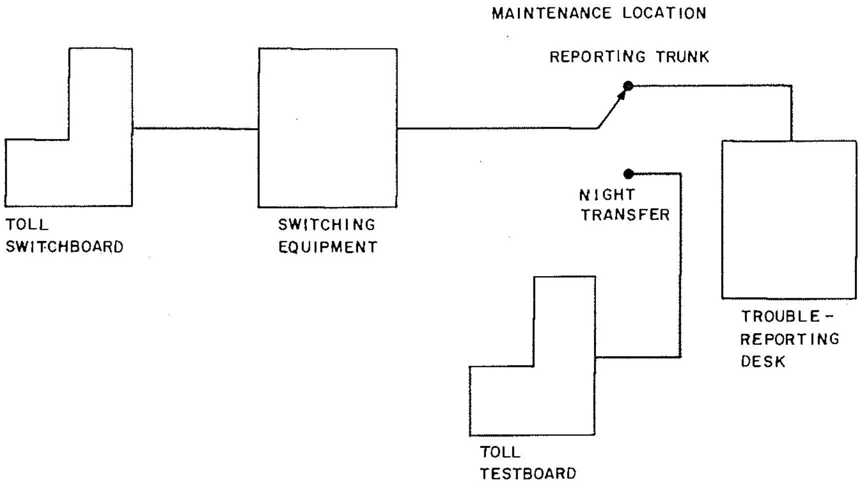


Fig. 9—Arrangement for Operator Trouble Reporting Using Code 161

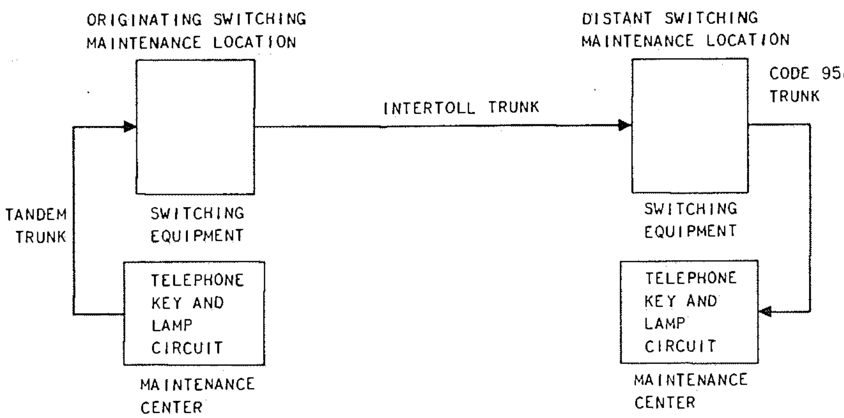


Fig. 10—Arrangement for Code 958 Communicating Trunk

2-way transmission tests. Test calls directed to this test line are manually originated. It is used to measure the near-to-far loss of 4-wire or equivalent trunks. This test line has two terminations, each reached by means of separate customer-type telephone numbers. After having measured the far-to-near end loss of all trunks in the group (using 102 test line), one trunk is selected as a reference trunk. Using the reference trunks, one termination of this test line is dialed. Then taking each of the remaining trunks in turn, the other termination of this test line is dialed and test power is sent out over the trunk under test and received on the reference trunk. By knowing the far-to-near end loss of the reference trunk and the overall measurement of the two trunks, the near-to-far end loss is calculated by subtraction. The features of this test line are as follows:

(1) Trips machine ringing.

(2) Provides idle circuit termination on each test number.

(3) When the second connection is made, both idle circuit terminations are removed.

(4) Provides direct connection between two test numbers.

(5) Provides a holding circuit through the sleeve to prevent switch-train release during supervision changes.

(6) Provides off-hook supervision after both test numbers have been selected.

2.23 A short-circuit termination and an open-circuit termination are provided to test the stability of trunks having negative impedance-type repeaters. The features of such a termination are as follows:

(1) Trips machine ringing

(2) Returns an off-hook signal to the calling end as long as the connection is held at the calling end

(3) Provides essentially an ac short circuit or open circuit across the tip and ring.

2.24 "Synchronous" type test lines are required for offices (usually in connection with the Bell System panel and crossbar offices) where ringing, tripping, and supervisory features are in the incoming trunk relay equipment. Marginal tests of the supervisory and tripping functions are provided. Tests may be originated on either a manual or automatic basis. In No. 1 ESS offices, an equivalent program-controlled test line operation is provided to satisfy the requirements of the originating office test frames. 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 a 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 seconds as an indication that the trunk circuit tripping features 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.

2.25 A "nonsynchronous" test line is required for all dial-type Class 5 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 cannot be applied directly to the incoming trunk circuit as is frequently the case with step 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 disconnections. Where the synchronous test line is provided, only the 60-IPM line busy signal is required.

2.26 The nonsynchronous test line, used in many Bell System step-by-step offices for the application of marginal tests to connector circuits, operates in the following manner:

(1) Starts to function under control of the ringing signal.

(2) Permits audible ringing signal 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 second 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-second on-hook period to permit disconnection from the test line.

(j) Alternate 5.5-second off-hook and 2.0-second on-hook intervals are repeated until disconnection takes place. The first two 5.5-second intervals are provided to facilitate testing of the ringing forward (rering) and control features provided on some operator-selected trunks to end offices and are desirable where these features are provided.

ASSIGNMENT OF TEST NUMBERS AT CLASS 5 OFFICES

2.27 To permit maximum use of automatic trunk test facilities for terminating trunks, a uniform assignment of test numbers is desirable. This is particularly important for all Class 5 offices homing on the same Class 4 office. Uniform test number assignment is also an asset to a well-organized maintenance plan. The number of directing digits preceding the test number should be kept to a minimum.

Trunk Transmission Test at a Manual Switchboard Position

2.28 A test line which furnishes 1000-Hz test power may be given a switchboard jack appearance to which incoming trunks may be connected manually by the operator. This procedure is similar to reaching the test power by dialing the 102-type test line where it is available. The requirements for this termination are as follows:

(1) Furnishes "off-hook" supervision and sends test power at 1000 Hz on the trunk to which it is connected for a test interval of about 9 seconds.

(2) Furnishes "on-hook" supervision and disconnects the test power for 1 second out of every 10 seconds continually during the test.

2.29 Jack appearances on switchboards may be provided for the loop-around, short circuit, open circuit, and balance termination test lines with operating features as covered in this section under Test Lines for Testing Toll-Connecting Trunks.

3. TRANSMISSION MAINTENANCE

3.01 The trend of transmission maintenance in the Bell System has been toward the development of mechanized and automated systems required to control the continuously expanding trunk network and associated facilities. The development activity for mechanized transmission maintenance has been concerned primarily with surveillance and testing systems.

3.02 A T-Carrier administration system has been developed which is a real-time surveillance system utilizing telemetry to monitor the status of T-Carrier systems in a metropolitan area. It is composed of status monitoring and performance measuring equipment located within selected offices which, in turn, can be controlled from a central location. This system fully implemented provides the following features:

(1) Automatically detects T-system failures and analyzes the nature of the alarm (outage or intermittent)

(2) Automatically sectionalizes failures to a defective terminal or span

(3) Rapidly identifies major route failures

(4) Monitors the status of maintenance lines and backbone lines required for restoration

(5) Makes routine periodic digital transmission performance measurement on all T-1 lines being monitored

(6) Provides periodic management reports on the performance of the metropolitan digital network.

3.03 The T-Carrier administration system, together with a centralized administrative organization such as a T-Carrier restoration control center, can provide an effective tool for eliminating many of the problems common to large metropolitan digital networks.

3.04 Surveillance and control of the broadband transmission plant is also accomplished through a remote centralized system. This system provides automatic surveillance of previously existing systems and uses telemetry for the primary control function. The surveillance and control system provides the tools and procedures to:

(1) Consolidate existing telemetry and alarm centers and to automate most of the existing manual operations and routine clerical functions that an alarm center performs

(2) Allow the establishment of end-to-end switch section alarm surveillance and remote control

(3) Provide real-time access to alarm information and control functions needed for more efficient management of broadband facility utilization.

The surveillance of currently unmonitored offices, as well as the encompassing of existing alarm systems, thus provides a more complete "view" of the ever expanding broadband plant.

3.05 Long-haul analog carrier systems and associated multiplex terminal equipment can be maintained by a carrier transmission maintenance system which provides centralized automated testing capabilities. This system permits one-person centralized fault locating by use of a broadband switched access network connected to equipment access points throughout the central office. Tests which a carrier transmission maintenance system performs include:

(1) Periodic level and gain measurements of terminal equipment

(2) Daily measurements of facility line pilots

(3) Measurement and analysis of transmission data to develop a carrier performance index

(4) Frequency response, white noise, fluctuation noise, and spurious tone measurements on radio facilities

(5) Demand measurements to localize trunk transmission problems

(6) Demand measurements to localize problems on Private Line Services.

3.06 Two types of maintenance philosophies are used. The first type includes monitoring and maintenance routines performed automatically at scheduled intervals. The system identifies those measurements that are out of limits. The second type provides measurements on demand of the tester. This will permit rapid access to various points along a carrier route to determine the area of trouble.

3.07 In addition to surveillance and maintenance of interoffice facilities, a larger problem exists in testing trunk networks throughout large geographical areas. A centralized automatic trunk measurement system has been developed to allow remote automatic testing of trunks in a defined geographical area.

3.08 The system uses a controller to obtain access to trunks to be tested via dialed-up connections to Remote Office Test Lines in the central offices in which the trunks originate. As an extension of the Automatic Trunk Measurement System (ATMS), this system utilizes the ATMS 51B responders (or equivalent) and new 52A responders (or equivalent) in conjunction with 105-type test lines. Figure 11 shows a functional block diagram of this system.

3.09 The controller can:

(1) Cause trunks to be seized by equipment located in surrounding central offices (eg, ROTLs)

(2) Cause the measuring equipment to be connected to each end of the trunks seized (eg, responders)

(3) Cause the measuring equipment to perform measurements on trunks

(4) Receive, analyze, and store all results of the measurement

(5) Further analyze and categorize present test result information in forms suitable for troubleshooting by proper telephone company personnel.

Figure 12 is a block diagram of the controller. Figure 13 shows a typical daily schedule of controller operations.

3.10 Remote Office Test Lines (ROTLs) provide the means for remotely accessing trunks over the switched telephone network as shown in Fig. 14.

3.11 Typical ROTL arrangements for the various switching systems are shown in Fig. 15 through 18.

3.12 All ROTL arrangements provide access to all outgoing or 2-way trunks in an office for transmission testing with the exception of testing operator trunks since voice communication with the operator is precluded. Access is provided to idle trunks and, if desired for a particular test call, to maintenance busy trunks.

3.13 Remote make busy and restoral to service upon request from an authorized manual

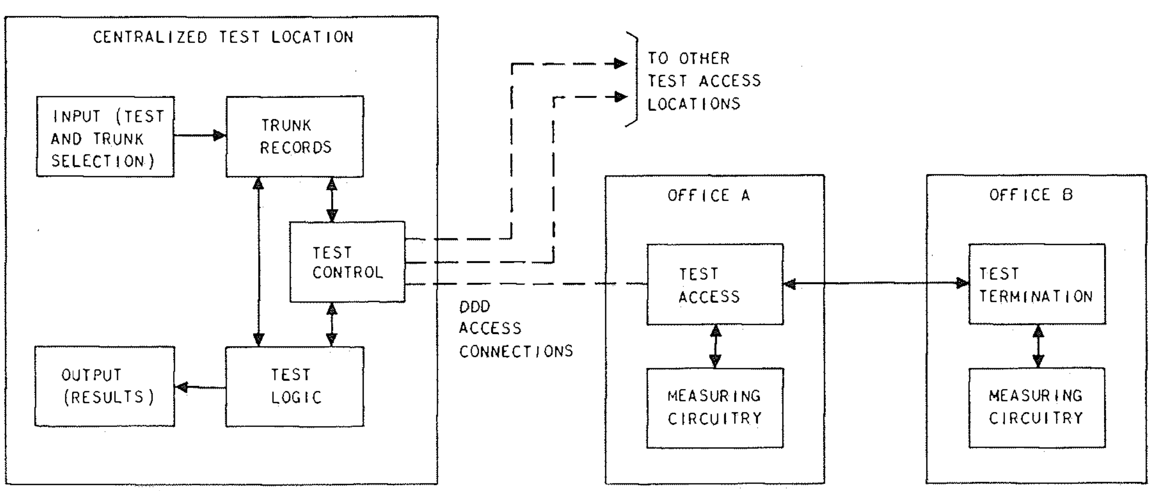


Fig. 11—A Centralized Automatic Trunk Measurement System

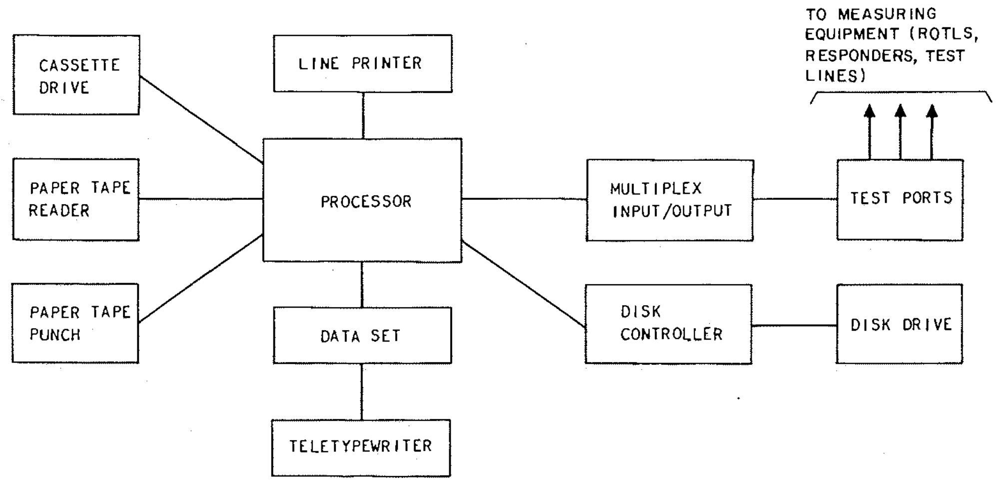


Fig. 12—Block Diagram of the Controller

position are provided for SXS, No. 5 Crossbar, and the ESS systems. The request includes the specific trunk identity and an indication to either remove the trunk from service or restore it to service. A verification of the completion of either action is returned to the requesting point in the form of a signal that can be aurally interpreted.

3.14 A program controlled interrogator is provided for No. 1 ESS to allow the central office personnel to make use of the same measurement circuits used on a routine basis by the system controller. In electromechanical systems, the manually controlled interrogator and ROTL control unit are planned in order to permit remote manual access for testing.

3.15 A portable ROTL test set has been developed to exercise the ROTL for maintenance and trunk testing. Two types of responders are used to perform the actual transmission measurements on trunks, the 51B and 52A, or equivalents. Commands received by the responder initiate either transmission measurements or a self-check of its own measuring circuit. The results of the tests are sent back to the controller.

3.16 The responder may be used in two ways as illustrated in Fig. 19 and 20. Shown in Fig. 19 is an ATMS director and responder in use in the Bell System today. The most general and most flexible use of the responder is shown in Fig. 20 where the test is completed between two responders rather than between an ATMS director and a responder. In this case, the ROTL is used in office "A" to establish the connection between the two responders over the trunk to be tested. The control of the ROTL is executed by the system connected to its access trunk via the telephone connection. The control location may be an ATMS director, a controller, or an interrogator.

3.17 After the ROTL has established a connection to the far-end office, office "B" in Fig. 20, it switches the access trunk through to the near-end responder and the trunk under test is connected between the two responders.

3.18 At the far end of a trunk under test, the responder usually interfaces with a 105-type test line. The purpose of this test line is to provide the necessary supervisory and terminating circuits required by the switching office, to return test progress (responder busy/idle) tones, to provide park-on arrangements so that test calls may be held while waiting for service, and finally to provide test information to the responder. In addition, the test line tells the responder whether the trunk is 4-wire or 2-wire. This system, which uses existing maintenance tools in the form of ATMS responders and Remote Office Test Lines, provides increased maintenance efficiency for routine trunk testing schemes in conjunction with centralized control.

3.19 Maintenance within an office has characteristically involved two or more people interacting on a circuit for both maintenance and

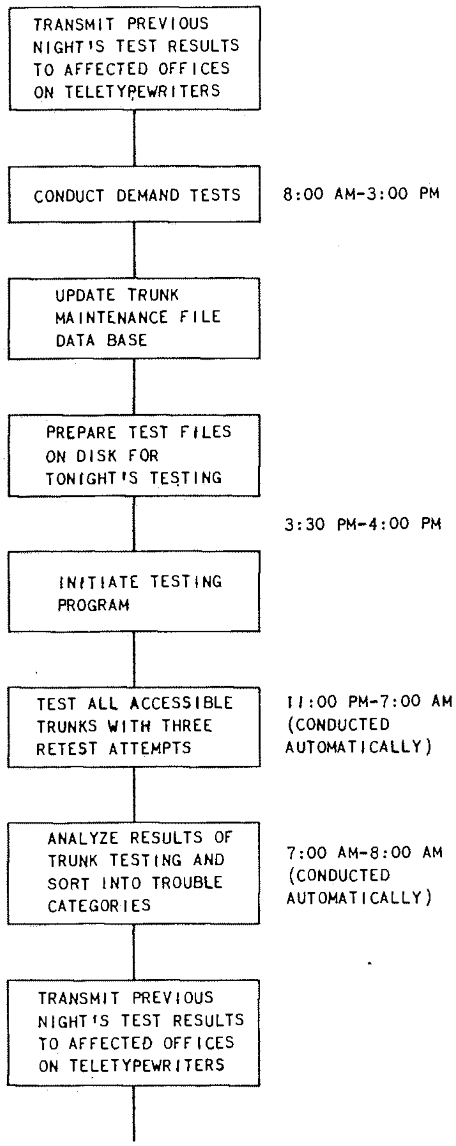


Fig. 13—Typical Daily Schedule of Controller Operations

trouble detection. The philosophy of maintenance and testing within the office has evolved toward the one-person concept using either switched or nonswitched test frames. Within the Bell System, there are four types of intraoffice transmission maintenance arrangements being used.

3.20 Figure 21 is a graphic presentation of the makeup of a circuit from a switching system to a high-frequency line. The test points on this circuit consist of the voice-frequency patch jacks in a centralized location. This gives access to the +7 dBm receive, −16 dBm transmit, standard test level points and provides a functional boundary between the voice-frequency equipment and the carrier equipment or line. The other manual access is via the manual testboard providing transmit and receive jacks on the drop side of the trunk relay and E&M lead jack access. The automatic test frame makes automatic transmission and operational tests on trunks and contains equipment for providing seizure of any specific trunk, signaling to obtain a test line connection, logic circuits to recognize operational failures during call setup, ATMS responder equipment, sequencing, and controlling logic for automatic measurements.

3.21 Sectionalization techniques within an office involve a 2-person team working together between the VF patch bay and the manual testboard access points to sectionalize the trouble to a specific component. Also, a 2-person team in the far-end office may be involved when sectionalizing trouble to a particular office.

3.22 The second arrangement, shown in Fig. 22, consolidates the transmission terminal equipment into one frame with the VF patching equipment. Although the need for a distributing frame is eliminated, a 2-person team is required for testing.

3.23 The provision of switched VF access back to the testboard, as shown in Fig. 23, provides the +7 dBm receive and −16 dBm transmit TLP at the manual testboard. Circuit terminal equipment is collocated within the same or adjacent bays. This arrangement allows one person at the manual testboard to perform maintenance testing but retains individual dedicated jack appearances for each trunk at the manual testboard.

3.24 The arrangement shown in Fig. 24 maintains the collocated terminal equipment concept and replaces the manual jack-ended testboard with a manual switched testboard such that every testing position in the office can access a concentrator which provides "all-trunks" appearance at the testboard. This arrangement also provides switched maintenance access to the VF patch point.

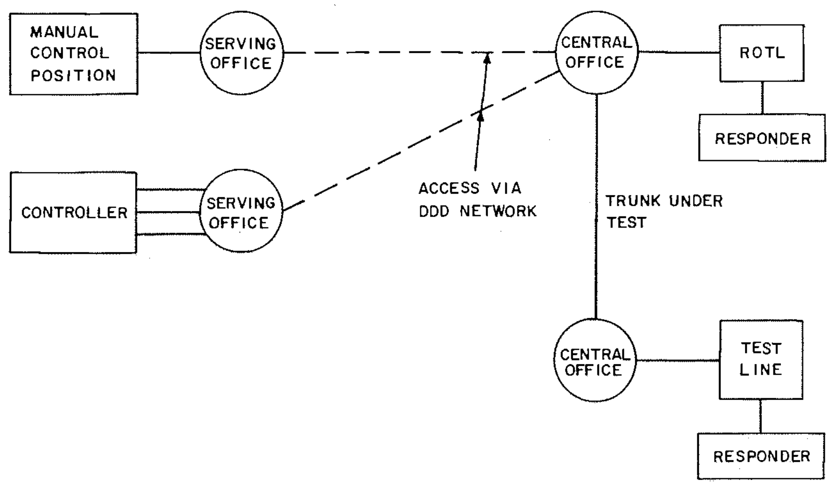


Fig. 14—Trunk Testing From Central Location Using ROTL

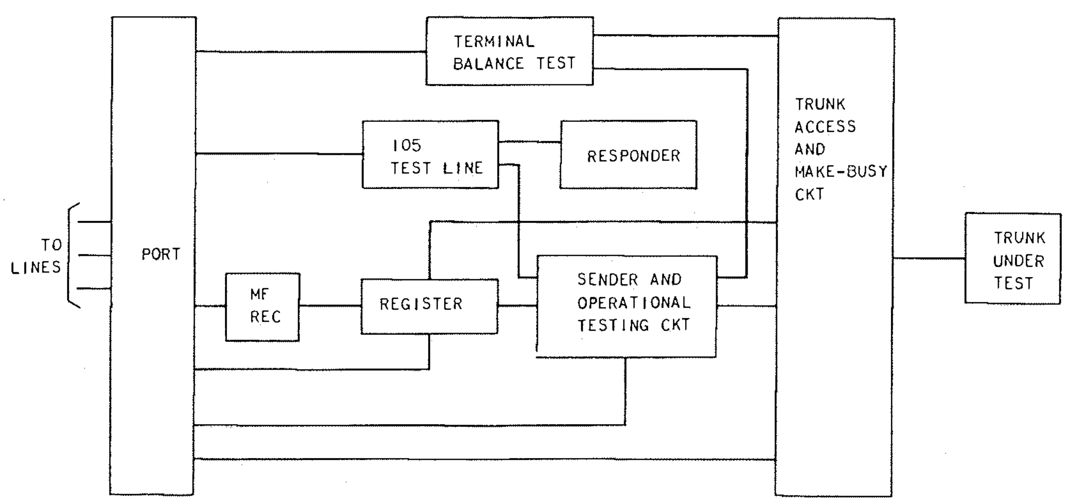


Fig. 15—SXS ROTL Features

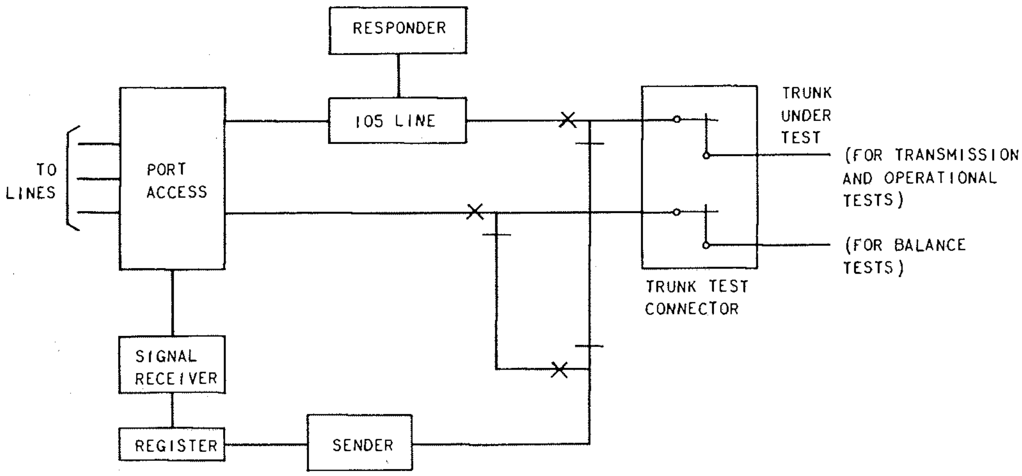


Fig. 16—Crossbar Tandem and No. 1 Crossbar ROTL

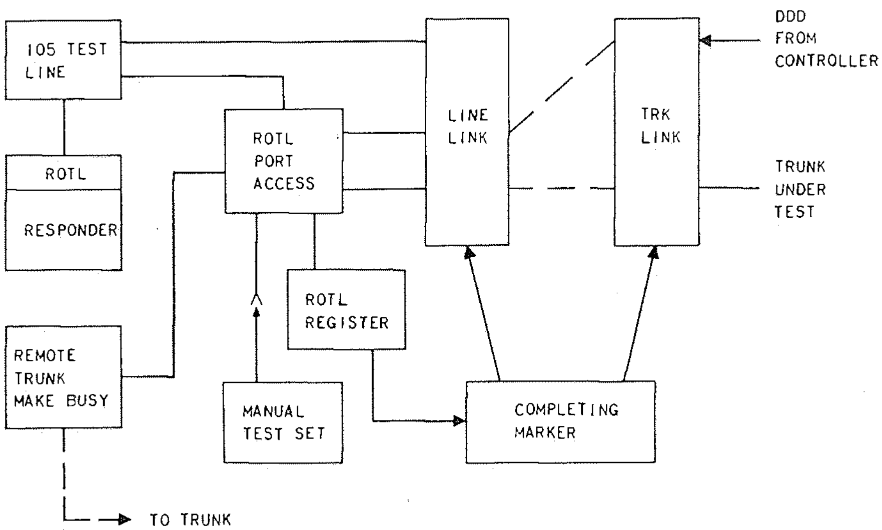


Fig. 17—No. 5 Crossbar ROTL Features

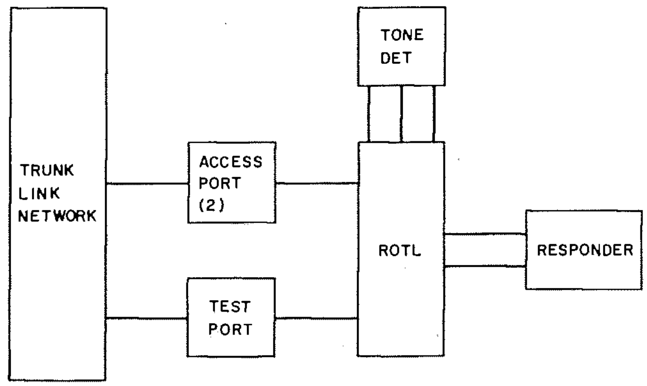


Fig. 18—Typical ESS ROTL Arrangement

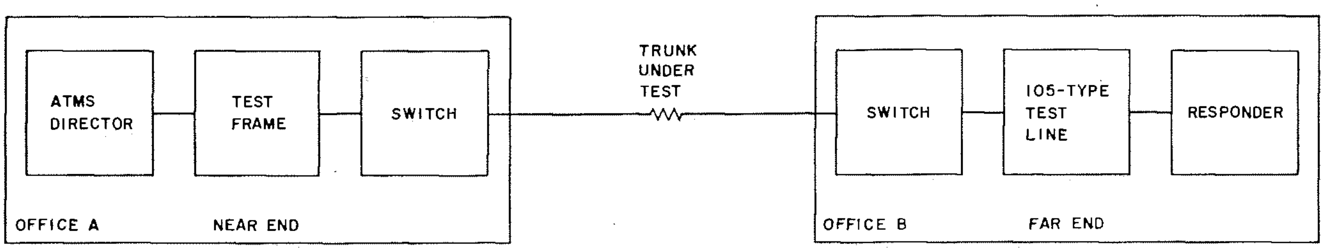


Fig. 19—The Responder in the Automatic Transmission Measuring System (ATMS)

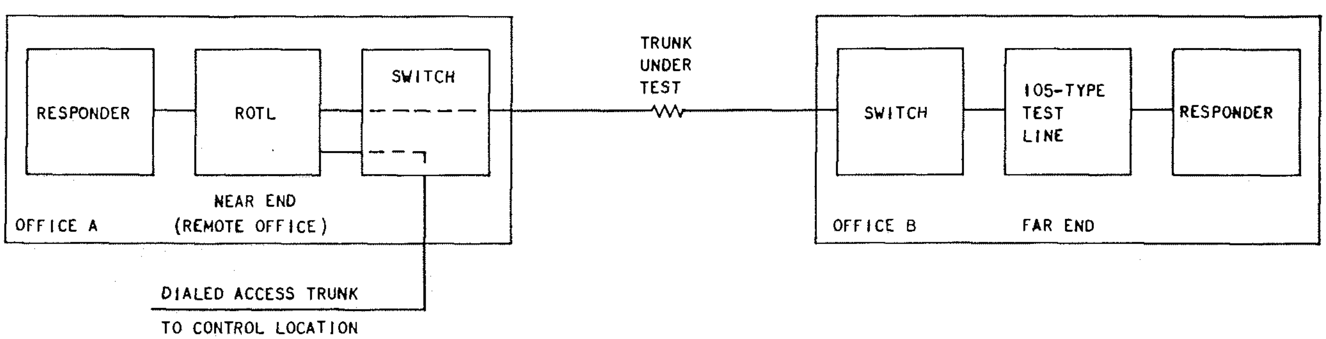


Fig. 20—Trunk Testing Between Two Responders

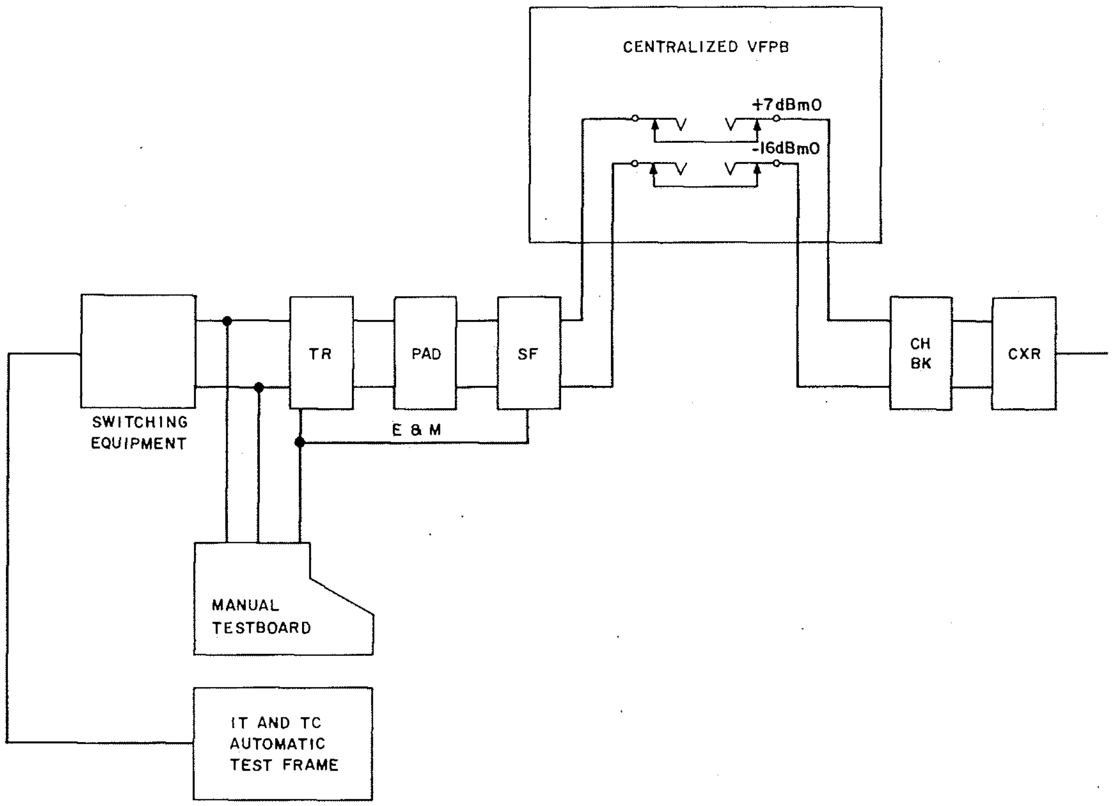


Fig. 21—Trunk Maintenance Arrangements Using Jack-Ended Testboard and Centralized VF Patch Bays

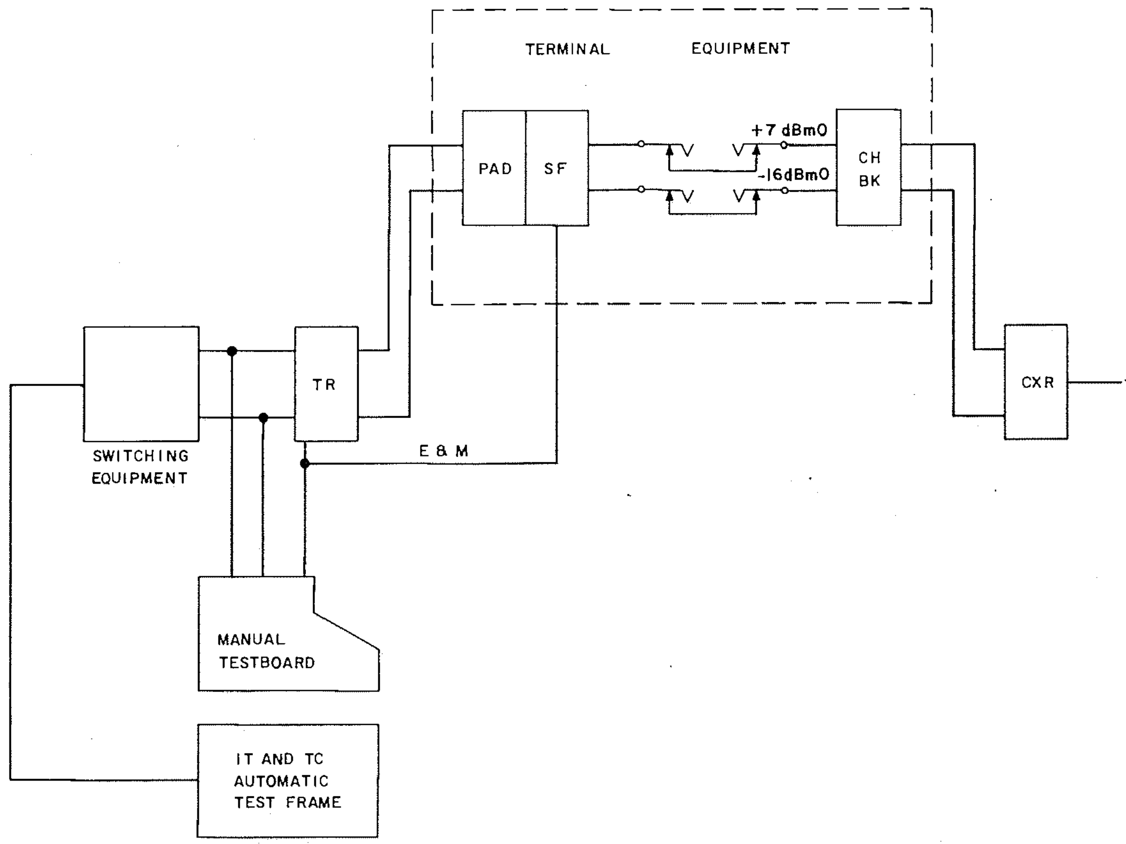


Fig. 22—Maintenance Arrangements Using Jack-Ended Testboard and Consolidated Circuit Terminal Equipment With VF Patch Jacks

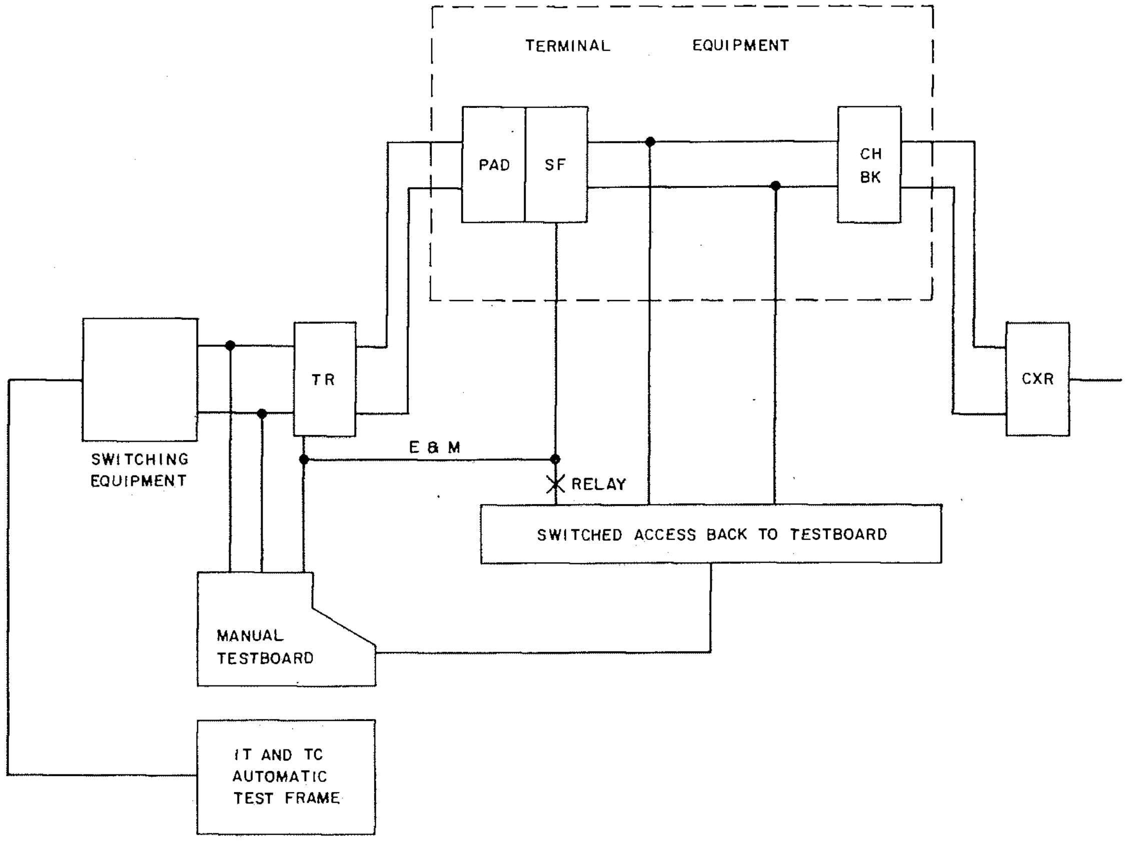


Fig. 23—Maintenance Arrangements Using Jack-Ended Testboard and Switched Access to the VF Patch Point

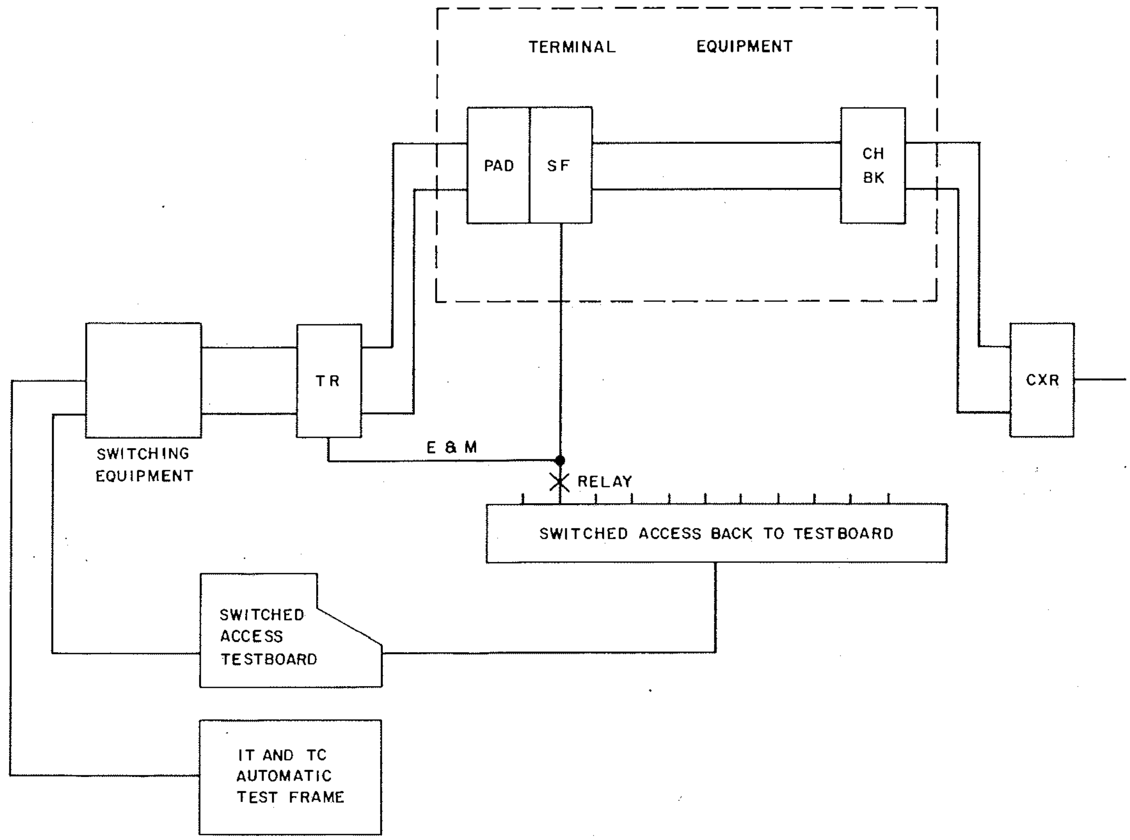


Fig. 24—Maintenance Arrangements Using Switched Access Testboard and Switched Maintenance Access

MAINTENANCE FACILITIES REQUIREMENTS BY CLASS OF OFFICE

(Subject to modification depending on type of trunk or circuit facility, type of switching system, and economic considerations.)

TEST AND MAINTENANCE FACILITY	CLASS OF OFFICE CLASS 3	 CLASS 4	 CLASS 5
Primary Testboard	x	x	
Secondary Testboard	x	x	
Patching Jack Bays	x	x	
VF Patch Bays	x	x	x
E&M Signaling Path Test Jacks:			
1. CX Line Jacks	x	x	
2. Equipment Units with Jacks	x	x	x
Pulse Repeating Test Set for CX	x	x	
Pulse Generating and Measuring Test Set for SF or N, O, ON, and Similar Carrier Systems	x	x	x
Switchboard Cord and Position Test Facilities	x	x	x
Centralized Trunk Test and Make-Busy Jacks for Maintenance Use Including Operating Room Trunk Make-Busy Facilities	x	x	x
Switching Equipment Maintenance Test Sets	x	x	x
Sender Test Facilities	x	x	x
Transmission Test Facilities	x	x	x
Carrier Test Facilities	x	x	x
Test Lines:			
1. Balance (100 Type)	x	x	x
2. Communications (101 Type)	x	x	x
3. Milliwatt (102 Type)	x	x	x
4. Signal-Supervisory (103 Type)	x	x	x
5. Transmission Measuring and Noise Checking (104 Type)	x	x	x
6. Automatic Transmission Measuring System (105 Type)	x	x	x
7. Data Transmission Test Line (107 Type)	x	x	x

Chart 1—Test and Maintenance Facilities by Class of Office

MAINTENANCE FACILITIES REQUIREMENTS BY CLASS OF OFFICE (Cont)

(Subject to modification depending on type of trunk or circuit facility, type of switching system, and economic considerations.)

TEST AND MAINTENANCE FACILITY	CLASS OF OFFICE CLASS 3	CLASS 4	CLASS 5
Test Lines (Cont)			
8. Echo Suppression Loop-Around Test Line (108 Type)	x	x	
9. 161 Trouble-Reporting Trunk	x	x	
10. 958 Switching System Maintenance Center Communication Trunk	x	x	
Test Lines for Toll-Connecting Trunks:			
1. "Synchronous" Test Line	x	x	x
2. "Nonsynchronous" Test Line			x
3. Loop-Around Transmission Test Line			x
4. Open-Circuit Test Termination	x	x	x
5. Short-Circuit Test Termination	x	x	x

Chart 1—Test and Maintenance Facilities by Class of Office (Cont)

NOTES ON DISTANCE DIALING

SECTION 9

WIDE AREA TELECOMMUNICATIONS SERVICE

CONTENTS PAGE

1. GENERAL

1.01 Wide Area Telecommunications Service (WATS) is a telephone service designed to meet the needs of customers who make or receive substantial volumes of long distance calls to or from many areas of the country. WATS is available by geographical areas called WATS Service Areas. Within the continental United States (excluding Alaska and Hawaii), a customer may subscribe to any of five interstate or nationwide WATS Service Areas. Statewide or intrastate service is also available in most states.

1.02 A subscriber to WATS is connected to the nationwide dialing network by a special WATS access line or lines. Each such line is arranged for either inward or outward service but not for both. These access lines may provide 240 hours of service per month or, for a lower monthly rate, 10 hours of service a month. Additional charges apply for use exceeding the basic allowance or when the number of monthly messages exceeds 14,400 or 600, respectively. Specific hour and message count allowances are controlled under national and local tariffs and subject to change. Since the operational requirements for Inward and Outward WATS are completely different, these services are described separately.

1.03 The cost for both Outward and Inward WATS is based on the WATS Service Area and hours of service subscribed to by the customer. Special numbering, routing, and screening arrangements are utilized for rate discrimination and call completion purposes. This imposes a requirement for centralized control of both code and station number assignments. Details regarding routing, screening, and code and number assignment are available through the WATS Coordinators in each Bell Company.

SERVICE AREAS—INTERSTATE

1.04 Service Areas or "bands" are arranged roughly in concentric circles around the home area. The exact Service Area for each band in each state is found in the appropriate tariff. The following general descriptive comments apply:

> Interstate or nationwide service starts with WATS Area One containing the states contiguous to your home state, but not including it, and sometimes one or two nearby states.
>
> Service Area Two includes Service Area One plus certain other states and so on through Service Areas Three, Four, and Five. Each successive Service Area includes the previous Service Area plus its own states up to Service Area Five.
>
> Service Area Five, the largest Service Area, includes the entire United States except Alaska, Hawaii, and your home state.

SERVICE AREAS—INTRASTATE

1.05 The serving arrangements for intrastate WATS vary according to the state and the company. Listed below are illustrations of some of the arrangements now used to serve intrastate WATS:

(1) Total State coverage

(2) Home NPA only in a multiple NPA State

(3) Home and adjacent NPAs in a multiple NPA State

(4) Coverage by "WATS STATE" divisions within a divided state.

1.06 WATS service is offered under two basic arrangements each of which can have up to a specific number of hours of calling per month within the "Service Area" subscribed to at a minimum monthly charge. Each hour or fraction of an hour above the specific number of hours is billed as an overtime charge. Each arrangement may also carry a specified monthly message count.

2. OUTWARD WATS

2.01 Outward WATS is provided over one or more dedicated access lines to the serving central office. Outward WATS can be served only in common control offices which have "class of service" features which can be used to limit calls to the Service Area subscribed to by the customer. As part of the screening in the originating office, the special Area code "800" associated with Inward WATS Service will be blocked to all Outward WATS subscriber access lines. This blocking will prevent double charging on calls from Outward to Inward WATS lines. Screening is also required to prohibit completion of calls from interstate lines to intrastate numbers.

2.02 Outward WATS lines may:

(1) Dial station-to-station calls direct to points within the selected "Service Area."

(2) Reach the WATS assistance operator who will establish calls within the "Service Area" that are not dialable or on which assistance is required to complete the call.

2.03 Outward WATS lines may be connected to telephone sets, jacks in a PBX switchboard, a telephone keyset or, in some instances, accessed by dialing a code at a dial PBX or Centrex system.

LINE NUMBERING

2.04 Outward WATS has a distinct line numbering plan for accounting purposes. The Outward WATS number consists of a 3-digit numerical code and a 4-digit number for a total of seven digits, ie, 0/1XY-XXXX.

(1) The first digit of the code (0/1) indicates whether the number is for full business day or measured time service. An initial digit 0 designates a full business day access line whereas the digit 1 is for a measured time access line.

(2) The second digit of the code (X) is reserved for assignment by the individual company. Usually a different digit is assigned to each state for identification purpose. A maximum of ten identities can be assigned.

(3) The third digit (Y) will designate the Service Area or band subscribed to by the WATS access customer as 1, 2, 3, 4, 5 for interstate calls. The remaining digits (0, 7, 8, 9) are available for assignment by the companies for intrastate WATS and the digit 6 is reserved for future interstate application.

(4) The remaining four digits (XXXX) represent the specific billing number for the line. This number is an arbitrary assignment. However, it should not be duplicated within a given band in a given NPA. Consequently, accurate records must be maintained by the WATS Coordinator to assure that no duplications occur. A maximum of 10,000 numbers (0000-9999) can be assigned to a band in each NPA.

SERVING CENTRAL OFFICE ADMINISTRATIVE CONSIDERATIONS

2.05 Outward WATS can only be served from those types of central offices where class of service distinctions are available. Class of service designations are necessary to define and control dialing to the Service Area subscribed to by the customer. Other considerations that need to be explored in Outward WATS serving offices are as follows:

(1) The effect of Outward WATS lines on the load-balance status of the serving central office. Most Outward WATS lines experience high CCS usage during their busy hour and careful attention must be given to the line assignments made for these lines.

(2) The Outward WATS serving central office may serve Outward WATS for a large surrounding area. In this event, the effects of the heavy calling created by Outward WATS lines need to be reflected in the provision of common control equipment. Since these lines are one-way out, heavy dial tone demands can be generated.

(3) Trunk access to the toll network must be continuously evaluated for those offices with Outward WATS service because of the high CCS load offered by this service.

(4) Some Outward WATS lines are used as outgoing lines from polling computers. These lines create a large number of short holding time calls in an extremely short period of time. New WATS line groups need to be screened to see if any of these type lines are to be served. If so, the effect on the serving office needs to be determined prior to installing the service.

(5) The details of all Outward WATS calls are placed on AMA tape or recording devices to collect hours of use and message count. Operator-assisted calls are recorded on an operator-prepared ticket. This data must be available for Billing, Engineering, Separations, and Division of Revenue purposes. Extreme caution must be exercised to assure that the AMA recording equipment is adequate in the Outward WATS serving office prior to assigning any additional lines to the particular office. When Outward WATS lines have high volume and short holding times, it is suggested that elapsed time and message count registers be provided in addition to AMA tape recording to assist in administration of the serving office.

3. INWARD WATS

3.01 Inward WATS is a form of long distance service which allows a subscriber to receive telephone calls originated within specified Service Areas without a charge to the originating party. This service is provided on two or more "terminating only" access lines arranged in a hunting series. These lines receive calls as follows:

(1) Dial station-to-station calls from points within the selected "Service Area" or "band."

(2) Calls placed through the long distance operator who will establish connections on calls within the "Service Area" that cannot be dialed direct from the originating station or on which assistance is needed.

3.02 The 2-line minimum is regarded as one line for billing purposes but consists of two physical access lines arranged in rotary series. Usage (hours and calls) for the second physical line will be included with usage for the first physical line for the purpose of determining excess usage.

3.03 Directory Assistance and Routing Information for both interstate and intrastate Inward WATS are provided on a centralized basis. Calling customers may obtain Directory Assistance by dialing 800-555-1212. Telephone Operators can reach the centralized bureau by keying 800-131 for Directory Assistance and 800-141 for Routing Information. These operator routes are not available for customer use.

NUMBERING PLAN

3.04 Inward WATS is handled by means of special code assignment, consisting of a Special Area Code (SAC) "800" followed by one or more specific NXX* codes for each telephone NPA. Of the 792 codes available, all "NX2" codes are reserved for intrastate leaving the others available for interstate usage. The code(s) assigned to each NPA are used for all interstate Inward WATS bands terminated in that NPA.

* Where: N is any digit 2 through 9
X is any digit 0 through 9

3.05 An Inward WATS customer's telephone number is always ten digits and has the following format: 800 + NXX + XXXX. The information contained in this format is described below and also shown graphically in Fig. 1. Inward WATS number series should be blocked to prevent call completion from normal local and toll telephone service.

800 Special Area Code (SAC).

NXX Interstate—This is a central office type code which represents the terminating NPA for an Inward WATS call and the designated Inward WATS Principal City switching system in that NPA arranged to handle this traffic. All interstate Inward WATS bands in an NPA are served by the same NXX code(s).

NX2 Intrastate—This central office type code identifies the Inward WATS number as intrastate service. A total of 80 NX2 codes are available for assignment in each state.

These codes can be used to:

(1) Represent the total state

(2) Represent an NPA in a multiple NPA State

(3) Represent a particular city within a state

(4) Represent a particular terminating serving central office within the state.

XXXX These digits represent the Inward WATS customer station digits. The first three digits, known as the "tens block," specify:

(1) An Inward WATS number series

(2) The "Service Area" or "band" subscribed to

(3) The local serving central office for this Inward WATS line

(4) The outpulsing requirements for this serving central office.

The last digit of the XXXX is used to designate the particular Inward WATS customer and start of hunting series.

ROUTING—INTERSTATE

3.06 When a customer dials an Inward WATS number (800 + NXX + XXXX), the call will preferably be routed to an office within the home "WATS State" which is capable of 6-digit (6D) translation. The Originating Screening Office (OSO) will, by 6D translation of the SAC and the NXX code, route the call to or toward the telephone NPA where the Inward WATS subscriber is located. As the call is forwarded toward the terminating NPA, it must retain its identity of "Inward WATS" and must also indicate the WATS band relationship of the originating WATS State to the terminating NPA where the Inward WATS customer is located.

3.07 An Inward WATS call must be directed to the designated Inward WATS Principal City office for the NPA in which the customer is located. This Principal City office, the Terminating Inward WATS Screening Office (TSO) for the NPA, must also be capable of 6D translation. The TSO must determine:

(1) If the called number is in the Inward WATS number series assignments

(2) Whether or not the call is from an allowable rate band location

(3) The routing to the customer's serving office if the call is from an inband location.

This general description of Inward WATS call routing is illustrated on Fig. 2. The following sections describe the basic functions at the various switching systems involved in the progress of the call.

Originating Screening Office (OSO)

3.08 Originating Screening Office (OSO) must be a common control office with 6-digit (6D) translation capabilities. The OSO can be a Crossbar Tandem, No. 4 Crossbar, No. 5 Crossbar, No. 1 ESS office, and all other suitable types of equipment.

3.09 There is at least one OSO serving each NPA for originating 800 + calls. The OSO will, by 6D translation of the SAC and NXX, route the call to or toward the designated Inward WATS Principal City office of the terminating NPA where the Inward WATS subscriber is located.

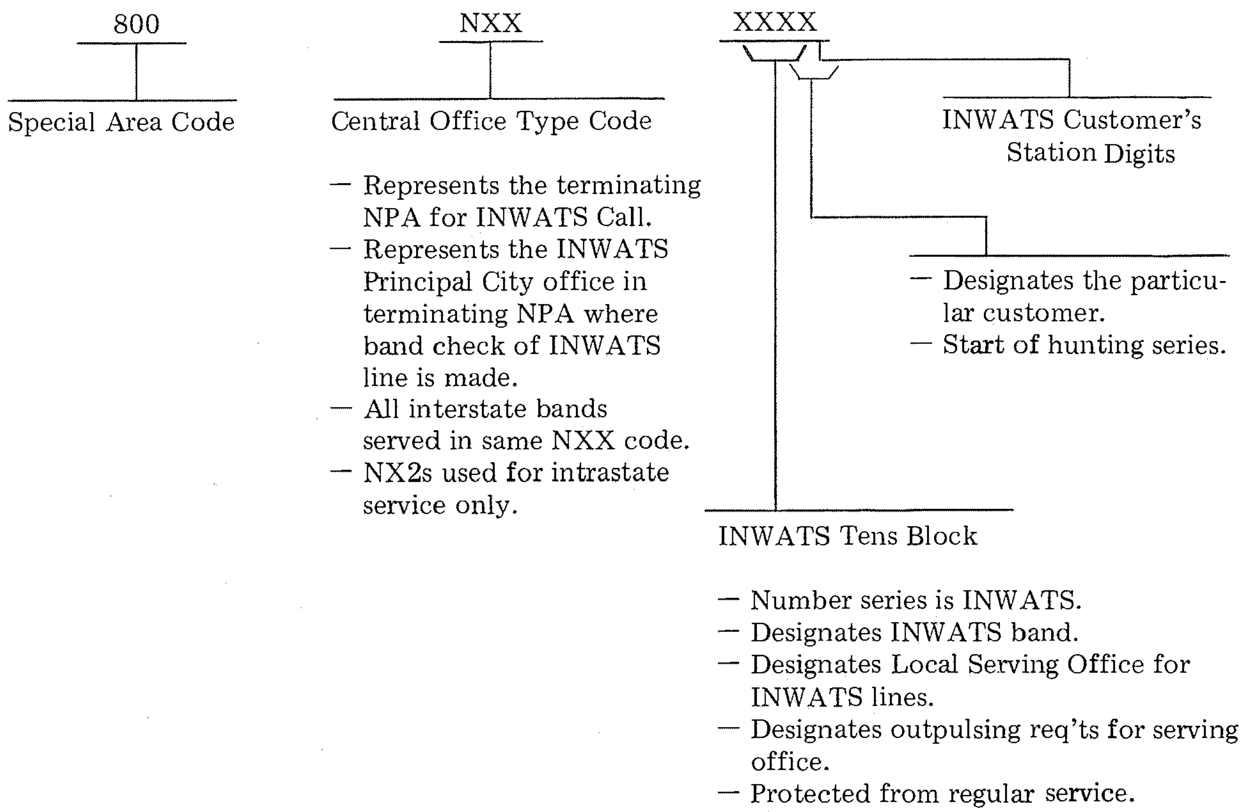


Fig. 1—Inward WATS Address Dialed

(1) Included in the information sent to or toward the terminating NPA is:

(a) An indication that the call is "Inward WATS."

(b) The rate band indication of the originating WATS State with respect to the terminating NPA.

(2) This is how a direct routed call is handled.

(a) The OSO will 6D translate the 800 + NXX to select the direct trunk group to the distant Inward WATS Principal City office.

(b) The 800 + NXX is code converted to the 1YZ format where the 1Y represents the 800 + NXX code and identifies the call as Inward WATS; the Z is the rate band indication described above.

(c) A 7-digit number, 1YZ + XXXX (the converted NXX code, the rate band indication, and the four digits of the Inward WATS subscriber's number), is now sent forward.

(3) The following details describe the handling of a tandem routed call:

(a) If the tandem office is in the same WATS State as the original OSO and handles other originating Inward WATS traffic, the Inward WATS call may be forwarded as received without code conversion (800 + NXX + XXXX).

(b) If the tandem office is in a different WATS State, the 800 SAC will be code converted to 08Z and the 08Z + NXX + XXXX sent forward. The "08" identifies the call as Inward WATS with the Z digit representing the rate band indication of the originating WATS State.

3.10 There are times when an OSO serves more than a single WATS State. In this situation,

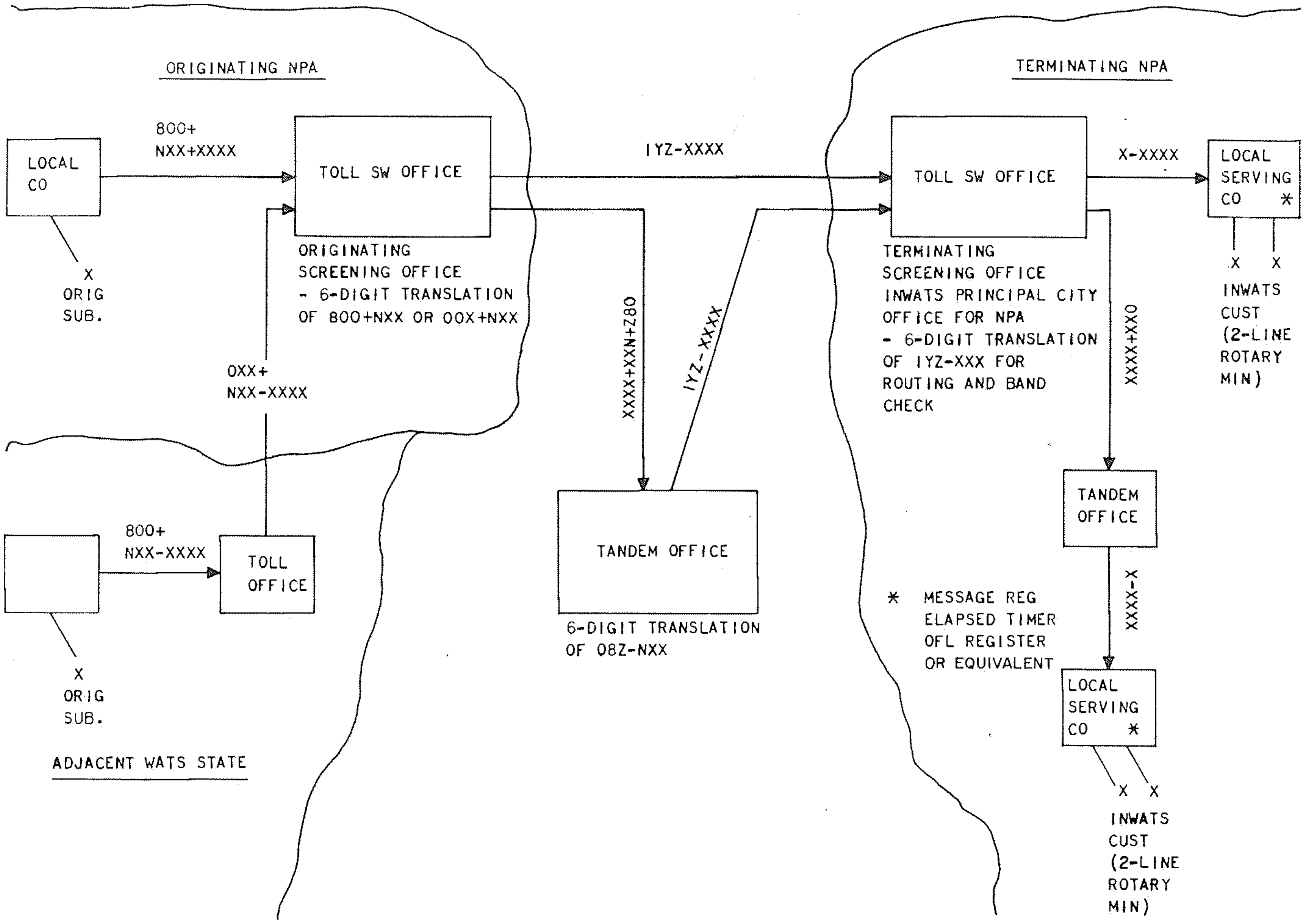


Fig. 2—Inward WATS Routing—Interstate

any adjacent WATS State must convert the originating 800 + calls to an 00X + NXX + XXXX format before it is forwarded to the OSO. The "X" digit in the 00X code will identify the originating WATS State and permit the OSO to prefix the proper rate band indications on all Inward WATS traffic from that state.

Terminating Screening Office (TSO)

3.11 The Terminating Screening Office (TSO) for Inward WATS calls is the designated Inward WATS Principal City office for that NPA. This office must have the ability to do 6-digit translation and can serve as the TSO for a maximum of five Inward WATS number series of 10,000 numbers each. It must be able to determine:

(1) Whether the incoming call is Inward WATS

(2) Whether the Inward WATS call has an allowable rate band indicator

(3) The routing of the call to the local serving central office if it is inband.

3.12 The TSO receives a 7-digit number (1YZ + XXXX) on all terminating interstate Inward WATS calls. Six-digit translation is made on the 1YZ + XXXX digits. The "1Y" designates the particular 10,000 number series to be checked. The "XXX", the first three digits of the called subscriber's number (the "tens block"), will be assigned in the translation if the "tens block" is a working Inward WATS number series. The "tens block" also defines the rate band assigned to the called subscriber which is matched against the "Z" digit for allowable completion of the call. If the call is inband and completion is allowed, the route and outpulsing requirements are obtained from the "tens block" assignment. These details are illustrated on Fig. 3. Outpulsing then occurs with the particular subscriber's line or hunt series selected by the last digit of the subscriber's number at the local office.

3.13 Routing to the serving central office may be direct or require tandem routing. These requirements are:

(1) Direct Routing From TSO—The TSO has a direct trunk group to the serving central office. The 1YZ is code converted to whatever digit the local office requires to identify the terminating NXX. This digit and the 4-digit line number are then forwarded to the local serving central office.

(2) Tandem Routing From TSO—When the TSO does not have a direct trunk group to the serving central office, tandem routing is used. The 1YZ is code converted to an 0XX type code. The 0XX and the 4-digit line number are sent to the tandem office. The tandem office will code convert the 0XX to whatever digit the local office requires to identify NXX and sends it and the 4-digit line number to the local serving central office.

Tandem Screening Offices

3.14 As indicated in the section covering the originating screening office, some Inward WATS calls are routed via a tandem office in another WATS State. These calls are received at the tandem office as 08Z + NXX + XXXX where the "Z" is the rate band indication of the originating WATS State. The tandem office 6D translates the 08Z + NXX and selects a route to the designated Inward WATS Principal City office in the terminating NPA. The call is then handled as if the tandem office were an OSO with this exception: the rate band indication included in the 1YZ-XXXX forwarded must reflect the same rate band indication it received, the "Z" digit of the 08Z code of the incoming call, not the rate band indication of the tandem office's own home WATS State.

ROUTING—INTRASTATE

3.15 Intrastate Inward WATS routing differs from Interstate routing. When an intrastate call arrives at the OSO, it is in the same format as an interstate Inward WATS call. Six-digit translation is also required to route the call and the NX2 code following the 800 SAC identifies the call as intrastate.

3.16 There are two ways of assigning NX2 codes for intrastate Inward WATS. In one case, each serving central office is provided with its

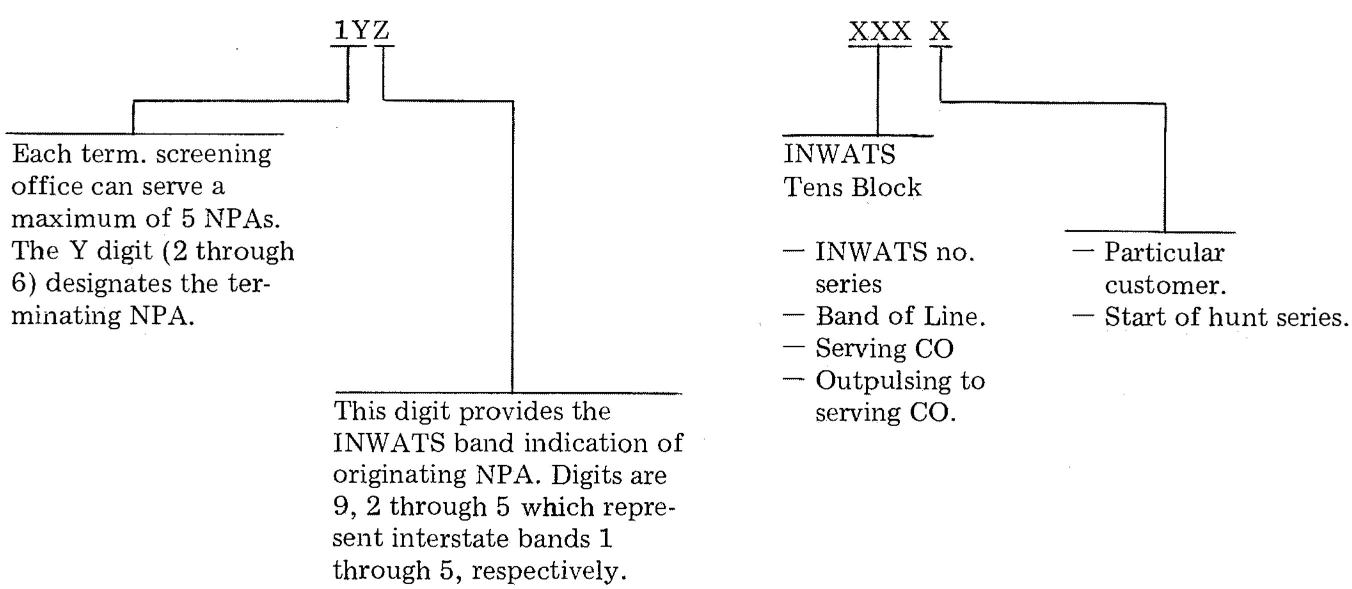


Fig. 3—Inward WATS Address—Terminating Screening Office

own NX2 code. In the other instance, an NX2 is assigned for several central offices. The routing that is necessary depends upon this assignment. Some areas use a combination of the two assignment methods.

3.17 ***Routing With NX2 per Local Serving Central Offices:***

(1) The call arrives at the OSO with the 10-digit number as dialed by originating party. The 6-digit translation indicates an intrastate Inward WATS call.

(2) The OSO performs 6-digit translation and code converts the 800-NX2 to an identifiable digit which the local serving central office receives. The local central office uses the central office code digit and the hundreds block to determine whether to allow or deny completion of the call. (See Fig. 4.)

(3) In the event that tandem routing is required, the OSO code converts the 800-NX2 to an 0XX code and forwards it to the tandem office. The tandem office converts the 0XX to the identifying digit for the serving central office and outpulses this digit and the 4-digit line number. The check is made as described in the previous paragraph. (See Fig. 4.)

3.18 ***Routing With NX2 for Multiple Local Serving Central Offices:***

(1) The call arrives at the OSO with the 10-digit number as dialed by the originating party. The 6-digit translation indicates an intrastate Inward WATS call.

(2) The 6-digit translation of the 800-NX2 does not provide enough information to properly route the call since this NX2 is shared by several local serving central offices. Since the switching systems that are used as OSOs cannot translate more than six digits, the digits needed to route the call cannot be translated. To overcome this obstacle, a group of "loop-back" or "loop-around" trunks is used. The 800-NX2 is code converted to 1XX code and this code and the station digits are outpulsed to reenter the OSO. The OSO then 6-digit translates the 1XX and the first three digits of the 4-digit line number. When this translation is made, the OSO performs the function of the TSO and makes the validity check. The serving central office is also identified by the translation of the 1XX and three digits. The route to the local serving central office is selected and the 1XX is code converted to the Central Office code digit and is outpulsed along with the line number. (See Fig. 5.)

(3) In the event that tandem routing is required, the call is handled the same as direct routing until the call reenters the OSO. The 1XX is code converted to a 0XX and is forwarded to the tandem office along with the 4-digit line number. At the tandem office, the 0XX is code converted to the Central Office code digit and forwarded to the local central office along with the 4-digit number. (See Fig. 5.)

Inward WATS Routing—Problem Areas

3.19 Inward WATS routing is complicated by the requirements for "code conversion" and the necessity to reach the Inward WATS Principal City office (TSO) of the terminating NPA. These conditions can create problems in route selection at the OSO, Tandem SO, and the TSO switching locations.

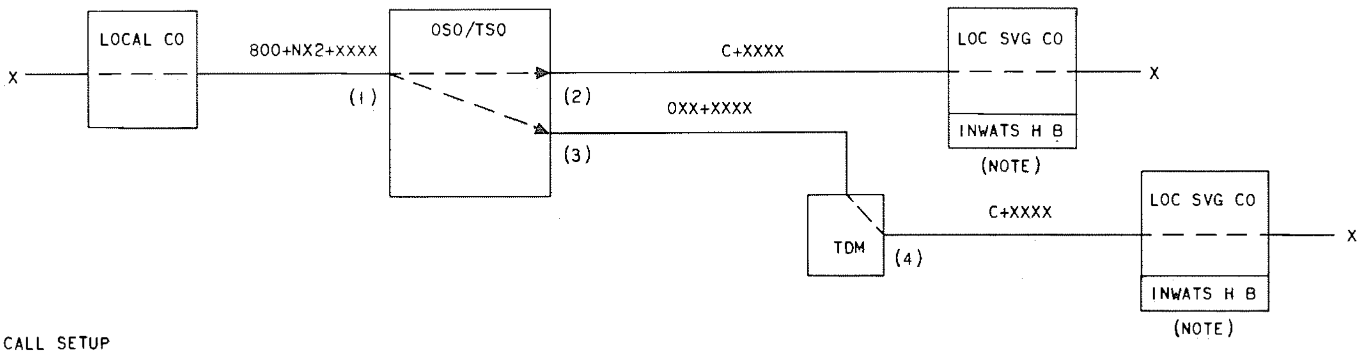
3.20 "Code conversion" limits the trunk group selection capabilities of some offices because their "route advance" capability is held to four subgroups having a maximum of 40 trunks each. The selection of the most efficient route for Inward WATS traffic becomes complex when the direct, first and second alternates, and the final routes applicable to normal traffic consist of more than 40 trunks each. Similar problems could exist in the toll-completing paths from the TSO to the local serving central office and a careful evaluation of the "trunk group availability" routing is also necessary.

3.21 Routing patterns for intrastate Inward WATS traffic must also be included in these evaluations, especially when this traffic is melded into the patterns applicable to the interstate Inward WATS routing requirements.

SERVING CENTRAL OFFICE REQUIREMENTS

3.22 Inward WATS lines can be served from a variety of central offices. It is desirable to serve the subscriber from the same office which provides the local service. Some companies have, however, chosen to designate selective offices in

800 - NX2 PER LOCAL SERVING CENTRAL OFFICE
- INWATS VALIDITY CHECK MADE AT SERVING CENTRAL



CALL SETUP

(1) SIX-DIGIT TRANSLATE ON 800-NX2
(2) SELECT DIRECT ROUTE TO SERVING CO AND CODE CONVERT TO INWATS "CENTRAL OFFICE CODE." OUTPULSE TO CO- INWATS "CO CODE" AND "HUNDREDS BLOCK" MATCH MADE AT LOCAL CO TO ALLOW OR DENY COMPLETION.
(3) TANDEM ROUTE SELECTED. "CODES" CONVERT TO 0XX TYPE CODE REPRESENTING SERVING CENTRAL OFFICE AND OUTPULSE.
(4) TANDEM OFFICE CODE CONVERTS 0XX CODE TO INWATS "CO CODE" AND OUTPULSES TO CENTRAL OFFICE. INWATS "CO CODE" AND "HUNDREDS BLOCK" MATCH MADE AT LOCAL CO TO ALLOW OR DENY COMPLETION.

NOTE:
A SPECIFIC "HUNDREDS BLOCK" NUMBER SERIES IS MARKED INWATS ONLY AND MUST MATCH INWATS "CO CODE" FOR VALIDITY CHECK.

Fig. 4—Inward WATS Routing—Intrastate—NX2 per Local Serving Central Office

the terminating area as Inward WATS serving central offices for their convenience in providing the service.

3.23 The basic requirements for Inward WATS service in the serving central office are:

(1) Inward WATS lines are "terminating" only and must be arranged for hunting.

(2) All numbers must be reserved in blocks of ten since this "tens block" provides an indication of the Service Area or band subscribed at the TSO.

(3) The "tens blocks" should, if possible, be so arranged to deny completion of local exchange or long distance calls to these Inward WATS lines.

(4) Each interstate (and eventually intrastate) Inward WATS line requires the determination of monthly hours and message count for billing and administrative reasons. The following auxiliary equipment is required:

(a) An auxiliary circuit arranged to detect "on- and off-hook" supervision at the line circuit.

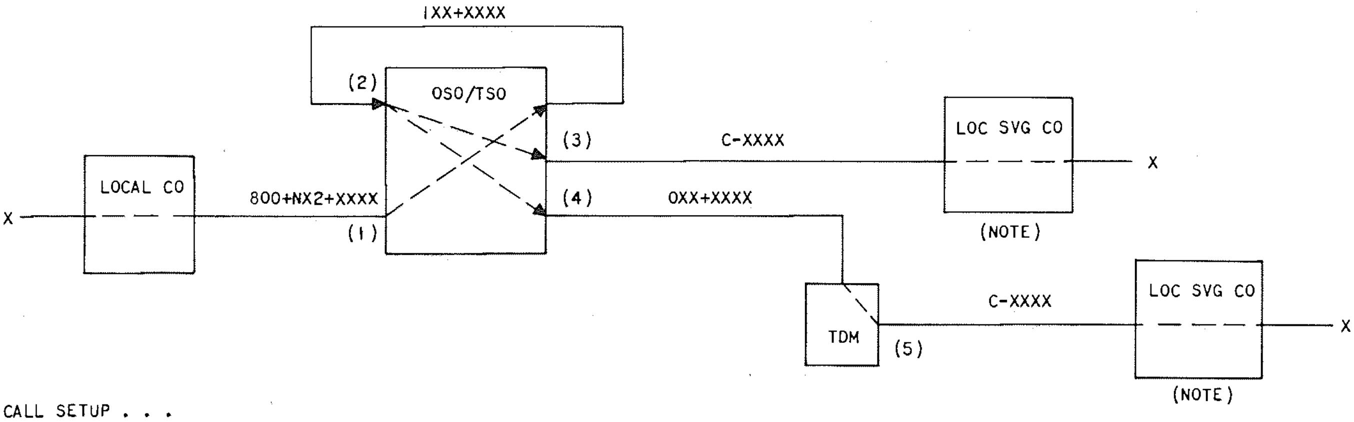
(b) An elapsed time register to score the "off-hook" usage on the line.

(c) A message count register to score on completed messages to the Inward WATS line.

(5) Each Inward WATS "band" group requires an overflow register which scores when calls are offered to the line group and all lines are busy.

(6) AMA recording of call details for Inward WATS calls is an alternate to the provision of the electromechanical registers and timers listed above.

800 - NX2 FOR MULTIPLE LOCAL SERVING CENTRAL OFFICES. . .
INWATS VALIDITY CHECK MADE AT TERMINATING SCREENING OFFICE



CALL SETUP . . .

(1) SIX-DIGIT TRANSLATE ON 800-NX2.
CONVERT TO 1XX AND OUTPULSE WITH STATION DIGITS.

(2) SIX-DIGIT TRANSLATE ON 1XX+XXX.
"TENS BLOCK" CHECK IS MADE FOR INWATS SERVICE AND SERVING CENTRAL OFFICE.

(3) SELECT ROUTE TO SERVING CENTRAL OFFICE, CODE CONVERT 1XX TO INWATS "CO CODE," AND OUTPULSE TO CO.

(4) SELECT ROUTE TO TANDEM OFFICE. CODE CONVERT 1XX TO 0XX TYPE CODE REPRESENTING THE SERVING CO, OUTPULSE TO TANDEM OFFICE.

(5) AT TANDEM OFFICE, SELECTS SERVING CO ROUTE, CODE CONVERT 0XX TO INWATS "CO CODE," AND OUTPULSES TO CO.

NOTE:
FOUR DIGITS MAY BE OUTPULSED TO SOME SERVING CENTRAL OFFICES IF "HUNDREDS BLOCK" MATCH IS NOT POSSIBLE. HOWEVER, INWATS NUMBERS SHOULD NOT BE ACCESSIBLE BY NORMAL TELEPHONE SERVICE

Fig. 5—Inward WATS Routing—Intrastate—NX2 for Multiple Local Serving Central Office

(7) The traffic characteristics of this service must also be considered in the serving central office requirements. These characteristics are:

(a) Some Inward WATS lines have an extremely long holding time per call. The effect of the long holding time on load balance and on the terminating central office needs to be determined.

(b) Other Inward WATS lines have a high volume of calls with extremely short holding times. In these cases, the effects of the high-call volume on common control equipment and on the incoming trunk groups must be evaluated.

(c) Some businesses that subscribe to Inward WATS service have an extremely peaked busy season. In these cases, additional lines are installed for the busy season each year and disconnected after the season.

Direct Connection to a Toll Switching System

3.24 There are instances where it will be advantageous to provide direct connection to the customer location from a toll switching system rather than double switch this traffic through a local serving office. Considerable savings in toll-completing trunks and central office equipment may be realized with direct termination to the customer's location in the following cases:

(1) The busy hour CCS load is excessively high and/or

(2) A high volume of busy hour very short holding time messages are being handled.

3.25 Direct completion from the toll machine to the customer's location may be considered when:

(1) The busy hour CCS load is approximately 1400 to 1600 CCS or more (local office frame load) and/or

(2) Approximately 2000 to 2500 busy hour attempts occur with a very short holding time.

3.26 When direct completion is used, each Inward WATS band subscribed to by the customer must be treated as a separate trunk group. When all circuits in a band are busy, the Inward WATS calls to that group are "routed advanced" to a group of Circuit Busy Announcement (CBA) trunks. These announcement trunks can be used in common for all direct completion Inward WATS band trunk groups in the office. These trunks must be arranged to return station busy (60 IPM) tone instead of the normal 120 IPM. This can be done by recording the 60-IPM tone on one channel of the announcement system and patching the special CBA trunks to that channel. A separate announcement system may be required for high-volume services.

3.27 Standard circuits may be ordered to permit completion from a 4A Crossbar type switching system to a 3A Automatic Call Distributor at a customer's location. As an interim arrangement, some of the existing toll-completing relay trunk circuits may be used for this purpose. Audible ring must be provided at the ACD in the interim arrangement. Testing and trouble reporting operations are provided on a local basis. The elapsed time, message count, and overflow registers described in 3.23, "Serving Central Office Requirements," are also necessary with this method of operation.

Intercept for Inward WATS

3.28 If a subscriber dials an Inward WATS number and it is out of band or nonworking, the call will be routed to normal vacant code announcement in most cases. If, however, the call is a legitimate combination for the first nine digits and an incorrect tenth digit is dialed, it is possible to reach a vacant, disconnected, or changed number within the Inward WATS tens block. With the assignment of an Inward WATS subscriber to a tens block of numbers, any numbers remaining within that tens block become unusable except for other identical Service Area Inward WATS lines.

3.29 Since these numbers are in actual local central offices, in some cases, it may be possible for them to be reached by a local or toll calling party using normal telephone codes. Intercept operators must be furnished information with which to respond for these cases. Whenever possible, Inward WATS "ten blocks" should be denied to local and normal long distance traffic. For those offices serving directly connected Inward WATS lines, a special group of trunks to the intercept equipment is required.