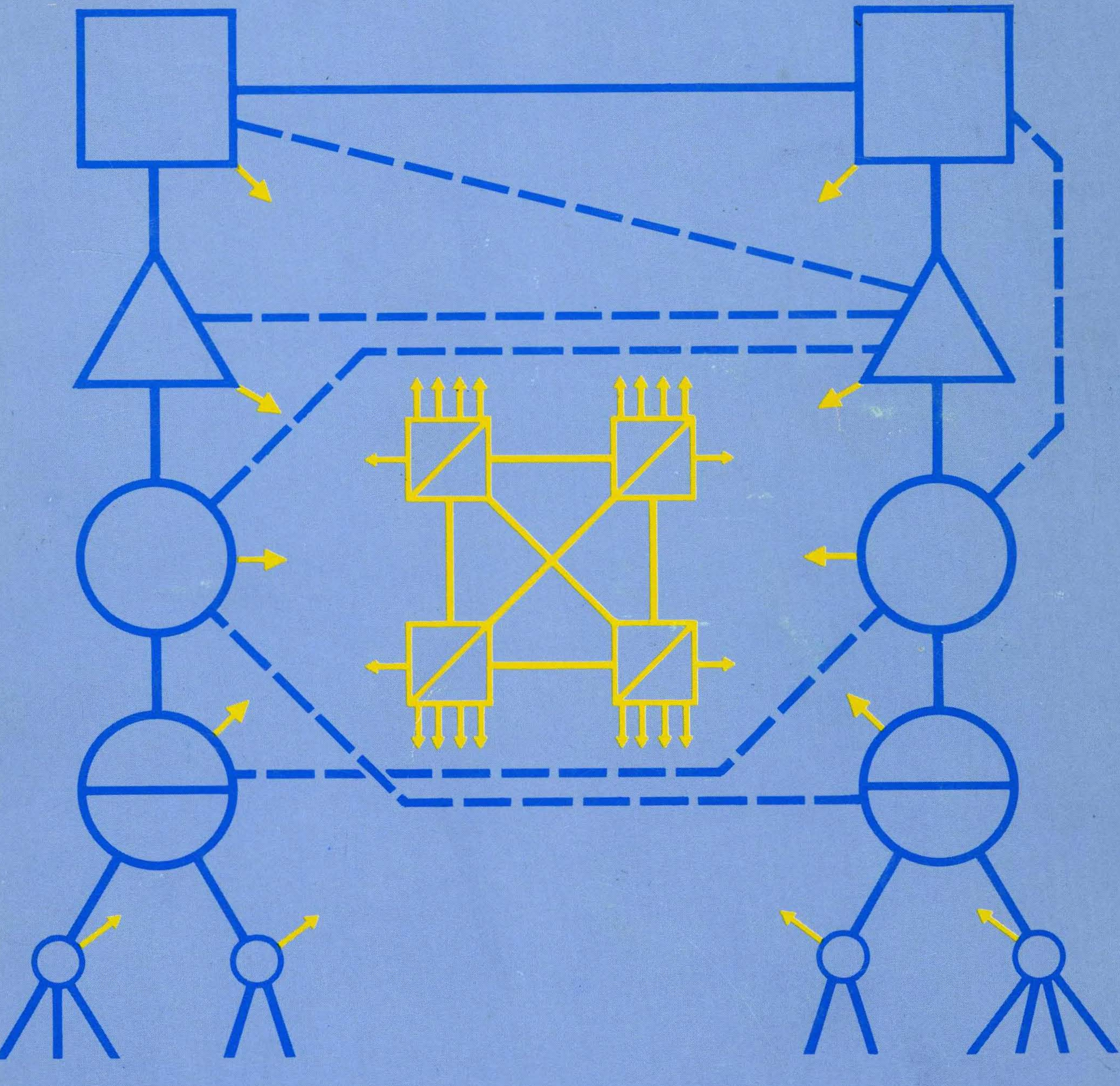
Notes on THE NETWORK



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AT&T

Notes on
THE NETWORK

AMERICAN TELEPHONE AND TELEGRAPH COMPANY
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NOTES ON THE NETWORK

FOREWORD

Notes on the Network supersedes the publication ***Notes on Distance Dialing.*** It is issued to reflect changes in technology and to amplify and clarify material published in the previous publications. The primary purpose of ***Notes on the Network*** is to outline the technical requirements and fundamental operating principles of the Bell and Independent Network.

The Network is a system of integrated parts consisting of transmission and switching facilities, a control and signaling process, and associated operational support systems. It is engineered, installed, owned, and managed by a partnership of American Telephone and Telegraph Company (AT&T) Long Lines, Bell System Operating Telephone Companies, and Independent Operating Telephone Companies. Its boundary is the location where the Network tariffed channel terminates on the customer's premises or where carriers other than those comprising the Bell-Independent partnership are provided local access. Its principal function is to provide, on demand, a communication channel connecting any two communications terminal devices for the exchange of information in a variety of forms.

Notes on the Network is confined to matters bearing directly on services and communications paths through the Network to its boundary as defined above. In addition to technical data required by engineering personnel, descriptions 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 personnel. For those interested in the overall plan rather than technical details, Section 1 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 facilities and switching systems into the 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 concerns in the Comptrollers, Marketing, Public Relations, and Network Services areas that relate to the Network but are beyond the scope of ***Notes on the Network.*** Nevertheless, ***Notes*** does furnish much of the information needed by the telecommunications industry for the successful coordination of efforts between operating companies in maintaining and expanding the Network.

It should be emphasized that an orderly program should exist to coordinate the introduction of new technological advances into the Network. While ***Notes on the Network*** describes the Network as visualized today, details will necessarily change as new developments and technology are introduced. Decisions in the technical areas should be based on the results of fundamental planning studies with the ultimate plan selected on the basis that it is of most value to the entire set of users of the Network.

A document of such general nature as ***Notes on the Network*** cannot cover all the detailed technical requirements of the Network. To care for questions concerning technical matters not discussed in ***Notes on the Network,*** continued contact at the local or state level between the Independent and Bell segments of the telephone industry is encouraged.

With customer needs and serving arrangements becoming more complex, the planning effort for the Network will continue to involve all Independent and Bell Company partners. In this connection, information relative to ***Notes on the Network*** reflects the combined efforts of the United States Independent Telephone Association (USITA) Engineering Subcommittee on Network Planning and AT&T. The importance of continuous joint planning by Independent and Bell Companies cannot be overemphasized since the plans of all are interdependent and influence the determination of the most economical industry solution.

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SECTION 1
GENERAL INFORMATION

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1. GENERAL

1.01 The Network is an integrated system of transmission and switching facilities, control and signaling processes, and associated operational support systems. It is designed to provide the capability for interconnecting virtually any household and/or office in the country with any other household or office on a direct connection basis.

1.02 These interconnections are established over the Network by an originating customer or operator dialing a unique address code for a specific terminating line without any assistance from intermediate operators. Centralized Automatic Message Accounting (CAMA), Traffic Service Position (TSP), or Traffic Service Position System (TSPS) operators who may enter on the connection for momentary assistance are not considered intermediate operators. The term, "network dialing," is used to describe calls dialed by customers to points outside their local or extended service area. When calls are dialed by an operator, the term, "operator network dialing," is sometimes used. Network dialing methods provide for fast, accurate, and dependable communications services and at the same time result in overall operating economies.

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

1.04 Generally, ***Notes on the Network*** describes the requirements that apply when network methodology has been fully realized and does 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.

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

1.06 The Network is in the early stages of an evolution toward an Integrated Services Digital Network (ISDN) which will provide end-to-end digital connectivity for a variety of services over the Network. Although the time frames for implementation of an ISDN and the services to be provided are not known at this time, it is clear that through extensive deployment of T Carrier, fiberguide, digital radio, and digital subscriber carrier systems along with time division No. 4 Electronic Switching System (ESS) switches, the Bell-Independent partnership is building the foundation of an ISDN for the future. In addition, the partnership has started deployment of time division digital local switches and the first major long-haul digital transmission system (an optical fiber system between Washington and Boston) has been announced. Future issues of ***Notes on the Network*** will address ISDN in depth as the information and deployment strategy concerning ISDN become available.

2. DESCRIPTION OF SECTIONS

NUMBERING PLAN AND DIALING PROCEDURES (SECTION 2)

2.01 A primary concern of any network dialing plan is the creation of a numbering or address system that uniquely identifies each station. A viable numbering plan should reflect uniformity, be convenient to use, and be compatible with existing local and extended area dialing arrangements.

2.02 The numbering system developed over the years for the Network utilizes the principle of destination code routing. Destination code routing is a combination of digits that provides a complete address to reach a specific terminal in the Network. Telephone numbers for the North American Network Numbering Plan consist of two basic parts:

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

(b) A 7-digit telephone number consisting of a 3-digit central office code and a 4-digit station number.

2.03 As the demand for telephone service increases and more switching systems are added, care must be taken in assigning NPA and central office codes for optimum use of the remaining unassigned code combinations. Parts 4 and 5 discuss relief plans for these codes. Economical utilization of these codes can be accomplished by careful planning and coordination.

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

THE SWITCHING PLAN (SECTION 3)

2.05 In order that traffic may be routed to its destination in an orderly and economical manner, a switching plan must be defined. This need is met by switching and trunking arrangements that adhere to the rules of a hierarchical network.

2.06 The switching plan takes full advantage of the overall economies offered by alternate routing within the limits of an orderly discipline. With automatic alternate routing, 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. Section 3 describes the switching plan in detail.

EQUIPMENT AND SYSTEM REQUIREMENTS (SECTION 4)

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

2.08 Section 4 includes those specific central office equipment arrangements which interconnect an office with the Network and which provide an interfacing between various operator systems such as the TSPS, Directory Assistance and Intercept, and the Network. The type of equipment employed is not important from the standpoint of the Network as long as the minimum requirements outlined in this section, Section 5 (Signaling), and Section 7 (Transmission Considerations) are met. For this reason, Section 4 covers a number of fundamental considerations regarding miscellaneous and somewhat unrelated items.

SIGNALING (SECTION 5)

2.09 The Network consists of many diverse types of equipment. To ensure that these diverse units function as an integrated entity, detailed information on the interacting signaling and control processes is required. With automatic switching, a complex system of signals is needed to pass information over the Network. These signals include address information for station or terminal identification, information for performing various network control and alerting functions, 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 address and information signals required for network dialing. Considerable technical information is included to illustrate the nature of the signals themselves as well as typical equipment arrangements required 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 illustrations and schematic diagrams showing 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 for which the voice and signaling portions of a call are separated. Essentially, CCIS provides 2-way signaling between switching systems independent of the transmission path of the message circuits.

2.12 Section 6 details the format and information content of CCIS. It also gives details on the advantages, potential, operation, administration, and maintenance of the CCIS system.

TRANSMISSION CONSIDERATIONS (SECTION 7)

2.13 The switching plan contemplates that most calls are to be completed on either direct circuits or over two or three intertoll trunks switched together in tandem. In some instances, a small portion of the calls may encounter as many as seven intertoll trunks within the United States or Canada. To ensure customer satisfaction for all calls and to minimize noticeable differences from one call to another, careful transmission design, as well as concentrated effort in maintaining transmission values close to design objectives, is required.

2.14 Design parameters and objectives for loop and trunk plant are covered in some detail in Section 7. The section is organized by transmission parameters. Within each part, 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 The objective of an effective overall maintenance plan is to provide a high quality of service at a reasonable cost. 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 extensive impact on service. With the expansion and increasing sophistication of the Network, trouble conditions in one part of the Network can have an adverse effect upon other parts. 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 troubles so that most trunk and equipment troubles may be cleared before they can cause extensive service reactions.

Section 8 describes automatic testing equipment, test lines, and various other testing facilities suited to the needs of the Network together with suggestions for their application.

WIDE AREA TELECOMMUNICATIONS SERVICES (SECTION 9)

2.17 Outward Wide Area Telecommunications Service (Outward WATS) and 800 Service (Inward WATS) are telephone services designed to meet the needs of customers who make or receive substantial volumes of long distance calls. Both Outward WATS and 800 Service are discussed separately since their operations are different.

2.18 Section 9 describes in some detail the line numbering, administrative considerations, and routing considerations for both interstate and intrastate Outward WATS and 800 Service.

INTERNATIONAL DIALING (SECTION 10)

2.19 International Direct Distance Dialing (IDDD) was first introduced in March 1970. At present, IDDD from the United States offers access to 74 countries. This section discusses the worldwide numbering plan which provides each telephone subscriber with a unique telephone number consisting of a country code followed by the national number. It also discusses the routing of traffic between the domestic telephone network and points beyond the North American numbering zone.

2.20 Section 10 describes the International Switching Centers, the International Operating Centers, and the International Originating Toll Centers and how they interface between the domestic network and international dialing.

NETWORK MANAGEMENT (SECTION 11)

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

2.22 Section 11 gives a conceptual description of network management responsibilities and organization. It also describes the functions and responsibilities of the Engineering and Administration Data Acquisition System/Network Management which collects data on the network performance on a real-time basis.

2.23 Network management actions such as cancellation of alternate routing, line load control, rerouting, and dynamic overload control are also discussed.

SYNCHRONIZATION OF THE DIGITAL NETWORK (SECTION 12)

2.24 The expanding application of digital technologies in the design of facilities and switching systems which are becoming an integral part of the telecommunications network requires that the clock rates between switching systems be synchronized. This section describes the need for synchronization and the hierarchical synchronization network which distributes the synchronizing signal from the Bell System Reference Frequency standard located in Hillsboro, Missouri.

BIBLIOGRAPHY (SECTION 13)

2.25 As mentioned previously, ***Notes on the Network*** is intended to describe the minimum requirements to be met in order to connect with the Network. For further details regarding subjects related to the Network, the Bibliography (Section 13) 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 ensuring good service. In addition to the subjects covered in detail in Sections 2 through 12, 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 Network.

3.02 Large sums of money are often required to provide for growth and service innovations tailored to customer needs. Effective planning is the key to ensuring that all network components (switchboards, buildings, trunk facilities, switching systems, and the like) fit together in an efficient and economically sound system.

3.03 Service-oriented planners must acknowledge and answer questions such 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:

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

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

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

3.05 Fundamental planning includes the following broad fields:

(a) Forecast and analysis of basic traffic data and methods

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

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

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

(e) Plans and programs to maximize the use of digital technology in providing facilities and switching systems to evolve toward the ISDN.

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

(a) Future routings under the switching plan for the Network

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

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

(2) The potential for eliminating cordboard handled traffic

(3) The portion of traffic to be handled from and by special service and other networks

(4) The use of the Network for nonvoice traffic.

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:

(a) The type of station identification to be used

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

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

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

(e) Operating economies which result.

3.08 Fundamental planning for a local exchange to be connected to the Network includes provision for:

(a) A unique 3-digit central office code

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

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

(d) Adequate interception of nonworking station numbers and vacant central office codes

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

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

(g) Automatic number identification whenever feasible.

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

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

(b) 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:

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

(2) Transmission design objectives under the switching plan with consideration for future integration of transmission and switching facilities

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

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

3.10 Because the sums invested are large and the service life of most plant involves many years, it is important that fundamental plans be made well in advance of any actual change. 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. TOTAL NETWORK OPERATIONS PLAN

4.01 Total Network Operations Plan (TNOP) is used to refer both to a project and a plan. The project is concerned with integrating the efforts of the many organizations at AT&T and Bell Laboratories that are preparing tools to facilitate future operating company operations. This plan is the vehicle used to present the current view of future integrated operations.

4.02 Operations centers are basic elements of the TNOP. An operations center is a group of people reporting to a common manager performing a set of related job functions for a specified geographic area.

4.03 Operations centers are supported by operating methods and, where cost-effective, by mechanization called operations systems. These are computer based systems that are not directly involved in providing telecommunications services to customers, but rather support network operations personnel in the performance of their assigned duties.

4.04 To facilitate planning, the set of network operations centers varies from those that support the local operation to those which are nationwide in scope.

4.05 Some centers have direct responsibility for the actual installation, maintenance, and administration of the Network. Other centers perform their functions in support of line operations for an entire company. In addition, some centers are intercompany. These are typically shared by AT&T Long Lines and operating companies.

4.06 When composite centers are feasible in an operating company environment, the basic centers should be collocated because of operational considerations. In some composite centers, certain job functions may be integrated unless job definitions and work loads dictate otherwise. In addition, there is a greater opportunity for sharing information among the basic centers.

4.07 The TNOP centers are an example of those that provide an operations structure which will permit the Bell System Companies to meet customer and market needs while at the same time maximize the payoff from mechanization of telephone company operations using computer technology. A key aspect is to construct a single, common basis for the planning, development, deployment, and use of operations systems throughout the telephone system for network operations.

4.08 Some specific objectives of the TNOP are as follows:

(a) To formulate a standard industry network operations plan for use by AT&T, the operating companies, and Bell Laboratories

(b) To guide AT&T, Bell Laboratories, and other industry partners planning and development

(c) To guide operating company operations through:

(1) Identification of a set of operations centers which will be supported by detailed methods planning

(2) Definition of the mode of operation for which the operations systems will be configured and designed

(3) Identification of the respective roles of and the evolutionary plans for the set of operations systems as a basis for deployment planning

(4) Definition of the information flows among the operations centers and systems and description of plans for mechanized intercommunications among these centers and systems.

(d) To provide perspective on the expected impact upon expense, capital, and service for the network segment.

4.09 Following are descriptions of centers already implemented that are applicable to the Network:

(a) ***CCIS Network Administration Center (CNAC):*** The CNAC has the responsibility for coordinating the establishment, administration, and operation of the intertoll CCIS network. The CNAC consists of four operating groups with basic responsibilities: Network Planning, Assignment/Administration, Cutover/Conversion, and CCIS 800 Service. To accomplish these responsibilities, the CNAC makes use of several support systems such as Planning and Analysis, Schedule Office Conversion and Cutover, Trunk Forecast, Signal Path Assignment Record Keeping System, and CCIS Network Total Administration System. The CNAC is also responsible for the services dependent on the CCIS network. The CNAC is located in Cincinnati, Ohio, and is staffed by AT&T Long Lines.

(b) ***Circuit Administration Center (CAC):*** The CAC has the basic responsibility of administering the trunk network. This involves the trunk servicing function of determining trunk requirements (demand and busy season) and issuing message trunk orders. Trunk forecasting for 1 to 5 years is also a CAC function. The CAC performs the network routing function which involves administering network routes and issuing Network Routing Orders. The CAC also performs record/schedule base management, data validation, and information exchange functions.

(c) ***Electronic Systems Assistance Center—No. 4 ESS (ESAC-4E):*** The ESAC-4E is a national staff support center that provides technical guidance for the No. 4 ESS operations. It is staffed by technical experts who consult on a complex trouble resolution and on the procedures for complex or new installation and software updates. If necessary, requests for trouble assistance are escalated to the Western Electric Regional Diagnostic Center or the national Western Electric Product and Engineering Control Center. Also included in the ESAC-4E is representation from the Maintenance Engineering organization. In general, the ESAC-4E can access the No. 4 ESS machine and the Switching Control Center System only after obtaining approval from the appropriate Switching Management Control Center.

(d) ***Machine Administration Center (MAC):*** The MAC is responsible for monitoring No. 4 ESS translations, performance, and equipment utilization through surveillance to ensure adequate service levels. The MAC is also responsible for traffic data and circuit order administration for the No. 4 ESS.

(e) ***Switching Control Center-Stored Program Control System (SCC-SPCS):*** The SCC-SPCS is responsible for the installation and maintenance of switching, message trunks, carrier, frame, special services, power, and billing equipment in Stored Program Control (SPC) central offices. It is also responsible for administration of all central office forces unless there is a separate Frame Control Center or Trunk Facility Control Center.

5. NEW SERVICES

5.01 As SPC and CCIS expand, their inherent power and flexibility make many new and innovative network capabilities possible. These capabilities are known collectively as Direct Services Dialing Capabilities (DSDC) and are based on the CCIS direct signaling capabilities described in Section 6. Currently, two major DSDC programs are planned for introduction in the early 1980s:

(a) ***Auto Bill Calling:*** One application, currently under development, is Auto Bill Calling (ABC). This capability allows a caller at a TOUCH-TONE® telephone to dial 0 plus the number being called. A tone or prompting announcement is heard whereupon the caller dials a billing number and a Personal Identification Number (PIN) associated with it. Such a call is routed to a TSPS or an equivalent system which uses CCIS to query a special billing data base to verify the billing information. If the billing information is valid, the call is allowed to proceed with no operator required. This can be thought of as automating credit card service which presently uses an operator.

Another version of ABC can be used when the billing number is the same as the called number, ie, when the call is collect. In this case, the caller dials 0 plus the called number and, after the prompt, simply dials the PIN associated with the called number. This automation of collect calls is useful in situations where the subscriber is expecting the collect call and "preauthorizes" it by disclosing their PIN to the caller.

(b) ***800 Service:*** Another application which is currently under development is an improved 800 Service. 800 Service is very popular and heavily used. However, it utilizes relatively inflexible routing techniques so that a different 800 number must be used for interstate and intrastate calls, and customers must change their 800 number if they wish to move their answering point to a different location within the country. In the improved version, on each 800 number call, a specially assigned telephone number will be obtained from a central data base using CCIS and the call will be routed to this number the same as any normal call. For each 800 number, the special telephone number can be a function of the originating area code, the time of day, and/or the day of the week. Later, when CCIS capability is available at the terminating central office, the routing can be based on the busy/idle status of the destination. Moreover, if all the lines at the destination are busy, the busy tone can be applied at the originating end of the call, thereby, effecting significant facility savings.

5.02 Besides 800 Service and ABC, which are scheduled for introduction, a large number of other new capabilities which utilize the SPC network have been proposed. Although no firm decisions have been made, it is expected that some of these capabilities may be introduced in the mid 1980s. Some future capabilities that CCIS could provide are:

- Using a single nationwide number to reach a ***function*** (not a location), such as the nearest hospital, poison control center, or the nearest local outlet of a specific retailer, real estate franchiser, or government agency
- Using a telephone number to reach a ***person*** (not a telephone) wherever he/she may be in the country
- Using the Network to track the location of people traveling throughout the country, such as vacationers or truck drivers
- Forwarding information about the call, such as the calling number to the terminating end, in order to selectively apply Call Waiting tones, make the phone ring distinctively on certain calls, or provide other uses.

NOTES ON THE NETWORK

SECTION 2

NUMBERING PLAN AND DIALING PROCEDURES

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Figures

1. GENERAL

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

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

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

(b) 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 central office codes" discussed in Part 4 of this section.

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

Where N = Digits from 2 through 9

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

X = Digits from 0 through 9

† Excludes N11 codes

1.04 When the network 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 digit (2L-5D) 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 CO 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-5D 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-5D numbers but also to convert all such existing numbers to ANC as soon as practical. The latter task has been completed in 1980 with 100 percent of the telephones assigned ANC numbers. With ANC, the CO 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 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 800 Service, TWX service, and DIAL-IT services. Figures 1 and 2 list the NPA codes assigned through 1979 numerically and alphabetically by areas served, respectively. Figures 3 and 4 show the geographic boundaries of NPAs in the United States and Canada as of the end of 1979, respectively. The assignment of area codes is controlled by the AT&T Assistant Vice President—Network Planning.

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 digit 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 the call 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 (HNPA) calls are completed on a 7-digit basis and Foreign NPA (FNPA) 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 1979) 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 Fig. 5. (The NN0 codes have been designated as the last to be assigned as CO codes; 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 NPAs 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:

(a) Boundaries ***must not*** extend across state lines.

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

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

(d) 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.

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

(f) 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.

(g) Any customers affected by a boundary realignment should not be affected by any subsequent realignment for at least 10 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 paragraph 4.03. 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, there 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
DIAL-IT Services	976
Plant Test	958 and 959
Time	844
Weather	936

Since time and weather services are expected to be included in DIAL-IT services, codes 844 and 936 will eventually become available for CO code use.

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 North American Network for the introduction of NNX type codes as NPA codes. Following is a list of CO code conservation measures recommended for CO code administration:

(a) 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.

(b) 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.

(c) 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 CO codes. Plans for new CO units and replacement units should be based on terminal-per-station equipment with its larger number fill potential.

(d) 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.

(e) CO codes should not be dedicated to individual Direct Inward Dialing (DID) customers, but shared with other DID or non-DID customers. The single exception would be a DID 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-PBX dialing and 2-digit access codes for tielines, dial dictation, paging services, attendant, etc.

(f) The multiline hunting feature provided in newer type central office equipment eliminates 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.

(g) 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.

(h) The 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.

(i) CO code sharing may be used if the entities involved are within the same toll rate exchange area and there are economic benefits to be gained. Code sharing is the assignment of the same CO code to two or more entities, thereby gaining increased utilization of station numbers in low fill offices. The offices are differentiated by the thousands, or "D" digit, of the station number. Code sharing is limited because of the costs associated with providing "D" digit translation, additional trunking, redesign of automatic rating equipment and coin raters, modification of AMA equipment, and modification of the billing system.

It should be noted that Measured Service will tend to reduce the opportunities for code sharing because of the shrinking of "free-calling" areas and the need to identify new rate zones for billing purposes.

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

(k) The CO codes dedicated for plant test and official 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 late 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 paragraph 3.02 have been exploited, the alternatives available to achieve CO code relief are:

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

(b) Introduce interchangeable CO codes within NPA requiring relief

(c) 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. However, since the introduction of interchangeable codes precludes the ability of central office equipment to determine whether to expect a 7- or 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.

(a) 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- 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.

(b) The preferred arrangement, which is called the "***prefix method***," utilizes the presence of either a "1" or "0" prefix to identify the call being dialed as having a 10-digit format. This arrangement has disadvantages in that it requires all customer-dialed, operator-assisted traffic to be dialed on a "0" + 10-digit basis and that, in areas with step-by-step equipment, HNPA 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 the prefix method be used to solve the 7-digit/10-digit ambiguity problem. Extensive studies conducted by 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+" HNPA traffic; but in areas with step-by-step equipment, the additional three digits also would be required for all HNPA 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 electronic equipment and only "0+" HNPA 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 The standard customer dialing procedures recommended for the long term when step-by-step is replaced are as follows:

- HNPA—7 digits

- FNPA—1 + 10 digits

- Operator-assisted HNPA and FNPA—0 + 10 digits.

The interim recommendations for customer dialing procedures are shown in Fig. 6.

5. TERMINATING TOLL CENTER AND OPERATOR CODES

5.01 A Terminating Toll Center (TTC) code 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. All code assignments for TTCs are within the "0XX" series.

5.02 Operator Codes (OpCs) are used exclusively by outward operators to designate specific operator groups associated with toll centers. Most OpCs 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 TTC code assigned, usually principal city offices, 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 LOCATION	CODES DIALED	DIGITS DIALED (EXAMPLE)
FNPA	Nonprincipal City	NPA+TTC+OpC	216+046+121
FNPA	Principal City	NPA+OpC	216+121
HNPA	Nonprincipal City	TTC+OpC	046+121
HNPA	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 "1" in the fourth-digit position of 10-digit calls as well as calls with a "0" or "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 800 Service and international services.

6. CUSTOMER DIALING PROCEDURES

6.01 The long-range standard dialing format assumes all switching systems throughout the North American Network to be electronic and use the prefix method described in Part 4 for machine identification of interchangeable codes as follows:

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

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

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

6.02 A long-term network objective is to standardize the dialing procedure for each type of call in all areas. This, however, is unlikely 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. Figures 6 and 7 outline recommendations for the dialing procedures for all types of direct dialed calls placed within the network except for those utilizing N11 codes. Figure 6 shows dialing procedures for areas ***with step-by-step*** equipment while Fig. 7 shows dialing procedures for areas ***without step-by-step*** equipment. 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 "811" as opportunities present. However, with the advent of the Centralized Repair Service Attendant Bureau (CRSAB) concept for both the residence and business market segments, the use of "611" and/or 7-digit numbers has been recommended. In addition, it has been recommended that the long-range CRSAB access arrangement involves the use of 800 Service numbers when Common Channel Interoffice Signaling (CCIS) is implemented in the network. 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 prefixes "011" for station calls and "01" for operator-assisted calls are now widely (but not universally) applied. Code "010" dialed without subsequent digits is reserved for possible use in connection with overseas assistance. See Section 10 for details on international dialing.

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

6.07 Directory assistance calls should be dialed in accordance with the procedures outlined in Fig. 8.

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 dialing procedures used in these areas must be those that favor the limited service offering rather than the EAS 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 paragraph 1.03 in order to be directly dialable from other network points. Thus, with regular 10-digit numbers assigned to telephones in these locations, recommended dialing procedures as shown in Fig. 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.

6.10 The standard network uses of the TOUCH-TONE® telephone symbols * (star) and # (number sign or square) are as follows:

* ***used as a prefix***—Currently being planned as the dialing arrangement for central office vertical services in No. 1/1A ESS offices. The symbol * plus a 2- or 3-digit access code will be dialed by a customer wishing to access a central office

vertical service. The digits 11 are the rotary dial equivalent of the * symbol.

* ***used as a suffix***—Reserved for future services.

used as a prefix—Future wideband data services.

used as a suffix—IDDD and custom calling services to cancel timing.

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, 225-9XXX. 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 directory assistance 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 CO 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

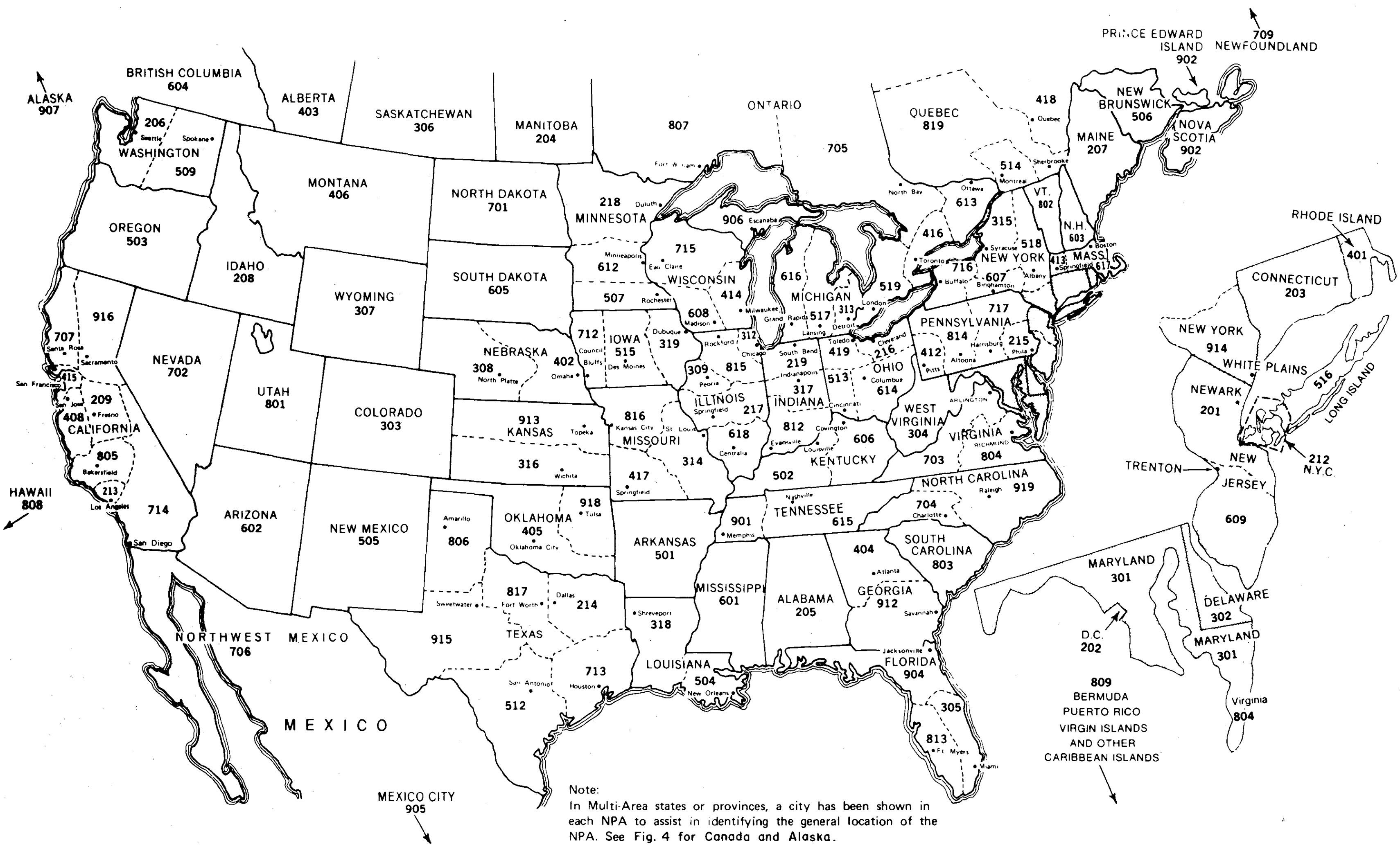
AREA CODE	STATE/PROVINCE OR OTHER SPECIAL USE
201	New Jersey
202	District of Columbia
203	Connecticut
204	Manitoba
205	Alabama
206	Washington
207	Maine
208	Idaho
209	California
212	New York
213	California
214	Texas
215	Pennsylvania
216	Ohio
217	Illinois
218	Minnesota
219	Indiana
301	Maryland
302	Delaware
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 (United States)
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
706	Northwest Mexico
707	California
709	Newfoundland
710	TWX (United States)
712	Iowa
713	Texas
714	California
715	Wisconsin
716	New York
717	Pennsylvania
800	800 Service
801	Utah
802	Vermont
803	South Carolina
804	Virginia
805	California
806	Texas
807	Ontario
808	Hawaii
809	Bermuda, Puerto Rico, Virgin Islands of the United States, and other Caribbean Islands
810	TWX (United States)
812	Indiana
813	Florida
814	Pennsylvania
815	Illinois
816	Missouri
817	Texas
819	Quebec
900	DIAL-IT Services
901	Tennessee
902	Nova Scotia and Prince Edward Island
904	Florida
905	Mexico City
906	Michigan
907	Alaska
910	TWX (United States)
912	Georgia
913	Kansas
914	New York
915	Texas
916	California
918	Oklahoma
919	North Carolina

Fig. 1—Numeric List of NPAs Assigned at End of 1979

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

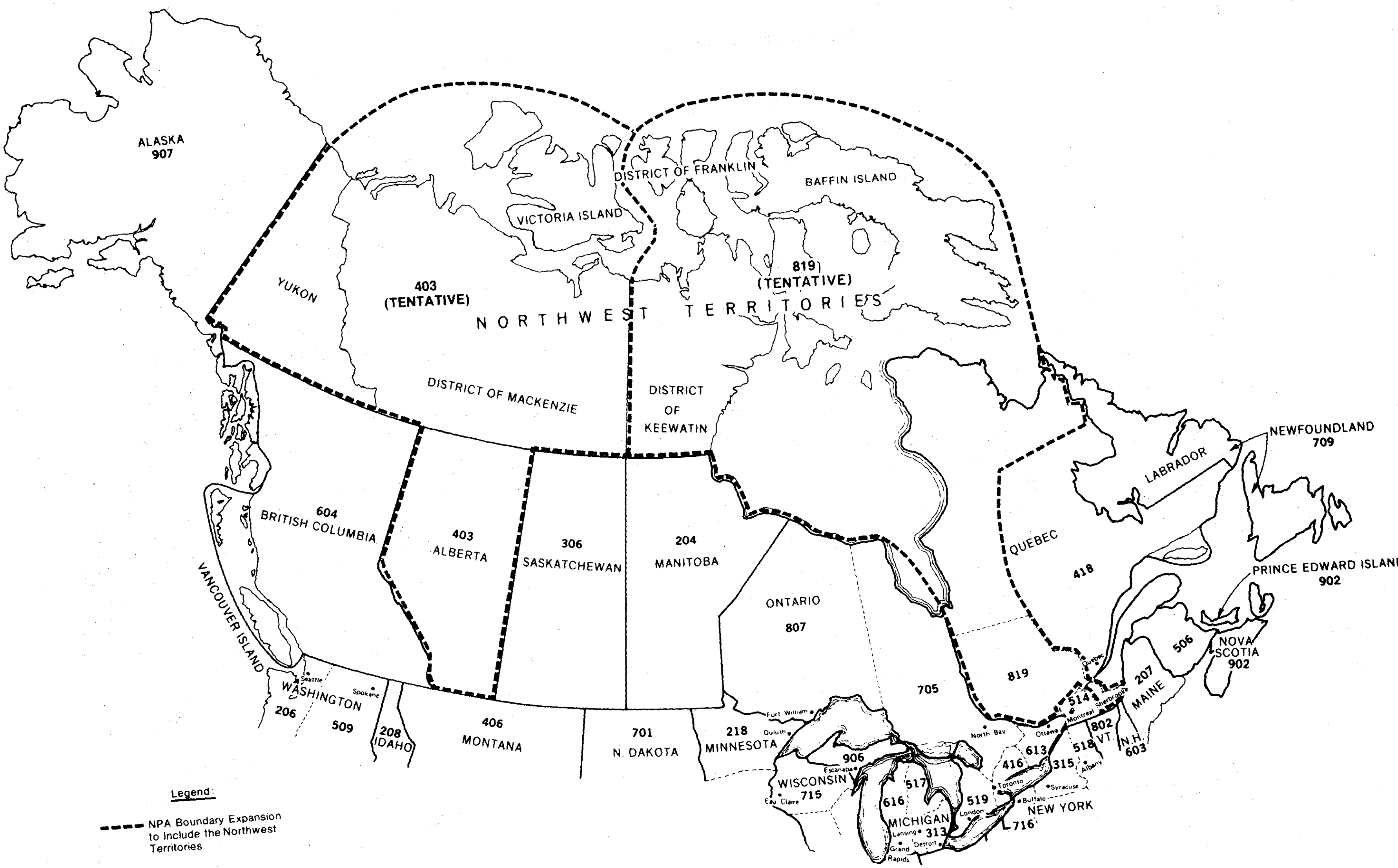
STATE/PROVINCE OR OTHER SPECIAL USE	AREA CODE
Alabama	205
Alaska	907
Arizona	602
Arkansas	501
Bermuda, Puerto	809
Rico, Virgin Islands	809
of the United States,	809
and other Carribbean	
Islands	809
California	209
California	213
California	408
California	415
California	707
California	714
California	805
California	916
Canada:	
Alberta	403
British Columbia	604
Manitoba	204
New Brunswick	506
Newfoundland	709
Nova Scotia and	902
Prince Edward Island	902
Ontario	416
Ontario	519
Ontario	613
Ontario	705
Ontario	807
Quebec	418
Quebec	514
Quebec	819
Saskatchewan	306
Colorado	303
Connecticut	203
Delaware	302
DIAL-IT Services	900
District of Columbia	202
Florida	305
Florida	813
Florida	904
Georgia	404
Georgia	912
Hawaii	808
Idaho	208
Illinois	217
Illinois	309
Illinois	312
Illinois	618
Illinois	815
Indiana	219
Indiana	317
Indiana	812
800 Service	800
Iowa	319
Iowa	515
Iowa	712
Kansas	316
Kansas	913
Kentucky	502
Kentucky	606
Louisiana	318
Louisiana	504
Maine	207
Maryland	301
Massachusetts	413
Massachusetts	617
Mexico:	
Mexico City	905
Northwest Mexico	706
Michigan	313
Michigan	517
Michigan	616
Michigan	906
Minnesota	218
Minnesota	507
Minnesota	612
Mississippi	601
Missouri	314
Missouri	417
Missouri	816
Montana	406
Nebraska	308
Nebraska	402
Nevada	702
New Hampshire	603
New Jersey	201
New Jersey	609
New Mexico	505
New York	212
New York	315
New York	516
New York	518
New York	607
New York	716
New York	914
North Carolina	704
North Carolina	919
North Dakota	701
Ohio	216
Ohio	419
Ohio	513
Ohio	614
Oklahoma	405
Oklahoma	918
Oregon	503
Pennsylvania	215
Pennsylvania	412
Pennsylvania	717
Pennsylvania	814
Rhode Island	401
South Carolina	803
South Dakota	605
Tennessee	615
Tennessee	901
Texas	214
Texas	512
Texas	713
Texas	806
Texas	817
Texas	915
TWX:	
Canada	610
United States	510
United States	710
United States	810
United States	910
Utah	801
Vermont	802
Virginia	703
Virginia	804
Washington	206
Washington	509
West Virginia	304
Wisconsin	414
Wisconsin	608
Wisconsin	715
Wyoming	307

Fig. 2—Geographical Areas Served by NPAs Assigned at End of 1979



Note:
In Multi-Area states or provinces, a city has been shown in each NPA to assist in identifying the general location of the NPA. See Fig. 4 for Canada and Alaska.

Fig. 3—NPA Map of Continental United States



Legend:

NPA Boundary Expansion to Include the Northwest Territories

Note:
In multi-area states or provinces, a city has been shown in each NPA to assist in identifying the general location of the NPA.

Fig. 4—NPA Map of Canada and Alaska

ASSIGNMENT OF THE 63† NNO CODES

There are 36 NN0 codes which should be assigned as CO codes, to the extent practical, in the following sequence:

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 NN0 codes are used, the remaining 27 NN0 codes should be assigned, to the extent practical, as CO codes in the following sequence:

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 N 0/1 X 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 NN0 code (950) is reserved for future use.

‡ This code is temporarily used network-wide as a plant test code.

Fig. 5—NNO Code Assignment Sequence List

TYPE OF CALL	WITHOUT INTERCHANGEABLE CO CODES			WITH INTERCHANGEABLE CO CODES†		
	PRE-FIX	AREA CODE CO CODE STA NO.	USE	PRE-FIX	AREA CODE CO CODE STA NO.	USE
LOCAL – DIRECT-DIALED:						
HNPA		NNX-XXXX	R		NXX-XXXX	R
	1+	NNX-XXXX	NR	1+	NXX-XXXX	NR
		N 0/1 X +NNX-XXXX	NR		N 0/1 X +NXX-XXXX	NR
	1+	N 0/1 X +NNX-XXXX	P	1+	N 0/1 X +NXX-XXXX	P
FNPA (Protected Codes)		NNX-XXXX	R		NXX-XXXX	R
	1+	NNX-XXXX	NR	1+	NXX-XXXX	NR
		N 0/1 X +NNX-XXXX	NR		N 0/1 X +NXX-XXXX	NR
	1+	N 0/1 X +NNX-XXXX	P	1+	N 0/1 X +NXX-XXXX	P
FNPA (Nonprotected Codes)		N 0/1 X +NNX-XXXX	NR		N 0/1 X +NXX-XXXX	NR
	1+	N 0/1 X +NNX-XXXX	R	1+	N 0/1 X +NXX-XXXX	R
TOLL – DIRECT-DIALED:						
HNPA		NNX-XXXX	NR		NXX-XXXX	NR
	1+	NNX-XXXX	R	1+	NXX-XXXX	NR
		N 0/1 X +NNX-XXXX	NR		N 0/1 X +NXX-XXXX	NR
	1+	N 0/1 X +NNX-XXXX	P	1+	N 0/1 X +NXX-XXXX	R
FNPA		N 0/1 X +NNX-XXXX	NR		N 0/1 X + NXX-XXXX	NR
	1+	N 0/1 X +NNX-XXXX	R	1+	N 0/1 X +NXX-XXXX	R
ALL – OPERATOR-ASSISTED:						
HNPA	0+	NNX-XXXX	R	0+	NXX-XXXX	NR
	0+	N 0/1 X +NNX-XXXX	P	0+	N 0/1 X +NXX-XXXX	R
FNPA (Protected Codes)	0+	NNX-XXXX	R	0+	NXX-XXXX	NR
	0+	N 0/1 X +NNX-XXXX	P	0+	N 0/1 X +NXX-XXXX	R
FNPA (Nonprotected Codes)	0+	N 0/1 X +NNX-XXXX	R	0+	N 0/1 X +NXX-XXXX	R

Legend:

N — Any digit 2 through 9
0/1 — Digit 0 or 1
X — Any digit 0 through 9
R — Recommended procedure
NR — Procedure not recommended
P — Permissive procedure. May be permitted in addition to recommended procedure.

† These dialing procedures also will be applicable for interchangeable area codes. In that case, the area code format will become NXX also.

Fig. 6—Recommended Customer Dialing Procedures for Areas With Step-by-Step Equipment

TYPE OF CALL	WITHOUT INTERCHANGEABLE CO CODES					WITH INTERCHANGEABLE CO CODES†				
	PRE-FIX	AREA CODE	CO CODE	STA NO.	USE	PRE-FIX	AREA CODE	CO CODE	STA NO.	USE
LOCAL – DIRECT-DIALED:										
HNPA			NNX-XXXX		R			NXX-XXXX		R ‡
	1+		NNX-XXXX		NR	1+		NXX-XXXX		NR
		N 0/1 X +	NNX-XXXX		NR		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX-XXXX		P	1+	N 0/1 X +	NXX-XXXX		P
FNPA (Protected Codes)			NNX-XXXX		R			NXX-XXXX		R
	1+		NNX-XXXX		NR	1+		NXX-XXXX		NR
		N 0/1 X +	NNX-XXXX		NR		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX-XXXX		P	1+	N 0/1 X +	NXX-XXXX		P
FNPA (Nonprotected Codes)		N 0/1 X +	NNX-XXXX		R		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX-XXXX		P	1+	N 0/1 X +	NXX-XXXX		R ‡
TOLL – DIRECT-DIALED:										
HNPA			NNX-XXXX		R			NXX-XXXX		R
	1+		NNX-XXXX		NR	1+		NXX-XXXX		NR
		N 0/1 X +	NNX-XXXX		NR		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX-XXXX		P	1+	N 0/1 X +	NXX-XXXX		P
FNPA		N 0/1 X +	NNX-XXXX		R		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX-XXXX		P	1+	N 0/1 X +	NXX-XXXX		R ‡
ALL – OPERATOR-ASSISTED:										
HNPA	0+		NNX-XXXX		R	0+		NXX-XXXX		NR
	0+	N 0/1 X +	NNX-XXXX		P	0+	N 0/1 X +	NXX-XXXX		R ‡
FNPA (Protected Codes)	0+		NNX-XXXX		R	0+		NXX-XXXX		NR
	0+	N 0/1 X +	NNX-XXXX		P	0+	N 0/1 X +	NXX-XXXX		R
FNPA (Nonprotected Codes)	0+	N 0/1 X +	NNX-XXXX		R	0+	N 0/1 X +	NXX-XXXX		R ‡

Legend:

N — Any digit 2 through 9
0/1 — Digit 0 or 1
X — Any digit 0 through 9
R — Recommended procedure
NR — Procedure not recommended
P — Permissive procedure. May be permitted in addition to recommended procedure.

† These dialing procedures also will be applicable for interchangeable area codes. In that case, the area code format will become NXX also.

‡ These are the recommended long-term procedures to be applicable after step-by-step equipment and protected codes are obsolete.

Fig. 7—Recommended Customer Dialing Procedures for Areas Without Step-by-Step Equipment

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
	—	—	N 0/1 X	555	1212	6, 10
	1	—	N 0/1 X	555	1212	7, 10
FNPA-Local	—	411	—	—	—	1, 9
	1	411	—	—	—	2, 3, 9
FNPA-Toll	—	—	N 0/1 X	555	1212	8, 10
	1	—	N 0/1 X	555	1212	10, 11

Notes:

1. Standard for all areas.

2. Acceptable alternative for small step-by-step offices.

3. Acceptable alternative in areas with step-by-step equipment where it is necessary to record directory assistance calls at centralized automatic message accounting tandems.

4. Standard for areas without step-by-step equipment.

5. Standard for areas with step-by-step equipment.

6. Deny procedure.

7. Permit in addition to standard or acceptable alternative procedure.

8. Standard for areas without step-by-step equipment prior to interchangeable codes.

9. The number of practical applications should be minimized.

10. Area codes will be in NXX form rather than N 0/1 X after interchangeable area codes are introduced.

11. Standard for areas with step-by-step equipment prior to interchangeable codes and for all areas thereafter.

Fig. 8—Directory Assistance Dialing Procedures

NOTES ON THE NETWORK
SECTION 3
THE SWITCHING PLAN

CONTENTS PAGE

1. GENERAL

1.01 The telephone systems in the United States and Canada handle almost 600,000,000 telephone messages a day. These are routed over a comprehensive network of intercity trunks which interconnect over 1,800 toll 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 two or more trunks in tandem to build up the required connection. The locations where the connections are made are generally known as "switching centers" and the process of connecting trunks in tandem 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 service levels 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 make possible systematic and efficient handling of customer-dialed and operator-serviced traffic. These arrangements are discussed in this section.

1.04 The basic principles of the switching plan 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 switching plan are as follows:

(a) A numbering plan (discussed in Section 2)

(b) A switching plan (discussed in Parts 3, 4, and 5 of this section)

(c) Destination code routing (discussed in Parts 6 and 7 of this section)

(d) A transmission plan (discussed in Section 7)

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

1.06 The needs of the switching plan 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 1 of this section, entitled "Alternate Routing," discusses this principle.

1.07 Trends in the telephone industry are toward increasing traffic volumes and the use of mechanized switching and billing systems employing Stored Program Control (SPC) techniques. Operator service locations are trending toward more centralization as well as SPC mechanization 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. Two-way trunk groups achieve economies through the meshing of noncoincident busy hour loads and improved trunk group efficiencies.

2. DEFINITIONS

2.01 Under the switching plan, each switching system is classified and designated according to the highest 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.

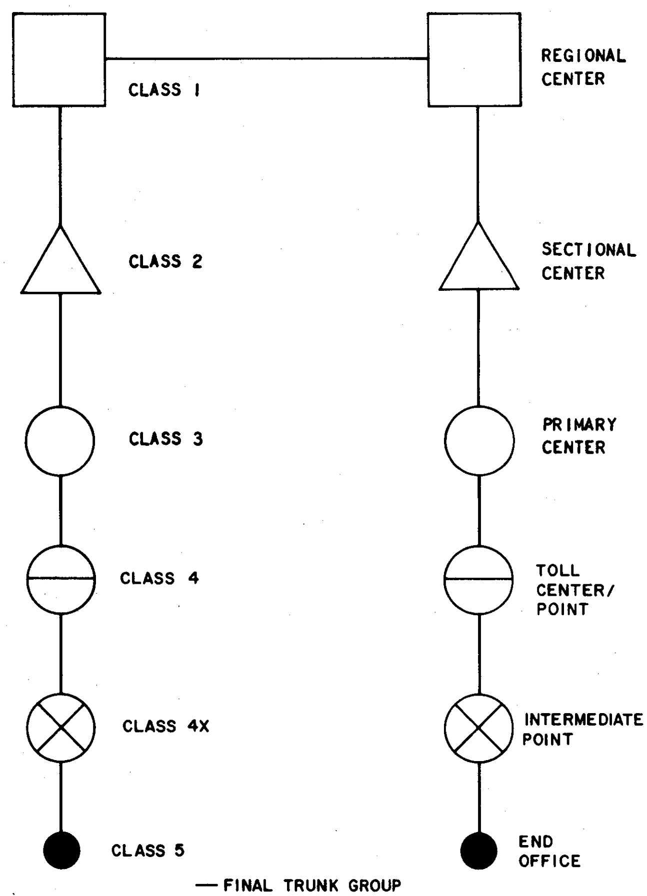


Fig. 1—Switching System Classification and Homing Arrangements

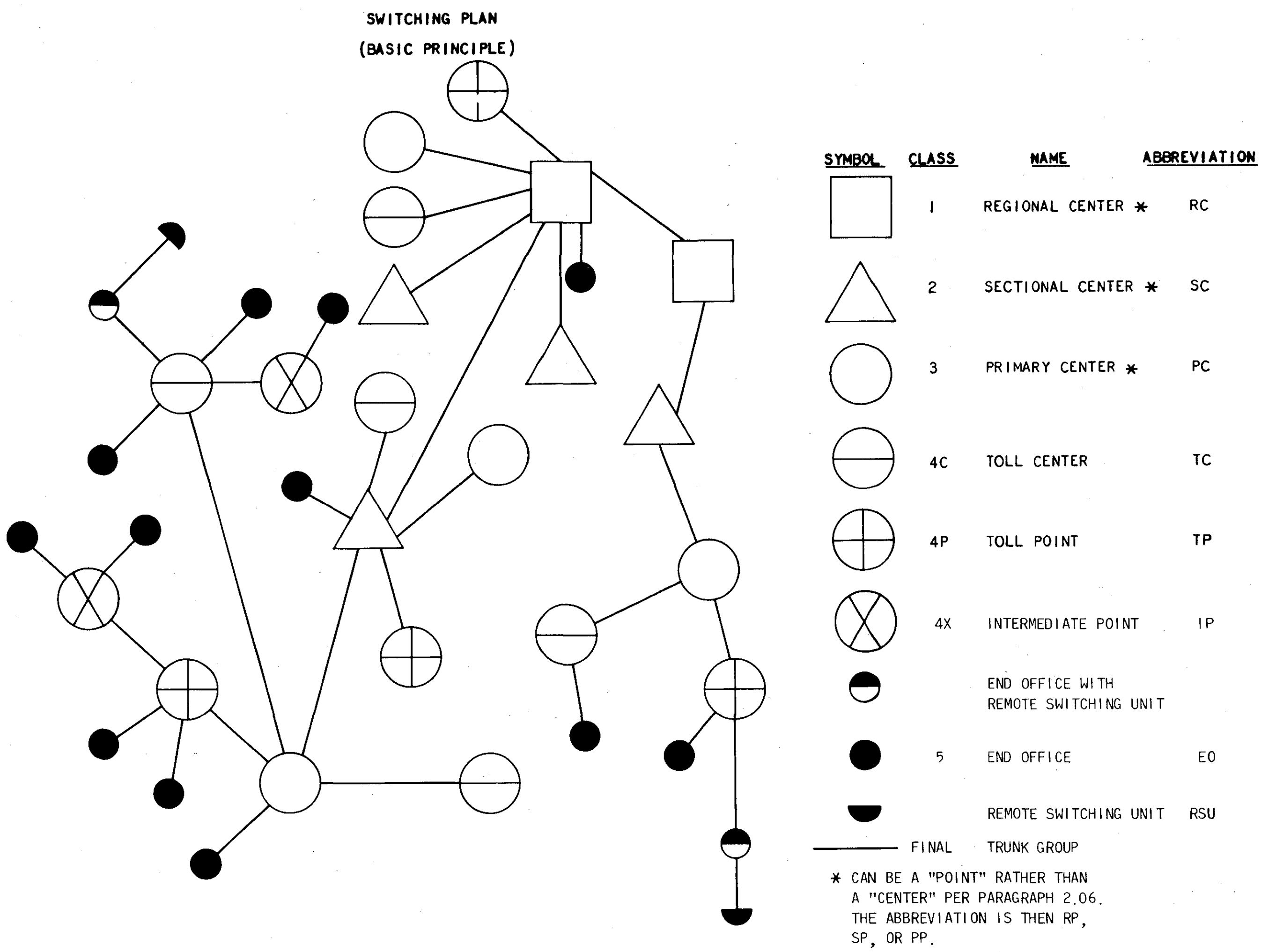


Fig. 2—Typical Switching System Groupings

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 stored program 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 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). The class 4X intermediate point is similar to the class 4P, but its application is constrained by the requirements discussed in Appendix 4.

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 class switching system. Appropriate listings in conformance 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 group of end offices to each other and to the network, are selected to serve additional 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. It is important to note that higher class switching systems can also perform lower switching functions. Where multiple switching functions are performed, the switching system is designated by the highest switching function present as shown in Table A.

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 class switching systems instead of the highest class system in the area. In these cases, the lower class switching system should have direct (nonswitched) access to the end offices served. 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 attached to these classifications.

2.07 A CSP is a switching system at which intertoll trunks are connected to other intertoll trunks. There must be at least one switching system of the next lower class homing on a CSP; eg, a class 2 switching system must have at least one class 3 switching system homing on it.

2.08 The backbone hierarchical network of "final" trunk groups, or the final route chain interconnecting the six classes of switching systems, is shown in Fig. 1. A final trunk group is always provided from each switching system to another switching system of higher class. That higher

TABLE A

SWITCHING SYSTEM DESIGNATION BY SWITCHING FUNCTION

SWITCHING SYSTEM RANK	DESIGNATED CLASS NUMBER	SWITCHING FUNCTIONS PERFORMED
Regional Center	1	1, 2, 3, and 4
Sectional Center	2	2, 3, and 4
Primary Center	3	3, 4, and sometimes 5
Toll Center/Point	4	4 and sometimes 5
Intermediate Point	4X	4X and sometimes 5
End Office	5	5

Note: Not all toll centers perform a class 5 switching function; eg, many primary centers perform a class 5 switching function. Sectional centers and regional centers are of such large size that the switching system used generally does not provide a class 5 switching function.

class switching system to which a given switching system is connected over a final trunk group is called its "home." Final groups to more than one higher class switch may be provided if it is necessary to have separate homing by class of service. The lower class or dependent switching system is referred to as homing on the higher class switch. 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 4X, 4, 3, 2, and 1. The network hierarchy is thus established from the bottom up, each switching system being assigned the lowest possible class. 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 categories are the Toll Centers (TCs), Toll Points, Intermediate Points (IPs), and End Offices (EOs).

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 Via Net Loss (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 (except 4X), or 3 offices always home on the next higher class (next lower number as shown in Fig. 1) switching system. For example, class 5 offices may be served directly from any higher class switch. Class 4X offices will exist only where interposed between a class 4 and its subtending class 5 offices. Possible homing arrangements for each class of switching system are shown in Table B and are illustrated in Fig. 2.

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 service objectives for final trunk groups call for an average of not more

TABLE B

HOMING ARRANGEMENTS

RANK	CLASS OF OFFICE	MAY HOME AT OFFICES OF THE FOLLOWING CLASSES
End Office	5	Class 4, 3, 2, or 1
Intermediate Point	4X	Class 4
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

than one call in 100 being blocked by an NC condition in the average time consistent busy hour in the busy season.

3.03 In addition to the final route network, High-Usage (HU) 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. HU trunk groups carry most but not all of the offered traffic in the busy hour. As discussed in Appendix 1, overflow traffic is offered to an alternate route. The proportion of the offered traffic that is carried on an HU 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). HU trunk groups are provided when they are shown to be economically desirable. Due to service considerations, trunk groups which would normally be in the HU 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; these trunk groups are called "special finals." Special finals effectively eliminate further alternate routing and truncate or limit the hierarchical final route chain for the items of traffic offered to them. Special finals can seldom be justified on the basis of economic considerations alone.

3.04 In general, both HU and final trunk groups between toll centers, intermediate points, and higher class switching systems are operated 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 1-way trunk groups. Where there is a significant cost differential between 1-way and 2-way trunk terminations on switching systems, there may be opportunities to trade off trunk termination savings against the lower occupancy of 1-way trunk groups. This usually is possible with electromechanical switching systems. A large 2-way trunk group may be subgrouped into two 1-way segments (for each direction) and one 2-way segment to which the 1-way subgroups would overflow. (In metropolitan local networks, large trunk groups are often provided as 1-way only in either direction with no 2-way subgroup.) Where direct distance dialing 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 and designated as 2-way operator office trunk groups. For larger end offices and CDOs, it is common practice to provide 1-way trunk groups to and from the home toll center.

3.05 Parallel Protective High Usage (PPHU) groups are sometimes used as a service protection measure for traffic which might otherwise be first routed on a final trunk group in excessive competition with alternate routed traffic. The PPHU groups are engineered in a manner comparable to HU trunk groups and are for exclusive use of first routed traffic loads which overflow to the final trunk group. The PPHU 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 switching systems establishing such a connection must be on the final route path. One or more intermediate switching systems on a final route path may be bypassed by an HU 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 limit rule discussed in Appendix 3. Referring to Fig. 1 and 2, a call originating in one final route chain must progress up that chain until an idle HU trunk to the second chain is found. On entering the second chain (eg, at the class 2 switching system), the call 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 2 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 in tandem 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. If a class 4X office is interposed between the class 4 and class 5 office as described in Appendix 4, one additional link is installed in the chain. 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 a single trunk, regardless of distance; relatively few encounter multiple switching systems. 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, in Fig. 3, Plan II 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, class, and number of CSPs which will result in the most economical overall network configuration over a reasonably long time span.

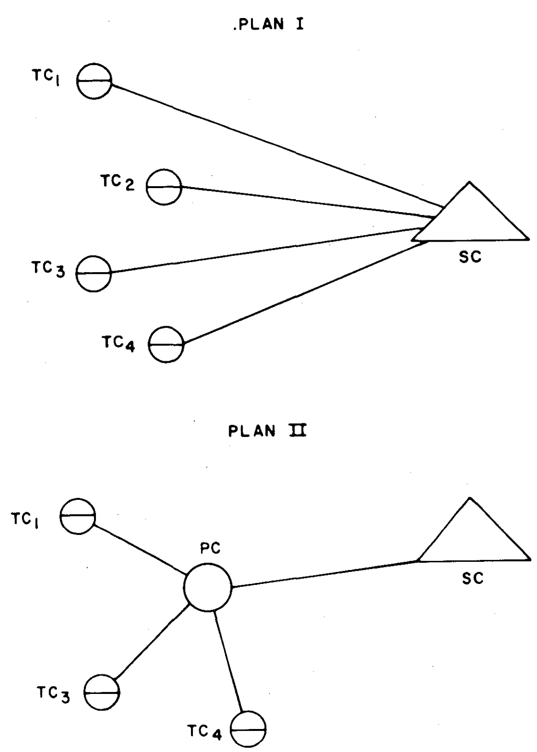


Fig. 3—Effect of Establishing a CSP

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 and SPC switching systems at lower levels in the hierarchy which permit additional HU 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 class of some existing switching systems.

SWITCHING SYSTEM REQUIREMENTS FOR A CSP

4.03 The requirements for switching systems serving as CSPs are as follows:

(a) Storing of digits

(b) Variable spilling—Deletion of certain digits when not required for outpulsing

(c) Prefixing of digits when required

(d) Code conversion—A combination of digit deletion and prefixing (also termed substitution)

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

(f) Automatic alternate routing.

4.04 The switching requirements delineated in paragraph 4.03 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. The transmission requirements provided in paragraph 4.05 can be met where step-by-step switching equipment is employed.

TRANSMISSION REQUIREMENTS FOR A CSP

4.05 The requirements for analog transmission are as follows:

(a) VNL operation of intertoll trunks.

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

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

(d) 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.

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

5. TRAFFIC ROUTING REQUIREMENTS

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 HU trunk groups or by adding trunks to existing HU trunk groups. Final trunk groups thus tend to grow at a lower rate than the overall growth rate for the total area involved. Appendix 1 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 economical network may be obtained and, at the same time, the needs during transition periods can be cared for adequately.

5.03 The final trunk group between any switching system and its home switching system should be engineered for low probability of blocking. (See Part 3.)

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 A.

5.05 Customer-dialed station sent paid traffic must be provided with automatic recording of call billing details at the originating local office (Local Automatic Message Accounting [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. See Appendix 4 for explanation of class 4X CAMA applications.

5.06 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 as stipulated in Appendixes 3 and 4.

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 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 Numbering Plan Area (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 NPA, 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 trunk group 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 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 class (ie, 1, 2, 3, 4, 4X) until the final trunk group to the terminating end office is reached. Of course, HU trunk groups will be used, where provided, to bypass one or more intermediate switching systems as discussed in Part 3. (Also see Appendixes 2, 3, and 4.)

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 NPA. 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.

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 NPA, there is a switching system (usually a CSP) which is designated as the "Principal NPA Tandem" for that NPA. A CSP may be designated as the Principal NPA Tandem for more than one NPA. A Principal NPA Tandem is defined as that lowest class switching system which can complete to every end office within an NPA on a final route basis, direct or switched. The Principal NPA Tandem 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 NPA Tandem. If the Principal NPA Tandem is within the NPA, the call is completed with the 7-digit destination code. If the Principal NPA Tandem 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. Paragraphs 4.03 through 4.05 outline 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.

7. ROUTING CHANGES

7.01 From time to time, new HU 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 a heavy traffic day such as 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 1

ALTERNATE ROUTING

1. GENERAL

1.01 The successful completion of traffic dialed by operators and customers depends upon a trunking network in which 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 of terms used in this appendix are listed below:

(a) ***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.

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

(c) ***High-Usage (HU) Trunk Group:*** A group of trunks for which an engineered alternate route is provided.

(d) ***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 HU groups overflowing to it.

(e) ***Special Final Trunk Group:*** A group of trunks which ordinarily would be an HU 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 special final 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 (HU) 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 in Appendixes 3 and 4.

FUNDAMENTALS

2.02 Alternate routing is advantageous because it provides the opportunity to minimize the cost per unit of carried traffic. With alternate routing, the load is allocated to HU and final routes in the most economical manner as discussed below. Alternate routing permits the meshing of traffic streams which have differing peak periods (busy hours or seasons).

MINIMIZING THE COST PER CARRIED HUNDRED CALL SECONDS (CCS)

2.03 Figure 1 depicts an alternate routing arrangement.

2.04 Figure 1 illustrates an HU trunk group connecting Toll Centers A and B with an alternate (final) route via a Primary Center C. In general, the direct or HU route is shorter and less expensive 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 Figure 2 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.

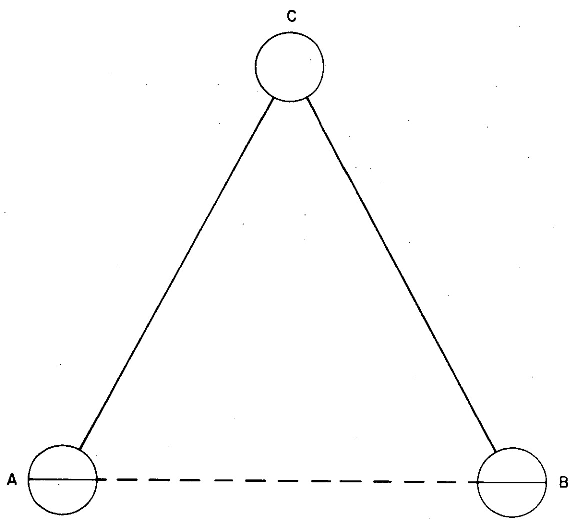


Fig. 1—Alternate Routing Arrangement

The HU trunk group cost, of course, increases in direct proportion to the number of HU trunks.

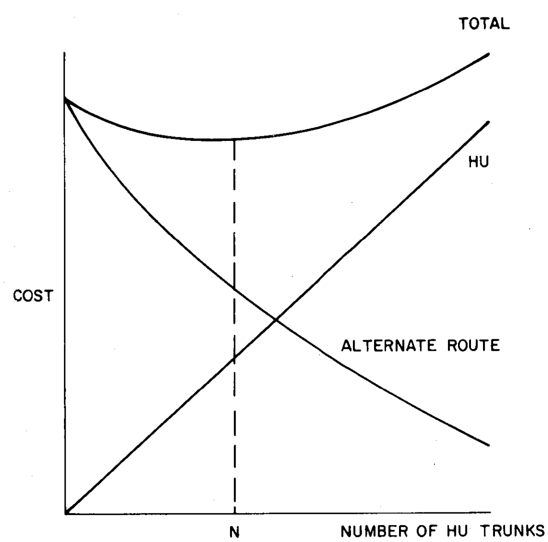


Fig. 2—Relationships Involved in Alternate Routing Arrangement

If there are no HU trunks, all of the offered traffic must be carried on the alternate route so that the incremental 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 incremental 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. 2.

*This principle may be illustrated by assuming the case of a step-by-step switching system offering a call to a group of ten 1-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 the following equation which is the basis of ECCS engineering.

$$\frac{\text{CALT}}{\text{CHU}} = \frac{28}{\text{ECCS}}$$

Where: CALT = Cost of a path on the alternate route

CHU = Cost of a trunk on the HU route

28 = Capacity in CCS added to the alternate route by the addition of an incremental trunk (path)

The equation is solved for the ECCS which is the load to be carried by the "last" or least efficient trunk in the HU trunk group. Given the ECCS and the offered load, standard trunking tables can be entered to determine the number of trunks required which is the largest number of trunks for which the load carried on the last trunk is not less than the ECCS.

2.09 Since the equation is solved for the ECCS, the other elements of the equation must be known. The left portion 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 Thus it can be seen that with low cost ratios, the ECCS will be high and fewer HU 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 HU trunk group, the less traffic will be overflowed to it.

2.12 It will be noted in Fig. 2 that the total cost curve has a rather broad minimum. As a result, errors in ECCS which might result from minor cost ratio or incremental CCS errors will not have a significant impact on network costs.

EFFECT OF LOAD VARIABILITY

2.13 The number of HU 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. Where such variability is present, equivalent random engineering techniques are required and Neal-Wilkinson capacity tables are used to size grade-of-service engineered trunk groups.

NONCOINCIDENT BUSY HOURS

2.14 Traffic volumes reach peaks during certain hours. Trunks 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, trunks 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, trunks 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 an HU 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 HU 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 administrative costs and traffic measurement variability, 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.

NETWORK DIALING—AUTOMATIC SELECTION OF ALTERNATE ROUTE

3.04 The principle of alternate routing is basic in the design of the network. Switching equipment automatically seeks out the alternate routes. The field of application in long-haul networks is more extensive than in short-haul since a call may be subject to routing through more switching systems if long-haul.

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, HU 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 in tandem in accordance with 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 in Part 3, Section 3. Appendix 2, entitled "Routing Patterns Under the Switching Plan," describes how alternate routing is used.

APPENDIX 2

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. Economic and other considerations determine various individual patterns. Examples are included.

1.02 Figure 1 illustrates many (although not all) permissible High-Usage (HU) trunking patterns within the framework of the standard routing plan. It should be understood that the traffic items permitted to justify HU trunk groups between switching systems which are not the same class or which have more than one class difference are limited by the one-level limit rule discussed in Appendix 3.

2. TYPICAL ROUTING PATTERNS

2.01 Figure 2 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 HU 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 HU trunk group (between C and R) were busy, the call would next be offered to the HU 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 HU trunk group to Q or, if all trunks in this group were busy, (2) over the final route chain S - R - 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. At D, all HU 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 HU trunk groups.

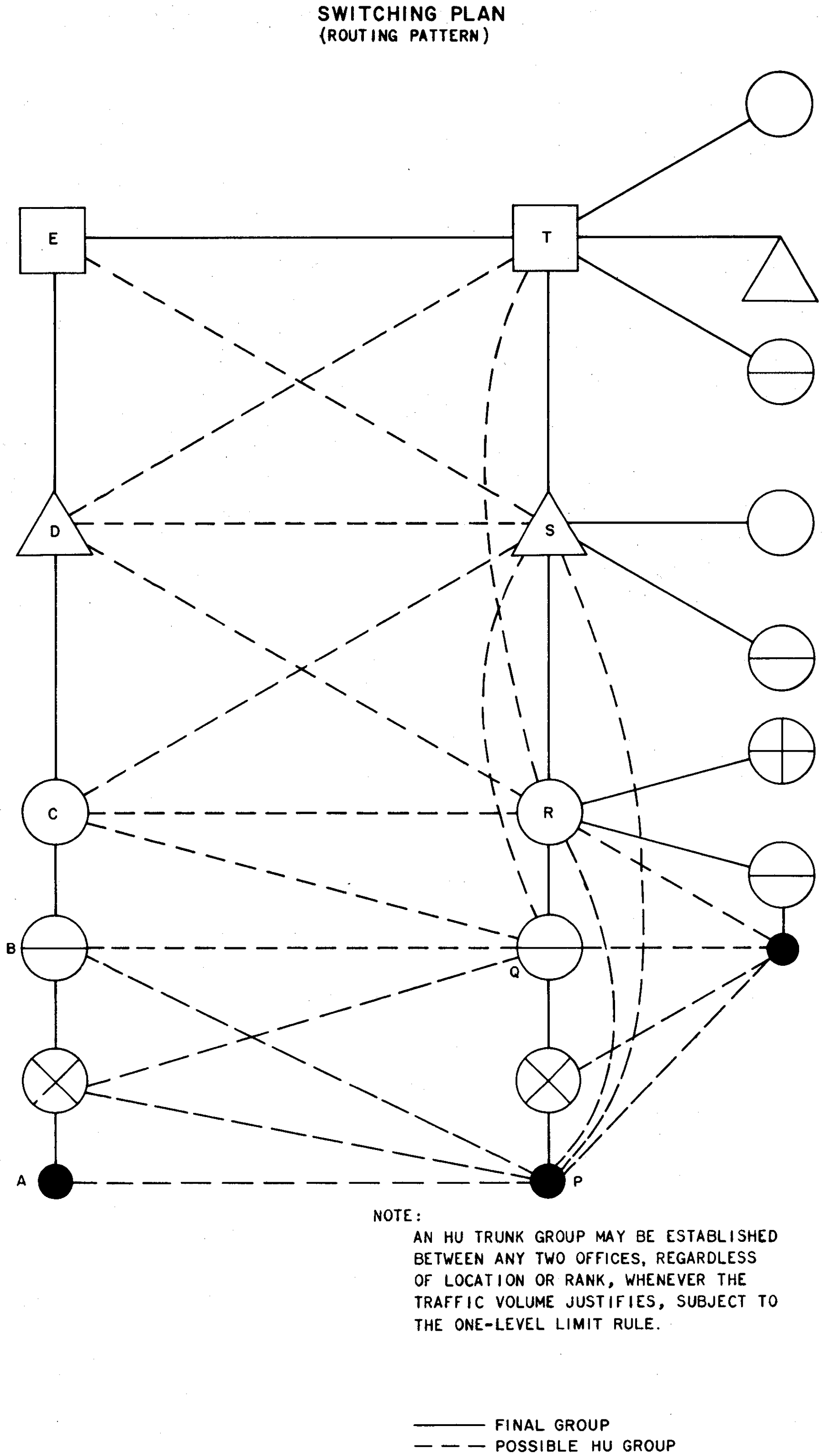


Fig. 1—Standard Routing Plan High-Usage Trunking Patterns

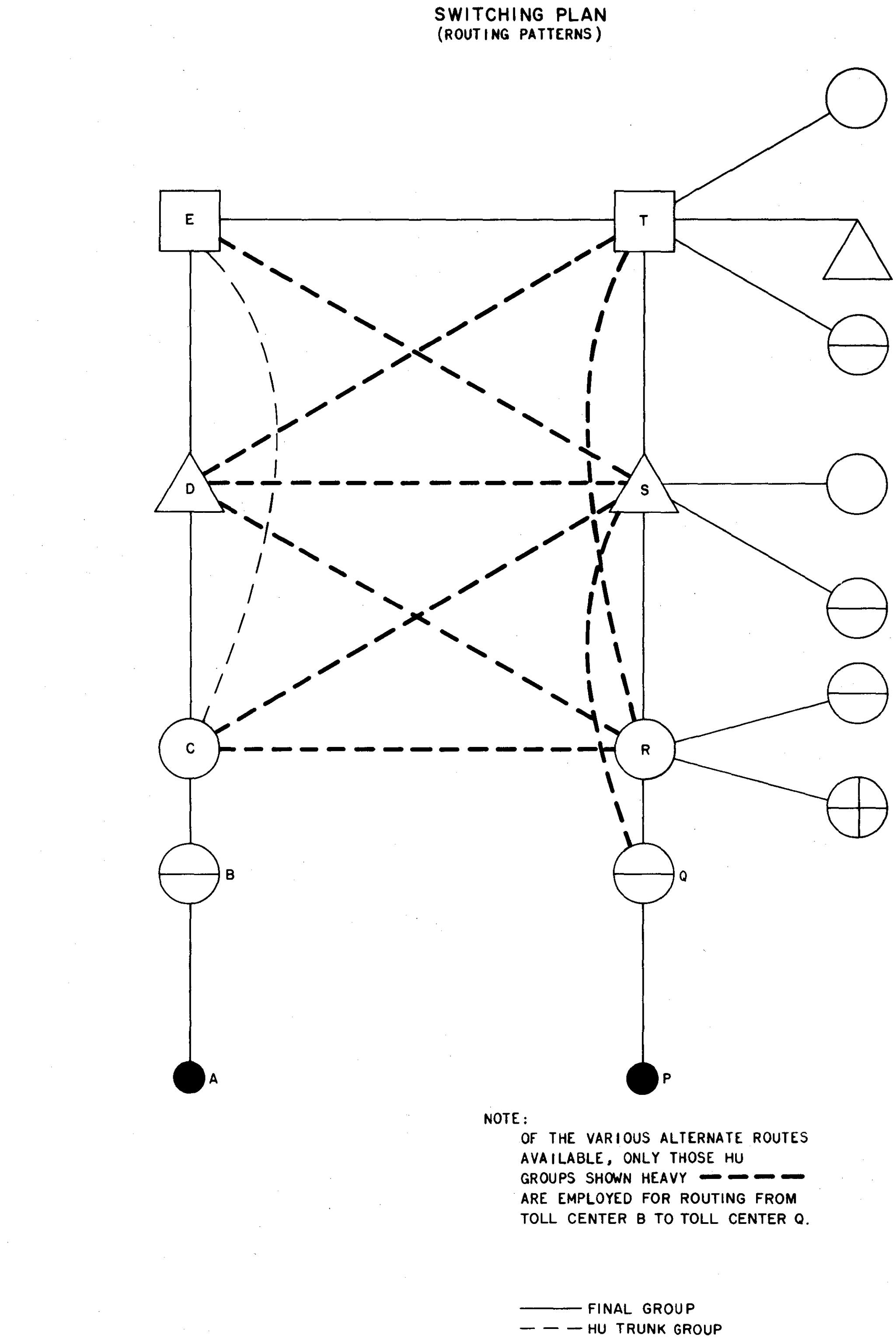


Fig. 2—Typical Routing Pattern

APPENDIX 3

ONE-LEVEL LIMIT RULE

1. GENERAL

1.01 In general, a High-Usage (HU) trunk group may be established between any two offices if the volume of the traffic items permitted to route over it, and the 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 limit rule" has been established.

2. DEFINITION

2.01 The basic purpose of the one-level limit rule is to avoid the use of a high class 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 necessary. Under the one-level limit rule, an HU trunk group can only be justified by those first route traffic items for which the switching functions performed at each end of the trunk group differ by no more than one level. Once justified, other items may also route over the group as discussed in paragraph 3.05. The group must, of course, be sized for all traffic offered to it. Illustrations of proper application are provided in subsequent paragraphs.

3. SPECIFIC APPLICATIONS

3.01 The following are specific applications of the one-level limit rule. In Fig. 1, Toll Center B (class 4 switching function) may have HU trunk groups justified by first routed traffic to:

(a) Toll Center Q (class 4 switching function ***same*** as B)

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

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

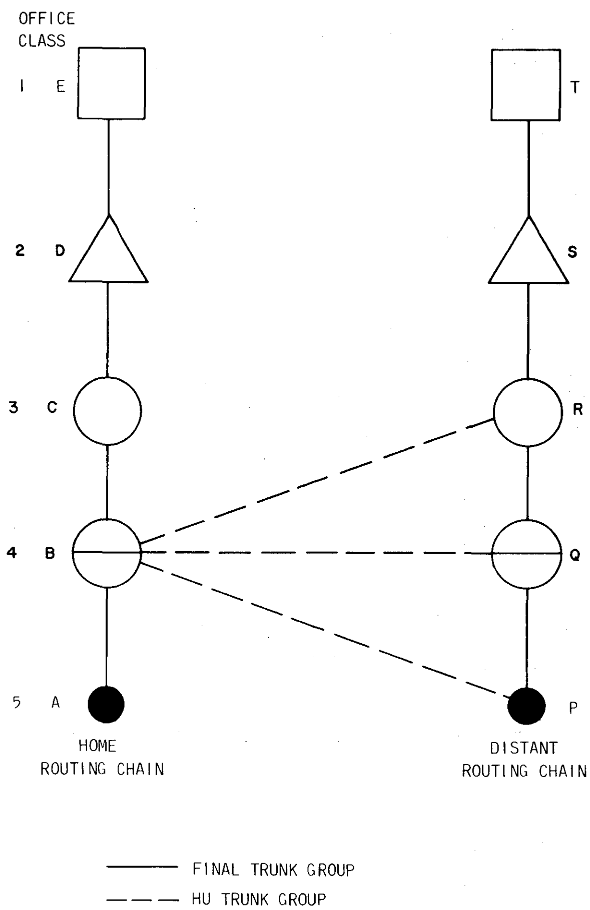


Fig. 1—Application of One-Level Limit Rule to Trunk Groups Out of a Class 4 Office

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 limit rule permit an HU 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 limit rule is shown in Fig. 2. In this case, the B - S trunk group is justified by the traffic load utilizing the class 3 and class 4 switching functions of Sectional Center S. In this illustration, there is insufficient traffic to justify HU 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 HU trunk groups at lower hierarchical levels as soon as traffic volumes and costs can justify them.

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 if justified by the class 4 switching function performed by that regional center switching system (Fig. 3), ie, 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 the T routing chain destined for A will use this trunk group. This follows the principle of utilizing the most direct HU 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 limit rule applies also to the home routing chain in a manner similar to that for a distant routing chain. In Fig. 4, for example, an HU 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

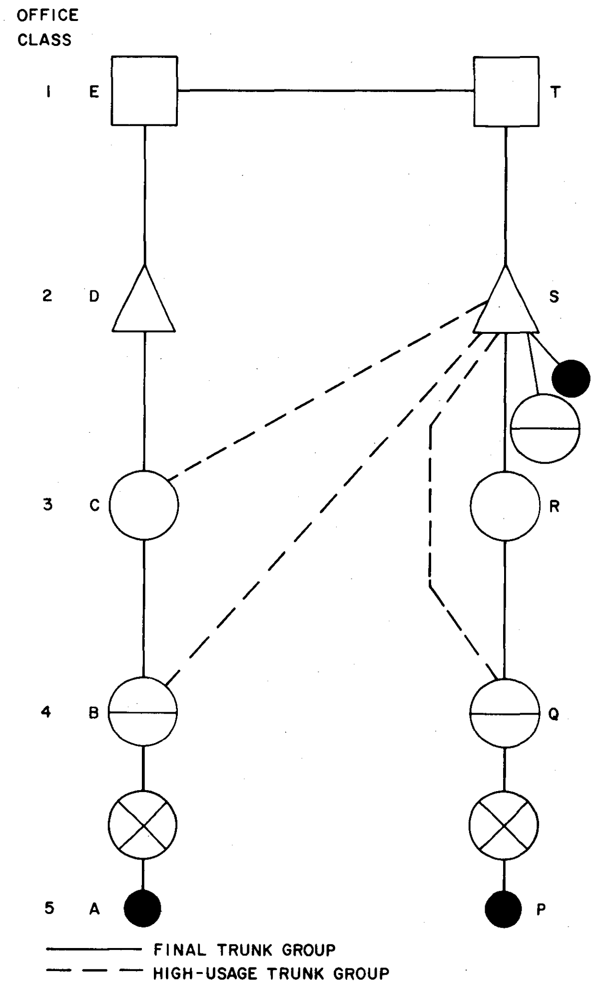


Fig. 2—Application of One-Level Limit Rule to B - S Trunk Group

performs a class 4 switching function. Similar HU routes can be established for the various classes of switching systems and 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.

3.06 Figure 5 illustrates the application of the one-level limit rule to the trunk groups out of a class 4X office. The switching function performed by the class 4X switching system is intermediate between 5 and 4. Therefore, in accordance with the rule, trunk groups can be justified by traffic items for which the switching function performed at the distant end of the group is either 5, 4X, or 4. Trunk groups from B′ to P, Q′, or Q are therefore permissible. Trunk groups to R, S, or T can be justified only by the switching function 4 loads at those switching systems, ie, for the end offices homed directly on R, S, or T.

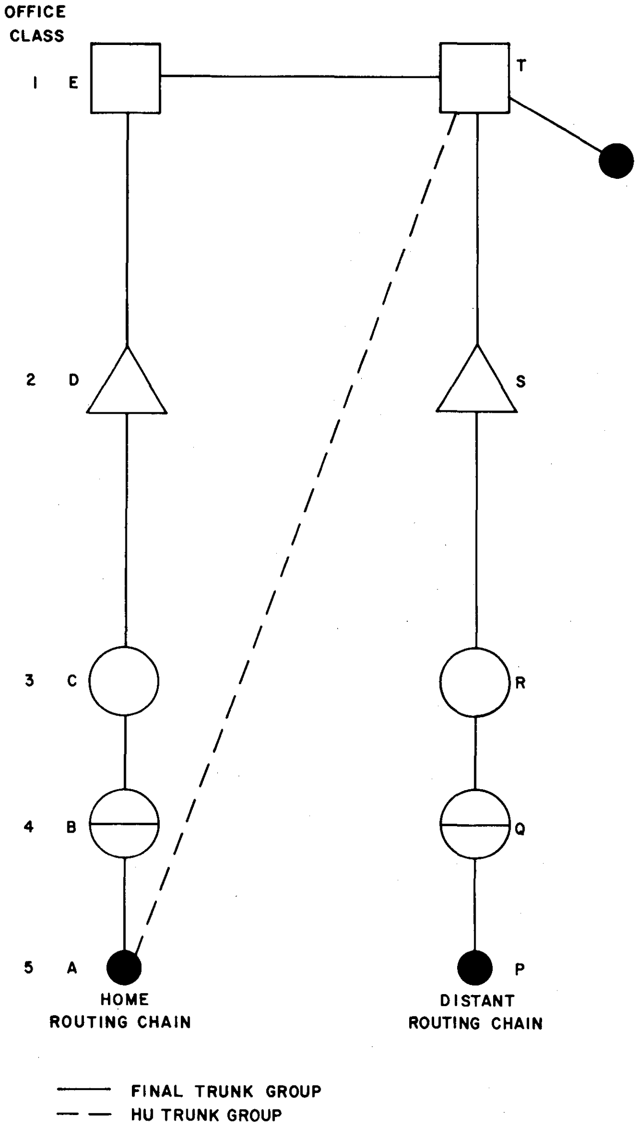


Fig. 3—Application of One-Level Limit Rule to Establish a Trunk Group Between an End Office and a Distant Regional Center

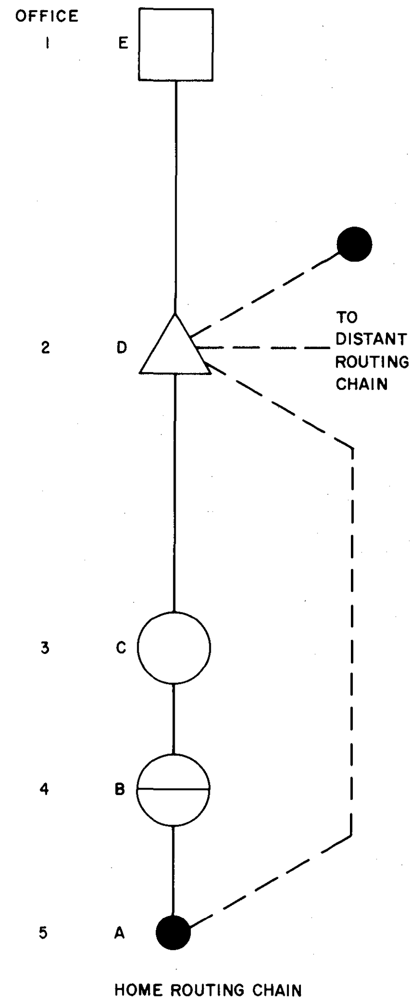


Fig. 4—Application of One-Level Limit Rule to Establish a Trunk Group Between an End Office and a Sectional Center

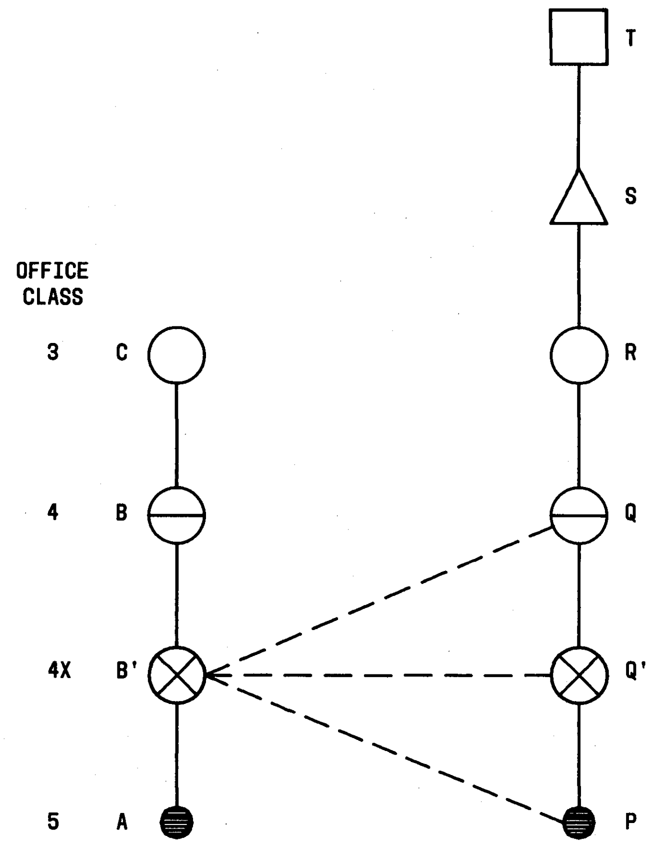


Fig. 5—Application of One-Level Limit Rule to Trunk Groups Out of Class 4X Office

APPENDIX 4

CLASS 4X OFFICE AND REMOTE SWITCHING UNITS

1. GENERAL

A. Introduction

1.01 The availability of digital Stored Program Control (SPC) switching systems with Remote Switching Unit (RSU) capabilities affects the provision of Centralized Automatic Message Accounting (CAMA) for class 5 offices, the acceptability of certain Traffic Service Position System (TSPS) routing and incoming tandem trunk configurations, and the specification of RSU/host office hierarchical classifications. Therefore, clarification of current guidelines for office classification and homing arrangements is needed as this modern technology is introduced in the network.

1.02 This appendix provides that clarification. It reviews newly sanctioned trunking and routing arrangements and discusses associated switching, signaling, trunking, transmission, maintenance, and network management requirements. In particular, emphasis is placed upon the post-dialing signaling delay as affected by deployment of some of these new arrangements.

1.03 The impetus for these changes has come from the introduction of local digital SPC switching systems in the network. In a number of locations, the addition of local digital SPC offices for modernization purposes will offer the opportunity to provide CAMA recording capabilities at small incremental costs. These local offices will often serve as host for RSUs and may also provide recording for nearby electromechanical class 5 offices. Since these SPC offices are frequently located on a main facility route or are natural facility hubs, the opportunities for performing not only recording but other concentration functions (including the tandeming of incoming traffic) are enhanced.

B. Planning

1.04 Planning for the evolving network should be a joint Bell-Independent Telephone Company effort since the plans of one likely affect the plans of others and influence the determination of the most economical industry solution. Proper classification of switching systems in the network hierarchy is essential to the trunk provisioning and design process, to assure an adequate grade of service to all customers, and to minimize degradation of voice and data transmission on calls regardless of length or number of links.

1.05 The switching plan for distance dialing was formulated to meet the requirements for a plan that would route traffic automatically, economically, and rapidly to its destination. The plan incorporates switching and trunking arrangements that adhere to the rules of a hierarchical network. It contemplates that most calls will be completed on direct intertoll trunks or over two or three intertoll trunks switched in tandem. Still, a small portion of the total number of calls may currently encounter as many as seven intertandem trunks plus the usual two tandem connecting links to end offices. This possibility imposes a need for careful transmission, signaling, and switching system design as well as diligent maintenance effort.

2. NEW OFFICE CLASSIFICATIONS, TRUNKING, AND HOMING ARRANGEMENTS

A. Host Office Classifications

2.01 ***Classifications and Settlements:*** An RSU shares the class 5 designation of its host office. Furthermore, pure RSU/host configurations should always carry class 5 designations. New symbols have been established to identify the RSU and the RSU host office. (See Fig. 1 and 2.)

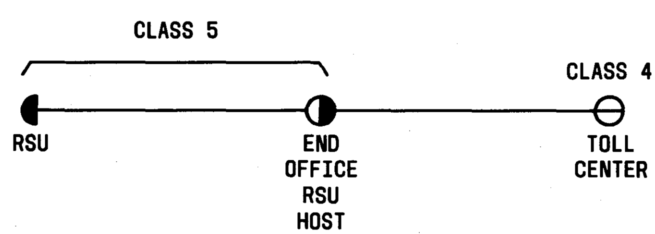
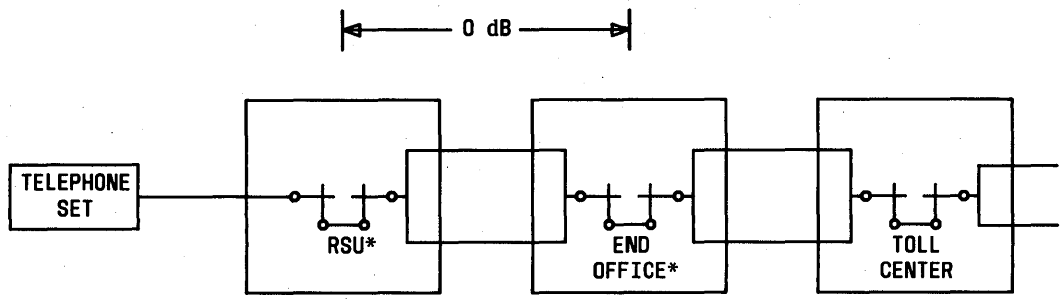


Fig. 1—Standard RSU/Host Office Classification and Homing Arrangements



* MAY BE 2- OR 4-WIRE SWITCH

Fig. 2—Transmission Path

2.02 ***Pair Gain Applications:*** An RSU may also be deployed in pair gain applications. Some applications are planned, implemented, and administered as part of a particular subscriber feeder route. Although potentially large in size (several hundred lines or more), such installations do not possess such distinguishing wire center features as a well-defined area boundary, a service order access point for all customer facilities within the area, and other technical and administrative characteristics of a wire center location.

B. 4X (Intermediate Point) Function

2.03 To effect implementation of newly sanctioned CAMA, TSPS, and incoming tandem arrangements, a new class of office, 4X, has been established to describe an office that is interposed between a class 5 office and a conventional class 4 office in the network dialing hierarchy. In order to qualify for a 4X designation, the digital SPC switching system should be essentially "transparent" to the network, ie, maintain the same service levels between normal class 5 offices and class 4 offices as designated elsewhere in the ***Notes on the Network.*** However, this is not entirely possible because the class 4X office introduces additional post-dialing delay in the network. (See paragraphs 3.07 and 3.08.) The class 4X function is similar to the normal class 4 function in that it connects end offices to each other over grade-of-service trunk groups and to the network for originating and terminating traffic. In addition, the class 4X function may also perform a class 5 function by connecting subscriber lines to each other and to the network for originating and terminating traffic. However, the class 4X function is limited by the routing, homing, signaling, transmission, trunking, and blocking considerations discussed herein.

2.04 The constraints on the class 4X function are more clearly defined in subsequent paragraphs of this appendix. The new class 4X office function has been designated an Intermediate Point (IP) in the hierarchy and a new symbol has been devised. (See Fig. 3.) A revised routing ladder illustrating the position of the class 4X IP office in the network hierarchy is shown in Fig. 4.

SYMBOL	CLASS	NAME	ABBREVIATION
⊗	4X	INTERMEDIATE POINT	IP

Fig. 3—Class 4X Function Designation

2.05 ***Provision of CAMA for Class 5 Offices:*** CAMA is normally provided only at class 4 or higher offices. Consequently, where recording capability is provided in a class 5 office and that office is used to provide recording for other class 5 offices, the office has automatically assumed a class 4 designation in the switching plan and must be homed on a class 3 or higher office. (A current standard CAMA arrangement is shown in Fig. 5.)

2.06 Changes in this arrangement are now possible with the advent of the class 4X office, provided that the CAMA location is transparent to the subscriber and to the network. The exception to the signaling transparency requirement is discussed in Part 3 of this appendix. The class 4X

CAMA location ***must*** meet all the appropriate constraints listed in Part 3. (A possible class 4X office CAMA arrangement is shown in Fig. 6.)

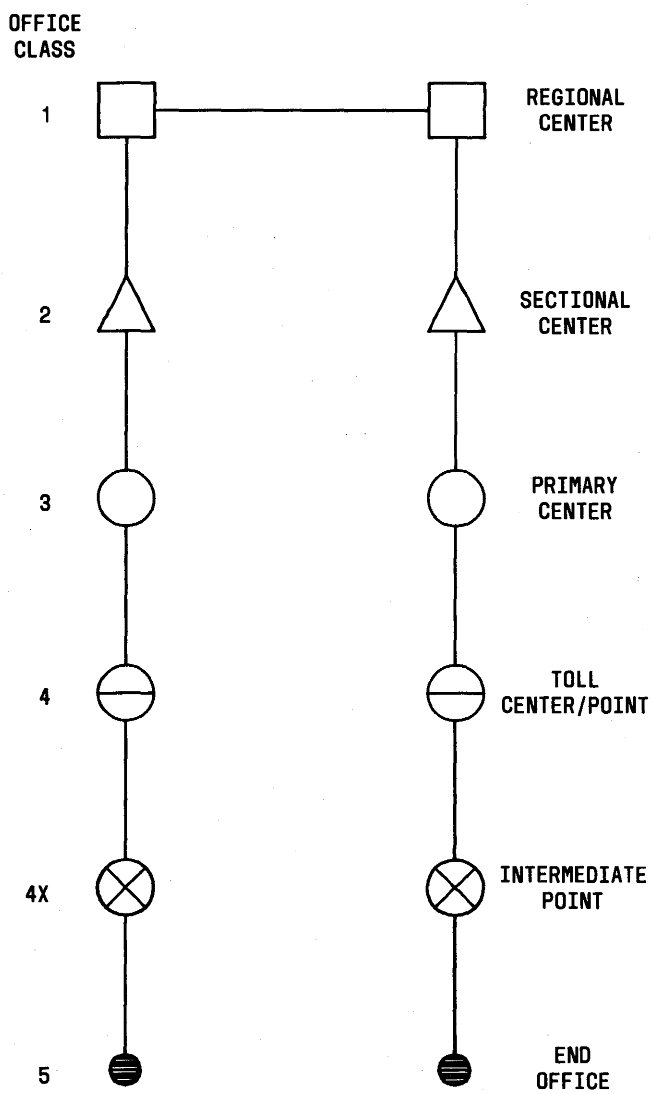


Fig. 4—Routing Ladder

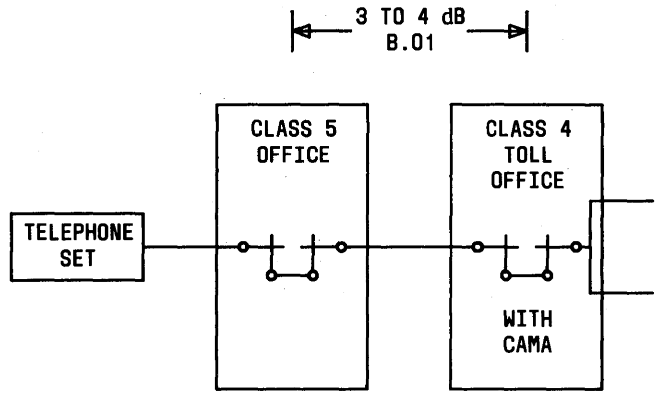


Fig. 5—Current Standard CAMA Arrangement

2.07 ***TSPS Trunk Concentration and Routing:*** TSPS trunk concentration at a class 4X office is ***not*** recommended at the present time. However, switching is permissible if the class 4X office is arranged to associate each individual incoming TSPS trunk with a predetermined outgoing TSPS trunk on a one-to-one basis. This dedication will assure that each call from a class 5 office to a class 4 office is always connected over a fixed path and thereby provides individual trunk control from the TSPS or Remote Trunk Arrangement (RTA) location.

2.08 The relationship of end offices (class 5) and toll switching offices (class 4) are well-defined in Section 3, Part 2. The class 4 office function currently provides the first step of concentration for network traffic originating at end offices and the final stage of distribution for traffic terminating at end offices. (See Fig. 7 for a current standard TSPS/RTA arrangement.)

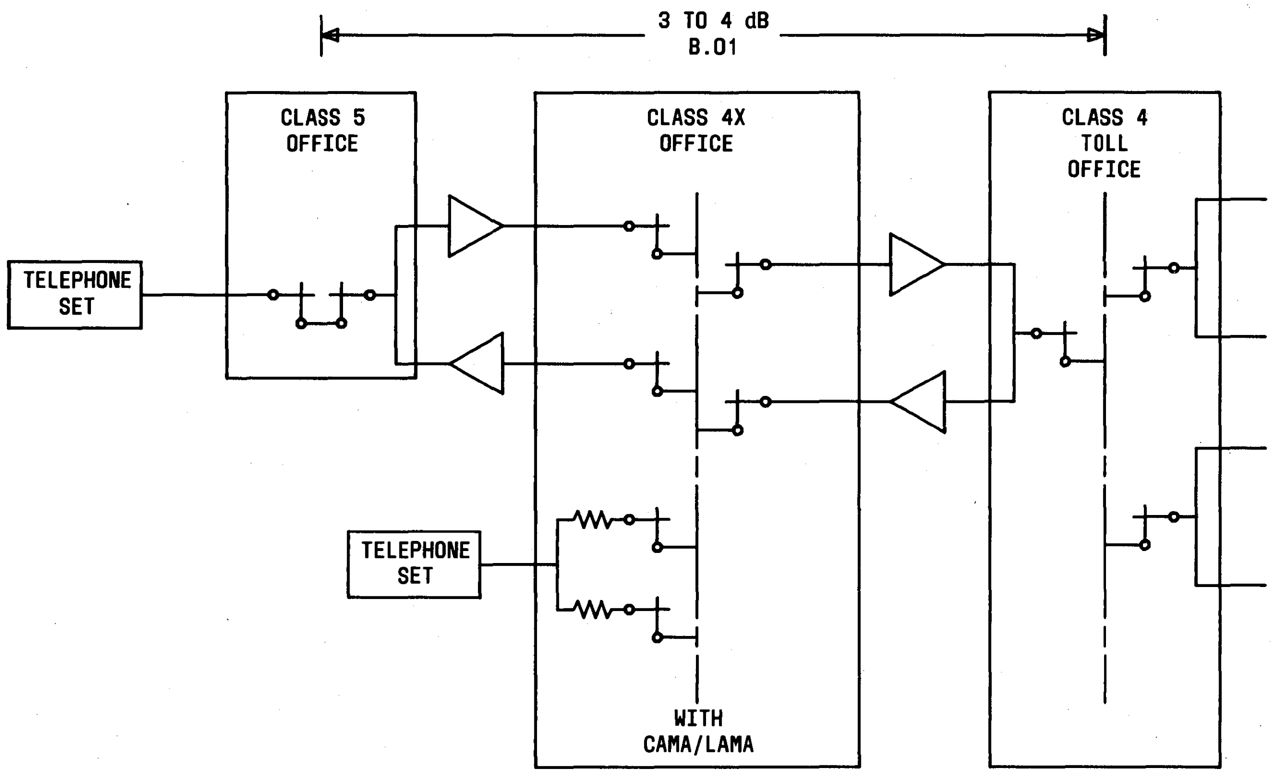


Fig. 6—Class 4X Office CAMA Arrangement

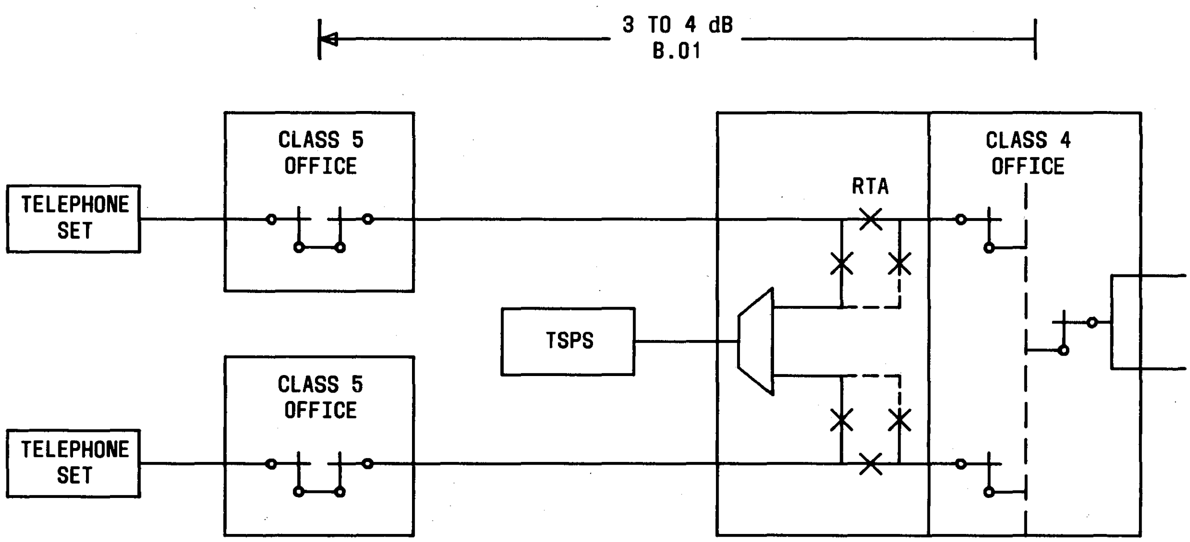


Fig. 7—Current Standard TSPS/RTA Arrangement

2.09 Any arrangement that seeks to interpose a switching office, ie, class 4X office, between the class 5 and the class 4 office for TSPS routing must provide the same grade of service designated by the prescribed switching plan. (See Fig. 8 for one possible class 4X office TSPS/RTA arrangement.) In addition, constraints discussed in Part 3 of this appendix must be met.

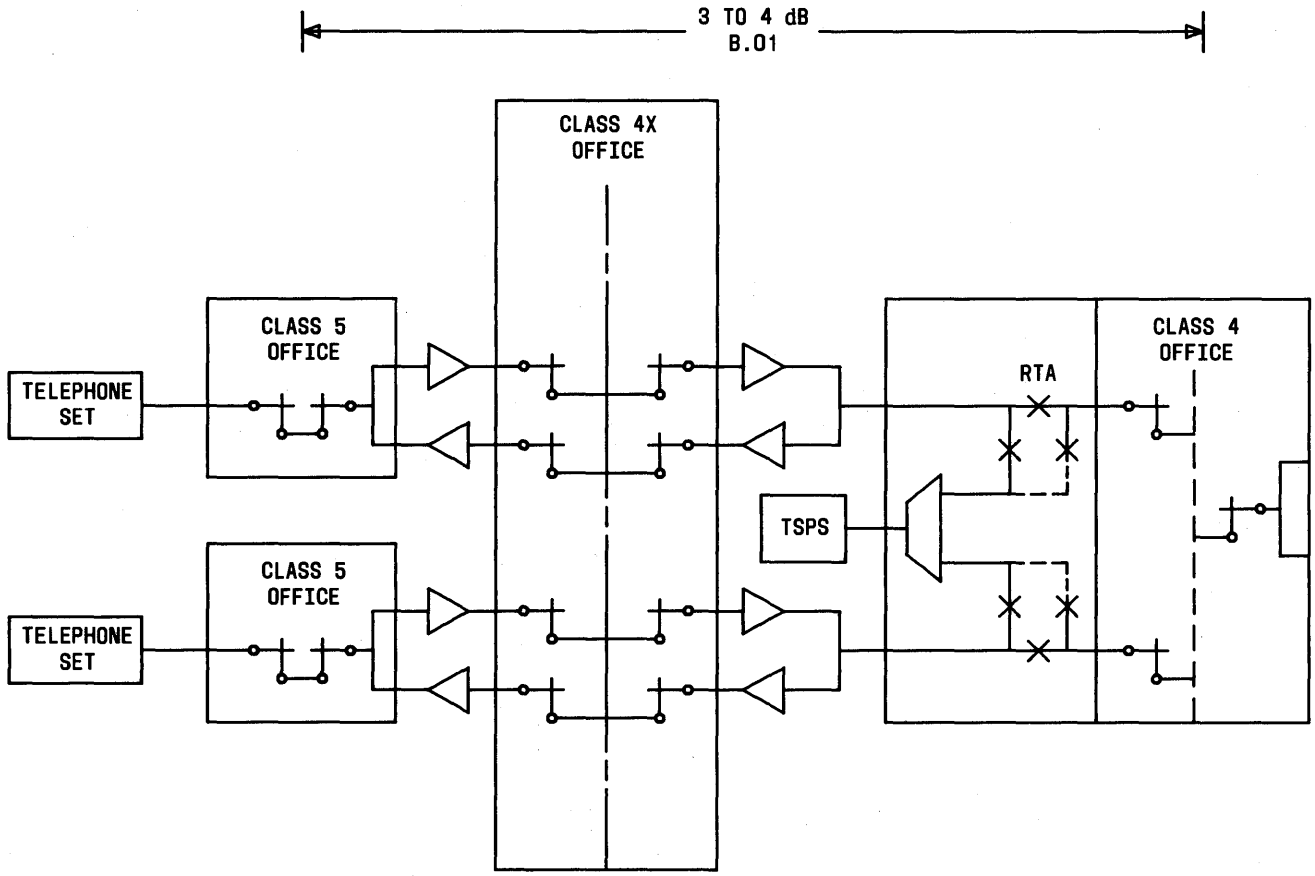


Fig. 8—Class 4X Office TSPS/RTA Arrangement

2.10 ***Incoming Tandem Arrangement for Terminating Traffic:*** Switching systems proposed for use as a class 5 office should normally have direct trunks from the class 4 office. (See Fig. 9 for the current standard arrangement for terminating traffic.) Exceptions to this arrangement are possible with the class 4X office, provided that the constraints in Part 3 of this appendix are met and that the class 4X office performs the incoming tandem function. No tandem or through switching will be permitted at the conventional electromechanical class 5 office. (See Fig. 10 for one possible class 4X office incoming tandem arrangement for terminating traffic.)

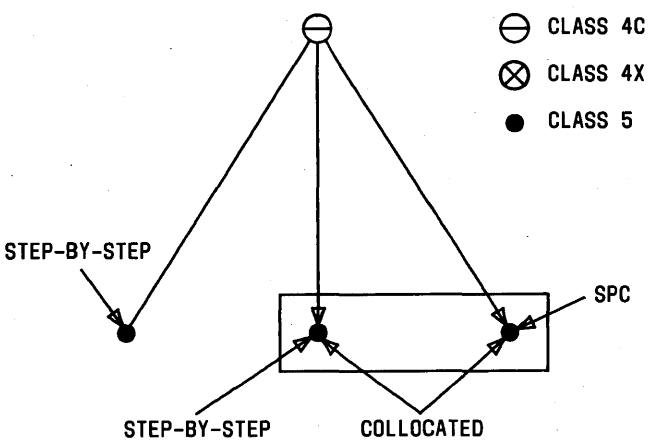


Fig. 9—Current Standard Arrangement for Terminating Traffic

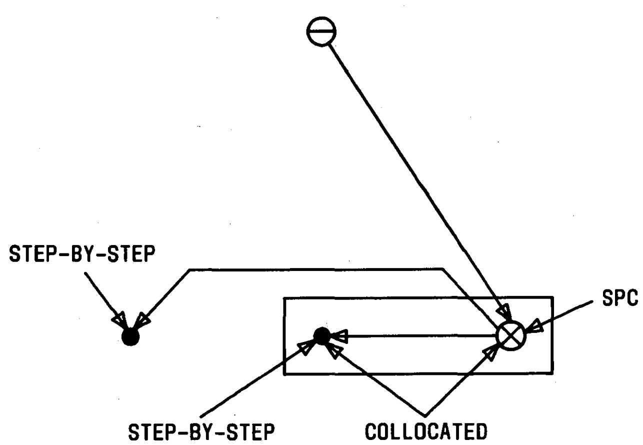


Fig. 10—Class 4X Office Incoming Tandem Arrangement for Terminating Traffic

3. CONSTRAINTS ON THE CLASS 4X FUNCTION

A. Introduction

3.01 The following paragraphs discuss the constraints which must be satisfied in order to deploy class 4X office arrangements in the network. Each application should be analyzed and evaluated on its own merits considering the anticipated benefits and possible risks, especially in view of the post-dialing delay effect discussed in paragraphs 3.07 and 3.08.

B. High-Usage Trunking

3.02 High-Usage (HU) trunking is permitted at a class 4X office but not at subtending class 5 offices. This constraint is necessary to preclude overflow on the 5-4X group which is sized using procedures which assume Poisson-distributed traffic. Also, this constraint is necessary to maintain the integrity of existing software support systems, which assume a 5-level hierarchy, including trunk forecasting, trunk servicing, network planning, and network maintenance systems.

3.03 Only-route groups which do not overflow are permitted at class 5 offices subtending the class 4X office and to connect subtending offices to the class 4X office for access to and from the toll network. These only-route trunk groups out of the subtending class 5 offices to other than the class 4X office should be sized for B.01 blocking using normal procedures.

C. One-Level Limit Rule

3.04 Under the one-level limit rule, the switching function performed for the first-routed traffic by the switching system at either end of the HU trunk group may be of the same class number of switching function or may differ by only one class number of switching function. In the case of the class 4X office, one class level above is class 4 and one class level below is class 5.

D. Switching

3.05 The class 4X office should be an essentially nonblocking switching system with appropriate synchronization arrangements.

3.06 Trunk concentration arrangements must have an overall probability of blocking that is no greater than that of current arrangements. Refer to paragraphs 3.15 and 3.16 for further details on the blocking service objective and its allocation.

E. Signaling

3.07 The class 4X office should not cause any loss of signaling information. However, it will impart additional signaling delay on calls through the switching system. In order to prevent the addition of unacceptable dial pulse signaling delay to the connect time (ie, end of dialing to start of ringing) of a call, the class 4X office may not home on a step-by-step class 4 office. In the case of other class 4 switching systems (ie, electromechanical or SPC), the additional signaling delay should not exceed an average of 2.5 seconds. This can be accomplished by utilizing either multifrequency signaling or common channel interoffice signaling capability. Further, the class 4X office must provide for proper reaction to supervisory signals and appropriate call seizure and disconnect timing. In this regard, answer supervision timing across the class 4X office of approximately 22 ms must be provided (ie, similar to the requirement for other toll offices in the network).

3.08 For class 4X TSPS/RTA arrangements, additional signaling requirements include provision of Automatic Number Identification (ANI), trunk group and originating office identity information, coin control and ringback capabilities, and TSPS control features (eg, ANI/Operator Number Identification [ONI], release guard, TSPS hold, distant end make-busy, overload control, etc).

F. Transmission

3.09 There should be no perceptible transmission impairment introduced by any class 4X office configuration. In order to avoid potential degradation in transmission performance, it is a requirement that the class 4X office be a 4-wire digital SPC switching system. In addition, 4-wire facilities are required on the 4X-4 links and are preferred on the 4X-5 links. Transmission quality will be impaired least when both 4-wire trunking and switching are utilized. Refer to paragraphs 3.15 and 3.16 for additional information on transmission objectives and allocations.

3.10 At this time, concentration of TSPS trunks at an intermediate switching point is ***not*** recommended. Therefore, the normal TSPS trunk design rules and maintenance plan are in effect from the end office to the TSPS bridging point. If the transmission path of TSPS trunks is through an intermediate digital switching system (eg, 4X), treatment is the same as for a digital carrier system.

G. Maintenance and Testing

3.11 The class 4X office should have make-busy features and trouble diagnostic, testing, and service restoral capabilities equivalent to current arrangements.

3.12 The class 4X office will be responsible for toll connecting trunk (ie, 5-4X link) terminal balance testing into the subtending class 5 offices, since the upstream class 4 toll office can no longer select those trunks.

H. Network Management

3.13 The class 4X office should have adequate network management capabilities where applicable, eg, traffic data, routing control, and overload control.

I. Economic Studies

3.14 Appropriate economic studies must be performed prior to implementation of these new arrangements; applications will frequently involve Bell-Independent Telephone Company joint studies. Wherever a study includes a 4X alternative, an evaluation should also be made of the more common class 5—class 4—class 3 hierarchical arrangement to ensure deployment of the most economically effective network. It should be made clear that the 5-level hierarchical arrangements are preferred for service reasons because the 4X arrangements introduce additional post-dialing delay in the network.

J. Blocking and Transmission Service Objectives

3.15 The blocking requirements between the class 5 and class 4 offices remain unchanged, ie, B.01. However, when a class 4X office is interposed between the class 5 and class 4 offices, blocking on the two links, ie, 5-4X and 4X-4, must be allocated to achieve B.01 overall. It is recommended that the 4X-4 link be sized to B.01 using normal procedures and the 5-4X link be sized so it is essentially nonblocking as is done with RSU/host links. This procedure involves converting the average busy season time consistent busy hour load, which would normally be used for sizing, to an equivalent 20-day Return Period Load (RPL) and then entering the Wilkinson B capacity tables with the RPL to determine trunk requirements.

3.16 Existing transmission requirements for tandem connecting and intertandem trunk design other than balance apply to the class 5 to class 4X and class 4X to class 4 office links, respectively. These requirements and allocations are applicable only to class 4X office arrangements for CAMA and terminating traffic as exemplified in Fig. 6 and 10. Balance requirements for these arrangements must ensure performance at the class 4 office equivalent to that which currently exists with a single tandem connecting trunk.

K. RSU/Host/4X Tandem Connections

3.17 At this time, a class 5 office may not host an RSU and still subtend the class 4X office; ie, RSU to host to class 4X connections are not permitted in tandem in the same final route chain. This is necessary to avoid the potential violation of transparency and signaling requirements referenced in this appendix.

4. SUMMARY

4.01 In evaluating the possible application of any "4X office arrangement" described in this appendix, it is imperative that all aspects of originating and terminating traffic be thoroughly analyzed for each case. Particular attention should be given to signaling delay, TSPS traffic, maintenance arrangements, and failure modes. Any arrangement that has a deleterious effect on service objectives, transmission levels, and especially signaling delay should be carefully considered before being implemented.

4.02 It should be emphasized that an orderly program is necessary to coordinate the introduction of new technological advances in the Message Network. Decisions in the technical area should be based on fundamental planning studies which consider all practical alternatives (with the ultimate plan selected on the basis that is least costly) and which consider service implications.

NOTES ON THE NETWORK
SECTION 4
EQUIPMENT AND SYSTEM REQUIREMENTS

CONTENTS PAGE

CONTENTS PAGE

1. GENERAL

1.01 The equipment arrangements and features described herein for originating and completing calls through the public switched telecommunications 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 various sections throughout the publication.

2. TERMINAL EQUIPMENT

2.01 Terminal equipment consists of that apparatus provided on the customer's premises to permit the telephone user to originate and/or receive communications over the exchange and toll networks. This equipment generally provides incoming and outgoing signaling, local switching, concentrating, and 2-way communication; but it is not limited solely to these functions.

2.02 Customer premises terminal equipment must comply with the requirements specified in Part 68 of the Federal Communications Commission (FCC) Rules and Regulations as a prerequisite for connecting to the network. Part 68 of the FCC Rules and Regulations contains requirements for the registration of terminal equipment which is to be directly connected to the telecommunications network for those services covered by the FCC Rules and Regulations.

2.03 Terminal equipment that responds to an incoming signal either rings a bell or operates some other alerting device to make the terminal equipment user aware that there is an incoming call on the line. When PBX Direct Inward Dialing (DID) 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. Upon answer, an off-hook indication is returned by the terminal equipment to the central office. With a PBX or Key Telephone System (KTS), the off-hook indication may be returned by the system rather than by the called station.

2.04 Terminal equipment, arranged for outgoing signaling, establishes an off-hook condition and initiates address signaling (dc pulses or tone signals) on a line to operate central office or terminal switching equipment to route a call to its destination.

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

2.06 Direct current is normally supplied to the terminal equipment over the local distribution wire pairs from a common battery located in the serving central office. This direct current is used for signaling the central office and, in some applications, for energizing the transmitter. With DID service, the terminal equipment provides the direct current source for signaling and supervision. The PBX also furnishes talk battery to its associated station terminals.

2.07 Individual lines are central office lines which serve only one customer. There may be several items of terminal equipment 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 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 employ various types of multiple frequency ringing such as harmonic ringing systems.

2.09 Terminal equipment arranged for outgoing signaling generates supervisory off- or on-hook signals (Section 5) and either dc pulses or Dual Tone Multifrequency (DTMF) pulses to 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, or an electronic equivalent, are used to generate dc pulses (alternate opens and closures of a dc loop) which are transmitted on a central office or PBX line. (See Section 5.)

2.11 The DTMF keyset is used to generate tones needed to operate central office or PBX equipment. The keyset is arranged to generate a pair of specific frequencies whenever one of the buttons is depressed. (See Section 5.)

2.12 Terminal equipment is divided into three basic categories:

(a) Terminals such as telephone sets, data modems, and ancillary devices (eg, answering sets and repertory dialers),

(b) KTSs, and

(c) PBXs.

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 is a terminal instrument which permits 2-way, real-time voice communications with a distant party over the network. It converts voice and voiceband acoustic signals into electrical signals suitable for transmission over the network and, conversely, converts received electrical signals into acoustic signals. A telephone set generally generates the control signals required to initiate a call on the network and to respond to an incoming call. A telephone set generally 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 or PBX.

2.14 A KTS is an arrangement of multiline telephone station apparatus and associated equipment which allows a user to selectively answer, originate, or hold calls over a specific central office or PBX line. Lines are selected or held by operating buttons (or keys) which are mounted either separately or internally to the station apparatus. Visual indications display line status, such as line select, busy, idle, hold, and ringing. Audible alerting generated internally or externally to the station apparatus is normally provided by bells or other means. Other features, such as intercom, toll restriction, exclusion, and conferencing may be provided either internally or connected externally through KTS auxiliary interfaces.

2.15 PBXs are either manual (paragraph 2.16) or dial (paragraph 2.17) 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.

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 dialing or DTMF signaling is used on central office lines terminated at a switchboard.

2.17 A dial PBX is also an assembly of equipment which allows individuals within a community of users to communicate with each other and provides access to and from the network by means of trunks between the PBX and the serving central office. Such connections within the PBX or to the switched network are made by the PBX equipment in response to user dialing action. When an appropriate access code is dialed, a PBX station can be terminated to a trunk to a central office, thereby gaining access to the network as indicated by a second dial tone. Subsequent dialing of the 7- or 10-digit number of the called party will result in the eventual completion of the call. An attendant position may be provided for answering incoming calls and for user assistance.

2.18 With PBX DID service, a central office call can be completed to the PBX station without operator assistance since the dial PBX 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 them through an attendant position. A dial PBX can be classified as either a manual switchboard (paragraph 2.19) or a console (paragraph 2.20) depending upon the type of attendant position. It can also be classified as either a direct control system such as a step-by-step system (paragraph 2.21) or a common control system such as crossbar or electronic (paragraph 2.22).

2.19 The manual switchboard (attendant position) associated with the dial PBX equipment is similar in appearance and operation to the manual PBX switchboard discussed in paragraph 2.16. 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.

2.20 Consoles serve the same purpose as attendant switchboards. However, they employ keys rather than jacks, cords, and cord circuits. Consoles are used rather than manual switchboards for reasons of appearance and efficiency. They occupy less space and reduce attendant motion.

2.21 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.

2.22 A common control PBX is one that uses common (or shared) control equipment to establish all connections. Common control PBXs may be either crossbar (paragraphs 2.23 and 2.24) or electronic (paragraphs 2.25 through 2.29). A typical common control system contains the following main parts:

(a) A switching network which provides the stages of switching for connecting an originating station line or outgoing trunk to the appropriate terminating station line or incoming trunk. These functions can be performed by electronic or electromechanical devices within the PBX.

(b) Trunk circuits which provide a dedicated supervision and signaling interface between the PBX switching network and the trunk facility terminating in the serving central office. In some cases, these trunk circuits also furnish battery to the network to perform the dc signaling and supervisory functions.

(c) Line circuits which provide a dedicated supervision and signaling interface between the station conductor loops and the associated terminals and/or ports on the line side of the PBX switching network. They also provide ringing current and battery to the remote terminal equipment.

(d) Originating registers which receive and store the address information dialed from the calling central office or terminal equipment. Typically, registers are shared by many PBX-central office trunks and/or PBX line circuits and are, therefore, connected to either the trunks or lines for a short period of time. The registers may also provide a dial tone to calling stations or trunks.

(e) A junctor circuit which completes line circuit to line circuit connections through the switching network. Typically, each junctor is shared by many line circuits. A junctor provides ringing current to the called station and talking battery and supervision for the calling and called stations.

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

2.23 In a crossbar PBX, the switching network is composed of a crossbar switch matrix through which a path is established by the operation of specific select magnets followed by the operation of hold magnets. This interconnects two verticals over a selected horizontal path called a link.

2.24 In a crossbar PBX, the logic element is usually a marker which 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 service bid in each trunk group and one station service bid in each horizontal group, sequentially.

2.25 In newer electronic PBX systems, use of a centralized stored program common control and solid-state devices permits a considerable reduction in the amount of equipment installed on the customer premises. The stored program directs all the processing and diagnostic maintenance routines as well as traffic data collection on switch units.

2.26 Electronic PBX systems may employ time division or conventional space division switching. In either case, printed wiring boards are usually the basic hardware element of the system on which are mounted integrated circuits, transistors, diodes, resistors, networks, etc.

Diagnostic maintenance printouts are often employed as part of the basic maintenance routines to indicate when circuit packs require replacement.

2.27 Time division switching is an application of the principle of speech sampling. This permits a number of conversations to use the same transmission path and drastically reduces the need for a large number of transmission paths.

2.28 Time division speech samples can be directly processed in their analog format. Alternatively, in a digital PBX, they are quantized and encoded into digital signals.

2.29 A hybrid PBX/KTS is a system that can be arranged through the common equipment to satisfy the definition of dial PBX and KTS as included in paragraphs 2.17 and 2.14, respectively. In particular, a PBX/KTS is an assembly of equipment which allows an individual within a community of users to originate or answer calls to or from the public network or other users (PBX line) within the community, and also allows a user to selectively answer, originate, or hold calls over a specific central office line.

3. DIAL SWITCHING EQUIPMENT

3.01 Network dialing places no restriction on the type of dial switching system (direct or common control) provided at class 4 or 5 offices. These may be step-by-step, crossbar, or electronic type switching systems. However, the facilities should have the capability to send, receive, and be actuated by the signals discussed in Section 5. Common control switching systems, which include crossbar and electronic type systems, are used in many instances to effect economies in switching traffic and to provide uniform dialing procedures. Class 1 and 2 offices are always equipped with common control switching systems. Class 3 offices are equipped 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 dialing plan for the network and requires a 10-digit address to identify the called station. However, the number of digits actually passed between offices may vary. Table A shows the minimum number of digits that all switching systems must be arranged to receive over incoming trunks. It may be desirable for a system to receive more than this minimum

TABLE A

MINIMUM NUMBER OF DIGITS SWITCHING SYSTEMS SHOULD BE ARRANGED TO RECEIVE FROM THE 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 generally need the number of digits indicated. Class 4P offices homed on class 3 offices equipped with direct control switching will frequently require seven digits.

2. Most class 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 class 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.

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.

3.03 Connections established through the network from customer terminal equipment to customer terminal equipment are generally controlled by the originating (or calling) terminal. Control signals in the form of off- and on-hook signals and address information in the form of dial or DTMF pulses will activate the originating local office switching system which, in turn, will connect to the network to provide a voice-grade transmission path between the originating and terminating terminal. The network or, more specifically, the various switching systems will provide the necessary audible supervisory signals to the originating terminal equipment indicating the progress of the calls and an alerting signal to the terminating terminal equipment indicating that a call is waiting. These tones and signals are described in greater detail in Section 5.

LOCAL SWITCHING SYSTEMS (CLASS 5 OFFICES)

3.04 Local switching systems provide access to the network. A telephone user can originate or receive communications to or from the network via a local switching system. The basic function of any switching system is to provide communication paths between originating customer terminal equipment and terminating customer terminal equipment. If both are homed on the same switching system, the communications path is through the one switching system only. If they are homed on different switching systems, the communications path is established via the telephone network. The switching systems function either as direct progressive control systems or as common control systems.

3.05 Direct progressive control systems use the pulses from the customer's dial or from other switching systems to directly drive the switching equipment. As the customer dials, each stage of switching responds to the dialed digits, thus, selecting a path progressively through the switching system until the called customer's line is reached. Direct control equipment is employed in step-by-step switching systems.

A. Direct Control Switching Systems

3.06 Many step-by-step switching systems are equipped with registers which are temporarily connected to the originating (or calling) customer line during the dial and call setup period. The customer-dialed digits are collected in this register and then outpulsed to the rest of the switching system. These outpulsed digits need not be the same as those dialed by the customer since the register can convert the original dialed digits into the proper pulsing information associated with a particular called party. If blocking occurs during the call, the register still has the dialed digits and a second attempt is possible. The registers are not dedicated to each customer but are common to many.

3.07 On local calls within the system or calls completing from distant switching systems, dial pulses actuate switches or relays in proper sequence to connect the calling customer to the called customer terminal equipment.

3.08 On outgoing calls to other switching systems, the central office (or NXX) code actuates switches or relays in the originating switching system to select a trunk to the distant switching system. The remainder of the dial pulses are transmitted to the distant switching system which completes the call to the called customer terminal equipment.

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.

B. Common Control Switching Systems

3.10 Common control equipment accepts dial pulses or DTMF signals from calling stations and dial pulses or MF signals from other switching systems. This address information is stored while the system determines the proper disposition of each call and then makes the connections accordingly. Common control equipment is employed in Electronic Switching Systems (ESSs) and crossbar switching systems.

3.11 On local calls within the system or calls completing from other switching systems, the incoming pulses or address information is first stored in a register. The common control processing unit which converts address information into equipment location then establishes a connection through the switching network to the called customer terminal equipment. If the called station is busy, the system returns a 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.

3.12 On outgoing calls to other switching systems, the system stores the address information received from the customer's equipment in a register. The common control processing unit which converts the address information into equipment location and routing information establishes a connection to an outgoing trunk equipment. After receiving a start signal from the distant end (assuming the trunk group is arranged for controlled outpulsing), the call processor controls the outpulsing of the address information to the called switching system using either dial pulses or MF signals.

3.13 Some common control switching systems have the ability to delete or convert digits, as required, to facilitate routing of calls at succeeding offices. An alternate route may be selected when the direct or most direct trunk group cannot be used.

3.14 Marker-type common control systems also use registers; but instead of driving the switches directly, the digits are passed to a marker. A marker is a wired logic unit which makes translations, tests possible paths before selecting one, and then operates the proper switches to make the connection. The crossbar switching system uses the marker to control both originating and terminating traffic.

3.15 ESSs use a central processor or Stored Program Control (SPC) to control the system. Rather than employ the wired logic of the crossbar system, ESSs use the electronic SPC to process, maintain, and administer all calls in an ESS.

3.16 SPCs manage a switching system by employing the concept of time-sharing of control; ie, the central processor simultaneously handles many calls in various stages of completion. The central processor executes one function per call in a very short time interval and then progresses to perform the same or different function on the same or different call.

3.17 In providing new services in an electromechanical system, it is often necessary to redesign circuits and to rewire them extensively in the field. In SPC systems, it is usually only necessary to change the stored program by electronically changing instructions in memory.

3.18 Because of the increased flexibility of ESSs, many new services have been made available which were economically unattainable with the older electromechanical systems. Some of the new basic services include: (1) Call Waiting, (2) Call Forwarding, and (3) Speed Calling.

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

3.19 Two types of switching systems are used in the toll network; they are electromechanical crossbar switching systems with common control equipment and ESSs which are processor controlled. However, some 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 network and to provide economical traffic routing arrangements including alternate routing for some trunk groups.

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

3.20 The No. 4 crossbar and No. 4 ESS are currently being used for many of these offices. Most No. 4 crossbar offices are equipped with the crossbar Electronic Translator System (ETS). The No. 1/1A ESS with a HILO network* is also being used to serve the need for small- and medium-size 4-wire toll offices. The features described in paragraphs 3.22 through 3.24 for the 2-wire common control and electronic arrangements are all used in the 4-wire toll offices as well. However, these 4-wire offices do not require through (office) balancing. 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.

*The HILO technique is a means of obtaining 4-wire transmission on a physical 2-wire path.

3.21 The No. 4 ESS is a completely electronic solid-state switching system. It was developed for toll and tandem switching applications to be used as a class 1, 2, 3, or 4 office. This system provides a replacement vehicle for existing electromechanical toll offices and combined toll/local tandem offices. The No. 4 ESS is a 4-wire electronic toll switching system employing a solid-state time division/space division digital switching network. It provides features comparable to those available in No. 4A crossbar systems equipped with ETSs. This system also provides a significant number of improvements. The No. 4 ESS also serves as an international switching center.

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

3.22 Crossbar tandem, No. 1/1A ESS, and No. 5 crossbar offices are often used for tandem and toll switching offices. The No. 1/1A ESS is used for new offices in small- and medium-size toll centers. These types of offices can be arranged to provide CAMA service for its tributaries and each must be balanced to meet transmission objectives.

3.23 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).

3.24 Traffic alternate routing arrangements are used to provide the most economical trunking arrangements. (See Section 3, Appendix 1.) Traffic separation peg counts are used for division of revenue purposes.

C. 2-Wire Direct Control (Class 3 and 4 Offices)

3.25 These are 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 (AMA) for their tributaries.

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

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

DIGIT CAPABILITIES AND TRANSLATION

3.28 ***Digit Capacities:*** Table B is a summary of digit and translation capacities for various switching systems. Any particular installation may not be equipped for the full capacity shown.

3.29 The dialing plan for the network employs the principle of destination code routing. Each customer terminal is assigned a unique 10-digit number which consists of a 3-digit area code, a 3-digit central office code, and a 4-digit station number. (See Section 2.)

3.30 ***Six-Digit Translation:*** When a Foreign Numbering Plan 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.)

3.31 ***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:

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

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

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

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

TABLE B

DIGIT CAPACITIES OF VARIOUS SWITCHING SYSTEMS

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

Notes:

1. Also translates three and four digits for TX calls.
2. Also translates four and five digits for TX calls.
3. 4- and 5-digit translation (although fully flexible in these systems) is used at present principally for TX codes.
4. Includes one or two exit digits.
5. Early crossbar tandem designs do not include all items listed in table.
6. Additional dial pulse digits may be sent if necessary.
7. Other No. 4 ESS options are possible but have no CAMA application.

(e) 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 paragraph 3.33.)

(f) 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.)

3.32 ***Prefixing:*** One, two, or three digits may be prefixed to the received digits. 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 Numbering Plan Area (HNPA) code to the office code and numbers received. The latter is necessary to bring the call back to the HNPA when it is routed via an office in an adjacent NPA.

3.33 ***Code Conversion:*** Digits may be substituted in some systems 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 toll office can delete some of the seven digits and instead furnish digits which fit the switching train.

TRUNK CIRCUITS

3.34 Per-trunk signaling* circuits should be arranged to transmit and receive on- and off-hook signals as required and discussed in Section 5. Common Channel Interoffice Signaling (CCIS) trunks should be arranged to meet the requirements specified in Section 6. Toll switching systems capable of CCIS include the No. 4 and No. 1/1A ESSs. The No. 4 crossbar switch equipped with an ETS is also capable of CCIS but requires significant equipment modifications.

*With per-trunk signaling (as opposed to CCIS), each trunk circuit contains its own signaling mechanism.

3.35 It is desirable that all operator trunks 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.

3.36 ***Joint Control Trunks:*** Although the 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:

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

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

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

3.37 ***Two-Way Trunks:*** Two-way trunks should have the following operating characteristics:

(a) The calling end of a 2-way trunk should be held busy 750 to 1250 ms for terrestrial facility operation and 1050 to 1250 ms for satellite facility operation after sending the disconnect signal forward to the called end. Note that with the No. 1 ESS, these intervals are 800 to 1000 ms for terrestrial facility operation and 1600 to 1800 ms for satellite facility operation. During this "guard" interval, off-hook supervision from the called end cannot be recognized.

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

3.38 ***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" and is discussed in Section 5.

SPECIAL REQUIREMENTS

3.39 Calls to inward operators are operator dialed but 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.)

3.40 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.

3.41 Equipment arrangements should be such that selection of the called customer's line will not occur until all digits (including the start [ST] signal on MF pulsing) have been received. Level hunting connectors used on dialed calls to reach PBX terminals should be arranged not to trunk hunt until all digits have been received.

3.42 Recorded announcements and various tones are used to advise calling customers of call progress. In most cases, the calling party will receive either a recorded announcement or a call progress tone to indicate a call completion failure.

3.43 The network imposes special requirements on signals and features sometimes found in local central offices. 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.

3.44 Control of the connection is achieved as follows:

(a) 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 5 seconds in overload conditions in ESS offices to 32 seconds in most other Bell System designed equipment.

(b) On operator-dialed calls, the connection between the operator and the calling customer should be under joint control except for the TSPS. With TSPS, joint control may be retained at the operator's discretion.

3.45 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.

4. OPERATOR SYSTEMS

4.01 Although the vast majority of calls completed through the network are established directly by the customer, there are many situations which require the services of an operator. Operators can be grouped into the two following major categories according to the functions performed:

(a) ***Toll and local assistance operators*** who directly assist in the completion of calls and assist in special billing arrangements

(b) ***Number service operators*** who provide information necessary for call completion.

4.02 Within the toll and local assistance category, there are three sets of functions:

(a) ***Toll originating functions:***

(1) Provide billing functions for calls not presently handled by switching systems. Examples are credit card, collect, and person-to-person calls and coin calls for which the operator rates the call and controls the collection and return of coins.

(2) Provide special services such as conference and call-back calls.

(3) Place calls to nondialable points such as certain mobile radios and marine stations and some foreign countries.

(4) Provide a manual switching capability where required.

(b) ***Assistance functions:***

(1) Answer customer requests for emergency assistance.

(2) Assist customers with miscellaneous requests, such as verifying busy-idle status of lines, accepting requests for credits, providing dialing instructions, and completing local calls when the customer encounters dialing difficulties on the network.

(3) Provide miscellaneous functions, such as night answering service for the telephone company business office and repair service, opening doors via remote control, and discharging plant alarms.

(c) ***Calling number identification function:*** Identifies the originating party on a dialable call not automatically recorded in the central office through the CAMA-Operator Number Identification (CAMA-ONI) operator. An operator is called in to request the calling number, which the operator then keys into the switching system for entry on the billing tape. The CAMA-ONI operator is located at either a tandem or toll switching point.

4.03 In the ***number service category,*** there are also three functions:

(a) Directory assistance operators respond to customer calls to 411 or (NPA) 555-1212 and also provide information to toll operators when required.

(b) Intercept operators handle calls to an unassigned or changed number.

(c) Rate and route operators provide operators with routing codes, rate information, and lists of numbers that are possible coin lines.

4.04 A typical topological view of operator locations in the network is presented in Fig. 1. Note that when a customer dials 0 for operator, an assistance operator responds.

INTERCEPT SYSTEMS

4.05 Calls attempted to nonworking numbers must be routed to a recorded announcement or intercept operator. Incoming calls to discontinued numbers are intercepted in the terminating central office and routed directly to an intercept operator. The caller must be told that the number is no longer assigned and, if possible, given the new number for the called party. Reassignment of a discontinued number is delayed long enough to ensure that very few calls intended for a previous customer will be routed to the number.

4.06 Calls destined for vacant and unequipped numbers are presently routed to a recorded announcement that tells the customer a nonworking number has been reached and invites the customer to stay on the line if the help of an operator is needed. Calls to changed or disconnected numbers are routed directly to an intercept operator, along with calls from customers who did not hang up after hearing the recorded announcement. The intercept operator asks the caller what number he/she is calling, consults a printed record of nonassigned numbers which is updated daily, tells the customer the status of the called number, and gives a new number if one is available.

4.07 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 (AIS) which should be arranged for cut-through to an operator.

4.08 The use of busy, reorder, audible ringback, "no such number tone," or no tone at all is considered unsatisfactory.

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

(a) Return neither answer supervision nor flash

(b) Not differentiate between local and toll calls

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

4.10 The AIS is designed to improve the processing of calls to nonworking numbers by automating and centralizing intercept service for large geographical areas.

4.11 A simplified block diagram of an AIS is shown in Fig. 2. Typically, an AIS serves a geographical area depending on call volumes. New York City has several. An entire state, such as North Carolina, may be served by a single system.

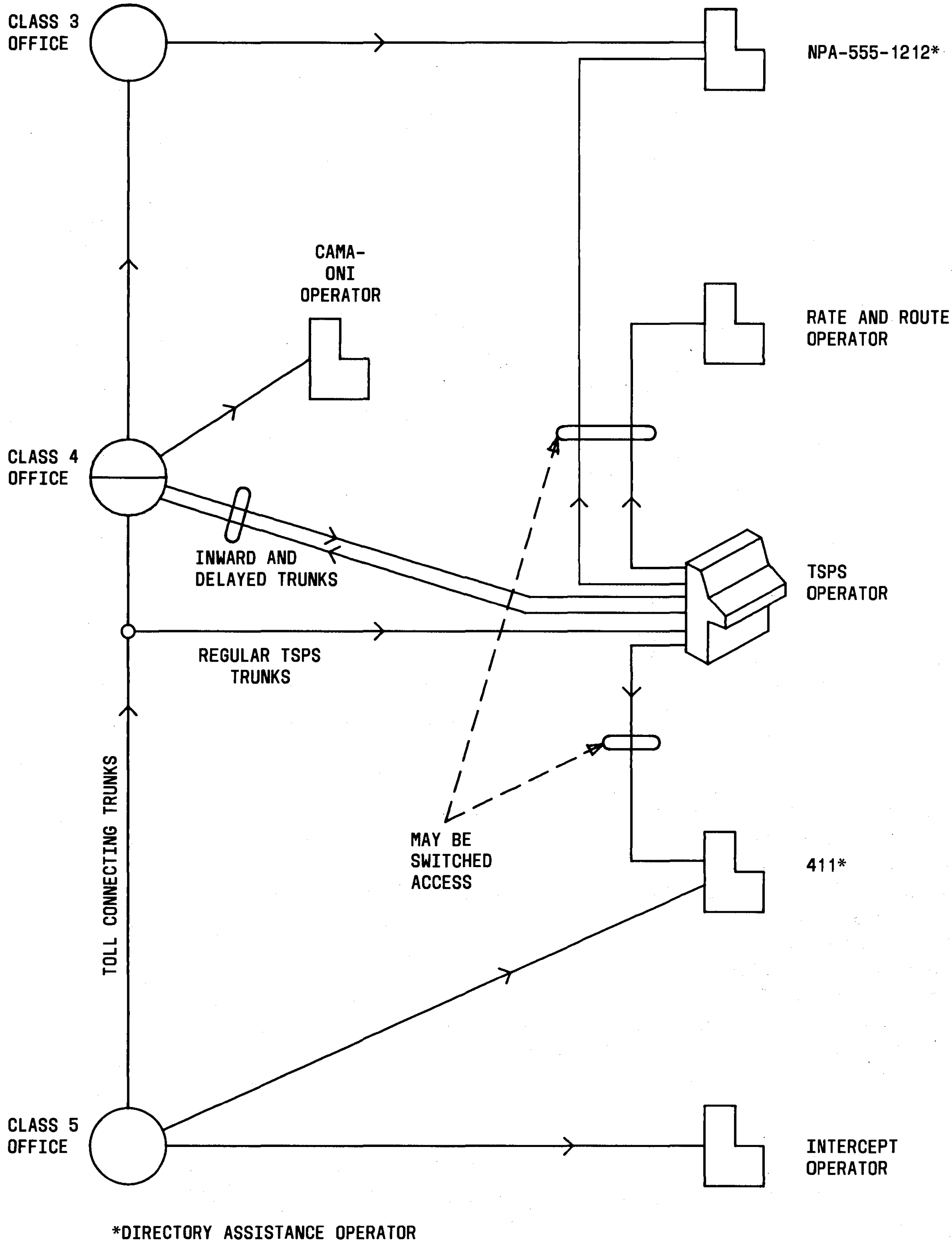


Fig. 1—Typical Topology of Operator Systems

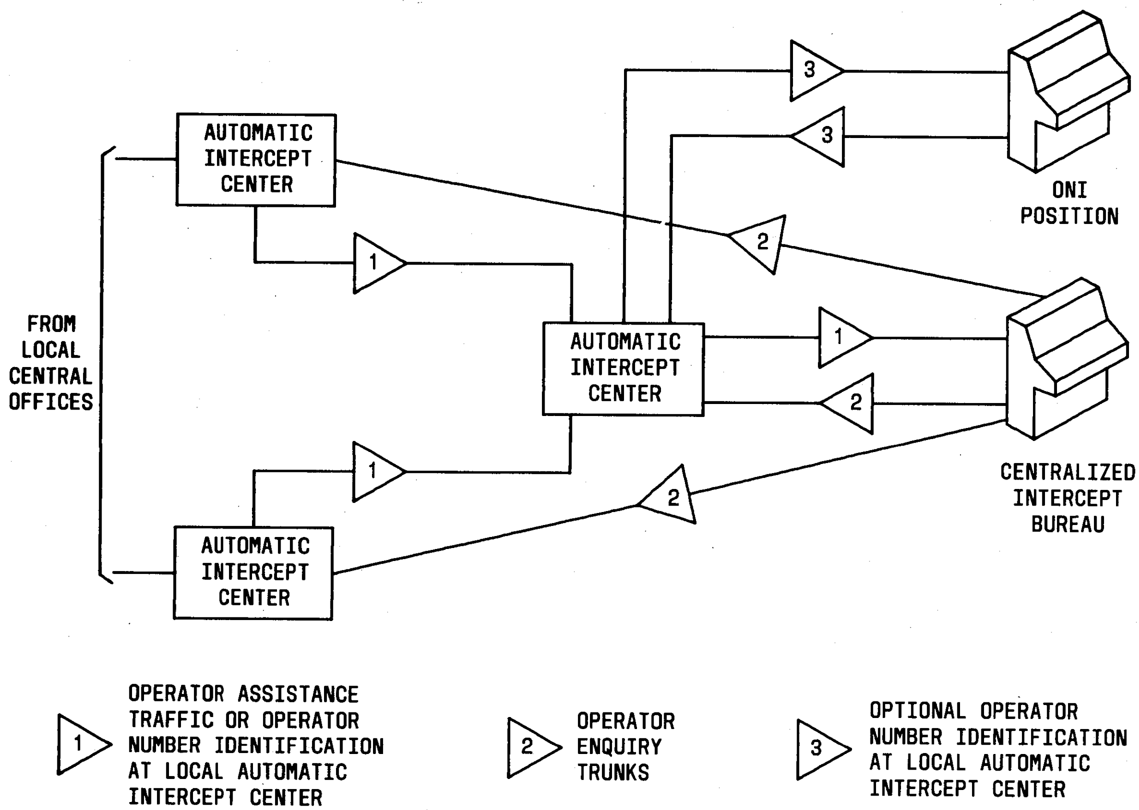


Fig. 2—Automatic Intercept System

4.12 Under automatic intercept service, calls in local offices are routed to a central Automatic Intercept Center (AIC). The files are searched for the called number, and a recorded announcement is connected to the customer's telephone. The "tailor-made" announcement contains all the information available, including the number the customer dialed and a new number if one is available. If the customer still needs help, the call is transferred to a Centralized Intercept Bureau (CIB) where specially trained operators handle the call.

4.13 In offices equipped for Automatic Number Identification (ANI), the intercept circuits are modified to use the ANI equipment for identifying the number. When a call to a nonworking number is intercepted, the number is reconstructed as the seven digits dialed by the customer and is placed in an outpulser. The outpulser is connected to a trunk to the intercept center and outpulses the number to the AIC.

4.14 When a call comes into the AIC from a local office, it is connected to an MF receiver, which receives the digits and passes them to the processor. The processor decides whether to connect a vacant number announcement immediately, to connect the call to a CIB operator, or to look up the called number in the files based upon the central office code dialed.

4.15 For situations in which local offices are not equipped to identify the called number on intercepted calls, ONI is provided at the AIC. Intercepted calls in these local offices are routed to the AIC via intercept equipment in the local office. The local office may handle all intercept traffic in a single trunk group without indication of the type of intercept, or it may send signals to the AIC to indicate intercept class (ie, changed numbers), vacant number, or trouble intercept.

DIRECTORY ASSISTANCE SERVICE

4.16 The incoming trunks to dial switching equipment in each toll center (class 4 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 office homed on that location. Customers in areas equipped for DDD can dial directly to distant points for directory assistance service by dialing 555-1212 for HNPA points and the appropriate NPA plus 555-1212 for FNPA 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 NPA or to an inward operator in the called NPA who will connect the customer with the proper bureau.

4.17 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.

TRAFFIC SERVICE POSITION SYSTEM

4.18 The TSPS is an autonomous system that stands apart from both toll and local switching systems. Functionally, it is placed between the local office and the toll office as shown in Fig. 3. The standard signaling and transmission interfaces for a TSPS are compatible with most of the local and toll switching systems. However, a TSPS outpulses MF only and will not work into a dial pulse office such as step-by-step intertoll.

4.19 The TSPS provides for the types of calls shown in Table C. In addition, the TSPS can handle guest-originated calls from hotels and can provide the hotel with an automatic, immediate teletypewriter printout of the charges.

4.20 International calls are also handled through the TSPS. For customer-dialed, station-to-station calls, the TSPS can serve as a CAMA point to record billing details without operator intervention. When local offices are not modified for international dialing, customers can place calls through the TSPS on a dial -0 basis. The TSPS operator then keys the overseas number, and the call is processed automatically thereafter.

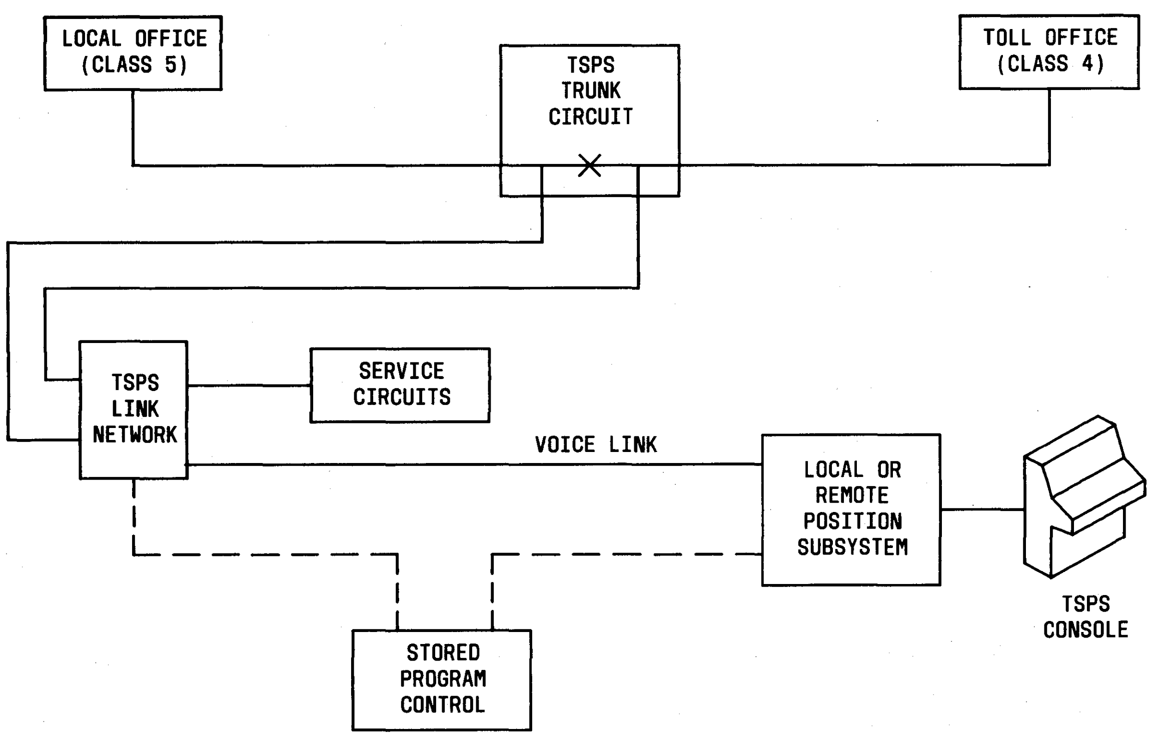


Fig. 3—Traffic Service Position System

TABLE C

TSPS OPERATOR FUNCTIONS

TSPS OPERATOR FUNCTIONS	TYPE OF CALL	
	FROM COIN STATIONS	FROM NONCOIN STATIONS
Obtaining billing information for credit card or third-number calls	1+, 0+	0+
Identifying called customer on person-to-person calls	0+	0+
Obtaining acceptance of charges on collect calls	0+	0+
Identifying calling numbers*	1+, 0+	1+, 0+
Monitoring coin deposits	1+, 0+	
Handling operator assistance calls	0–	0–
Type of call (as it appears on TSPS console)	1+ = Customer-dialed station-to-station calls 0+ = Customer-dialed special calls 0– = Operator assistance calls	

* Needed only when calling number is not automatically identified and forwarded from the local office (not equipped or failures).

4.21 Whenever a call is connected to a TSPS position, all call details are available from the system memory. These call details are directly equivalent to those that would be written on a ticket if the call were processed at a cord switchboard. The calling number, the number that is being called, a credit card number if keyed into the system, the number of a third telephone if one is being billed, or the charging rate on coin calls can be displayed.

4.22 Calls are automatically distributed to all attended positions in such a way that all operators receive an equal share of the traffic load. When a position is given a call, the operator hears a distinctive tone and is given a lamp display. A lamp indicates the type of the originating station, coin or noncoin, and whether the customer dialed 0 followed by 7 or 10 digits (0+), dialed 0 only (0-), or dialed a station-to-station call (1+). (The use of a "1" prefix for station calls is not universal; but for purposes of description, station-to-station calls are often referred to as "1+".)

4.23 As shown in Fig. 3, all trunks have two 2-wire appearances on the link network. The network connects the trunk to various service circuits: digit receivers, outpulsers, coin control circuits, tone circuits, and operator positions. The basic logic instructions for handling calls are in the memory and are executed by a processor. Changes of the supervisory state of trunk, service, and other peripheral circuits (including the positions themselves) are detected by scanners together with programs and memory indicating previous states. Output instructions via signal distributors and central pulse distributors control these circuits and the position lamps. The TSPS is a unique type of system because all the elements of a switching system are present only for the purpose of temporarily connecting equipment units and operators to the trunk circuit.

4.24 Because the TSPS works with any type of local office, it must be able to receive both MF pulsing and dial pulsing over both metallic and carrier facilities. Since the toll office may have either a 4- or 2-wire switching system, both 2- and 4-wire trunk circuits are provided. The 4-wire trunk circuits are used when the toll office has 4-wire switching and the incoming trunk facilities are 4-wire. As indicated in Fig. 3, the operator positions may be remotely located.

4.25 In addition, the Remote Trunk Arrangement (RTA) allows the extension of TSPS coverage to areas served by small toll centers which could not by themselves support a TSPS. As shown in the block diagram of the RTA in Fig. 4, a concentrator is placed near the junction with the toll connecting trunks being served by a TSPS. This concentration allows a relatively small group of circuits to be required over the distance to the TSPS base unit. The remote concentrator is controlled from the TSPS base unit processor via data link.

AUTOMATIC RECORDING OF MESSAGE BILLING DATA

4.26 Direct dialing of station-to-station calls by customers requires that billing data be generated and recorded in order that chargeable calls may be billed. Currently, two billing formats are used to provide details to the customer: bulk billing and detail billing. Bulk billing provides a total usage charge for the billing period. This format is normally used for local calls, ie, single and multimessage unit calls completed within a locally defined message rate area. Detail billing provides all details for each call made during the billing period. This format is normally used for toll calls, ie, calls to points beyond the local calling area. Table D shows the items needed to implement bulk and detail billing. The process of automatic collection, recording, and billing data processing is referred to as Automatic Message Accounting (AMA).

4.27 ***AMA Data Collection and Recording:*** A number of arrangements are available for automatic collection and recording of message billing data. These may be defined as local, centralized, and remote recording systems. They are discussed below.

(a) The Local Automatic Message Accounting (LAMA) systems are those in which the data collection and recording equipment is located at a class 5 (local) office. Chargeable local and toll messages, originated at the office by individual and 2-party line customers, are recorded locally on magnetic or paper tape.

(b) The Centralized Automatic Message Accounting (CAMA) systems are those in which the data collection and recording equipment is located at a centralized switching location, ie, a class 4 or higher ranking office. These systems record data for toll calls originated at connecting local offices not equipped with LAMA and for toll calls originated by multiparty line customers in all local offices. Interaction between the local and CAMA offices is required to obtain the identity of the calling customer. When signaled by CAMA, the local office ANI equipment identifies the individual or 2-party line directory number and forwards it to the CAMA office. Identification of a multiparty line number in an office with ANI or identification of any calling line number in an office without ANI is made with the assistance of a CAMA operator. Message data recorded at a CAMA office are recorded on paper or magnetic tape.

The centralized data collection and recording are also provided by a TSPS, a centralized operator position arrangement, interposed between a local office and a toll switching point. The TSPS provides operator assistance and AMA data recording on special toll calls, ie, person-to-person, credit card, special billing service, etc. Its AMA operation is similar to that of a CAMA office. Message data recorded at a TSPS are recorded on magnetic tape.

(c) Remote recording of AMA data, the most recent improvement in the AMA process, refers to the process of collecting AMA data at a local office and teleprocessing the data, via data link, to an Automatic Message Accounting Recording Center (AMARC). The AMARC collects data, transmitted in different formats, from a variety of recording systems. It assembles the data into a standard format, required for subsequent data processing, and records it on magnetic tape. Data transmitted to an AMARC from a particular local office may be only local call data required for measured service, or it may be all the data generated in an office.

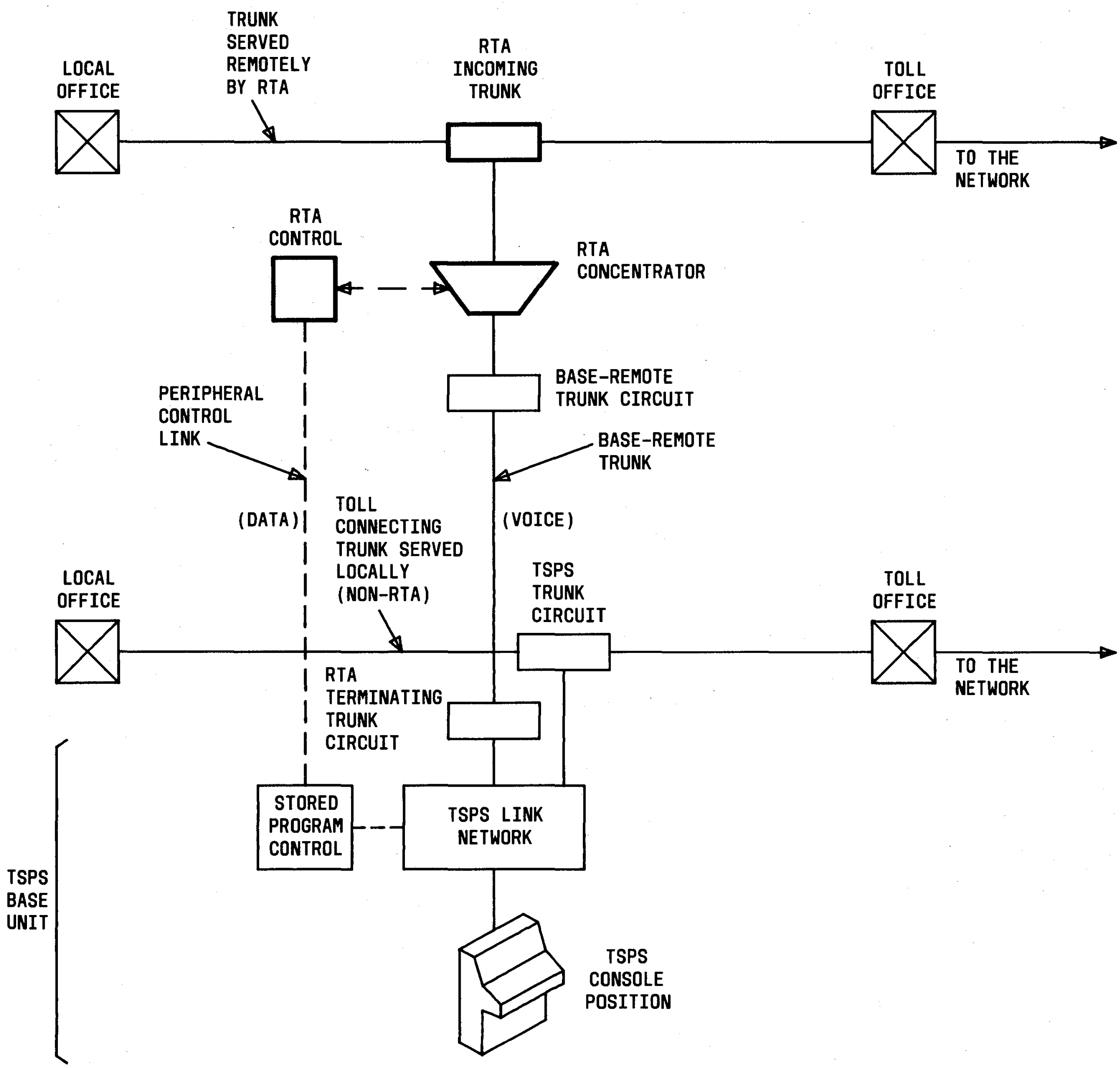


Fig. 4—Remote Trunk Arrangement

MESSAGE REGISTERS

4.28 Certain types of local switching systems 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 calls where the customers are billed on the number of message units used.

REVENUE ACCOUNTING OFFICE (RAO)

4.29 Data processing equipment at an RAO calculates the per-message charge based on data previously recorded on AMA tape. It combines these charges with other fixed monthly charges and prepares the customer's telephone bill. Currently, an RAO receives data recorded in a variety of formats. Data that is not in the format acceptable for subsequent processing must be converted to that format by the RAO.

VERIFICATION FACILITIES

4.30 A standard verification facility via a TSPS has been developed. The busy line verification feature associated with a TSPS enables an operator to determine the status of customer lines. This type of call is made at the request of a customer who has usually tried repeatedly and unsuccessfully to reach a line that appears to be busy. The operator is able to verify that a line is busy by accessing the line and being connected through a voice scrambler circuit to determine if there is conversation on the line. If requested, the operator can access the line to deliver an emergency message. An alerting tone is placed on the line to signal the subscriber when the operator accesses the line to deliver such a message.

SERVICE EVALUATION FACILITIES

4.31 It is desirable that suitable service evaluation 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 evaluation information,

TABLE D

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 by the Revenue Accounting Office (RAO) from the following data that needs to be available to the recording equipment:

   a. Message Billing Index (MBI*) or the called office code

   b. Duration of conversation

   c. Optionally, date and time of day.

* The MBI is a rate treatment indicator determined from the calling and called office code. It is used to indicate (to the RAO) the number of message units to be charged for the initial and overtime talking periods and the duration of the initial and overtime periods.

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.

4.32 Service evaluation facilities, if they are to be effective, should produce an adequate sample over a 24-hour period and should be capable of determining (where applicable):

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

(1) Speed of completion

(2) Speed of service

(3) Speed of answer to trunk signals

(4) Speed of attention to cord signals.

Note: Items (3) and (4) may not be required if operator speed of answer is obtained by independent measurement devices such as Modified Answering Time Recorders, Force Administration Data Systems, etc.

(b) ***Quality of Service:*** Measured in terms of errors, irregularities, and other significant qualities of performance of equipment, operators, and customers except speed.

(c) ***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.

TRAFFIC SEPARATION FACILITIES

4.33 ***Registers:*** Traffic separation registers are used to give an indication of the number of intrastate and interstate connections through toll switching offices. These numbers of connections are used as bases to which corresponding usage is related for the purpose of apportioning book costs of plant and related expenses between interstate and intrastate services.

4.34 ***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 crossbar 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 switching systems are provided with four incoming and seven outgoing classmarks for a total of 28 separate classes. When a No. 4 crossbar system is equipped with an 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 No. 4 ESS has a 32 $\times$ 64 matrix and 1984 available classmarks. The No. 1/1A ESS has an 8 $\times$ 16 matrix and 128 available (trunk) classmarks. Some No. 1/1A ESS combinations are reserved for intraoffice (line-to-line) calling. Matrix sizes are frequently a subject of reevaluation.

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SIGNALING

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1. GENERAL

1.01 Interoffice signaling for operator and customer dialing is described in this section. Full dial operation is assumed; therefore, ringdown and straightforward methods are not discussed.

1.02 The names given for the different signals are those which are well established by general use. A few alternative terms having considerable use are shown in parentheses in Fig. 1. The direction of each signal, the indication given to the customer or operator, and the on- or off-hook classification of the signal are shown where applicable.

1.03 Applications of several of these signals are listed in Fig. 2 for a 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- and off-hook signaling from the technical viewpoint as well as how they are used in signaling systems. The requirements for sender and register timing intervals are also included in this section.

1.05 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 network applications, they should be compatible with the equipment described in this section.

1.06 With the introduction of Electronic Switching Systems (ESSs) and Stored Program Control (SPC) in crossbar switching systems, a new type signaling system, known as Common Channel Interoffice Signaling (CCIS), has been developed for Bell System use. In this system, the signaling information for a number of interoffice trunks is encoded and transmitted over a separate data-link network. Between ESS and crossbar offices with SPC, the CCIS system permits eliminating all per-trunk signaling equipment. CCIS is covered in Section 6.

1.07 Signaling on international circuits to points outside the contiguous North American Network uses systems different from those in domestic service. At present, most such circuits terminating in the United States use the International Telegraph and Telephone Consultative Committee (CCITT) Signaling System No. 5. A new system known as CCITT No. 6 and similar in many respects to the CCIS system mentioned in the previous paragraph is also in use. Reference should be made to paragraphs 8.41, 8.42, and Section 10 for additional details concerning the signaling systems used in international dialing.

1.08 Signaling to and from the Traffic Service Position System (TSPS) is different in some ways from the signaling associated with toll cordboard operation. This has been taken into account at appropriate locations in this section.

1.09 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. The PCM systems can interconnect with E&M lead, loop reverse battery, and foreign exchange (FX) signaling. The signaling delay of PCM signaling is discussed in paragraph 7.41.

2. ON- 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 an old-fashioned telephone set receiver in relation to the mounting (hook) provided for it. If the station is on-hook, the conductor loop between the station and local central office is open and no current is flowing. For off-hook conditions, there is a dc shunt across the line and current is flowing in the loop.

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

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 is ready for dialing.	Steady tone	Steady tone	
Disconnect	√		——	→	No service is desired. Message is completed. Release connection.		Calling supervisory lamp lighted	
Answer (Off-Hook)		√	←	——	Called party has answered. Charge timing begins and depends on this signal.		Called supervisory lamp dark	
Hang Up	√		←	——	Called party releases. Message is completed.			
Delay-Dial (Delay Pulsing)		√	←	——	Called end is not ready for digits.		Start-dial or KP forward lamp dark	1
Wink		√	←	——	Called end is not ready for digits.		Start-dial or KP forward lamp dark	1
Start-Dial (Start Pulsing)	√		←	——	Called end is ready for digits.		Start-dial or KP forwarded lamp lighted	1
Stop		√	←	——	Some digits have been received. Called end is not ready for further digits.		Start-dial lamp changes to dark	1
Go	√		←	——	Called end is 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 (Automatic Number Identification [ANI])		√	←	——	Indicates that Centralized Automatic Message Accounting (CAMA) sender is ready to receive calling number.			
ANI Outpulsing (MF)								
Keypulse (KP)			——	→	Prepares CAMA sender for digits.			
Identification Digit			——	→	Indicates if service observed, whether automatic or operator identification, identification failure, hotel-motel, mobile, and coinless public telephone.			
Digits			——	→	Indicates calling number if sent.			
Start Pulse (ST)			——	→	Indicates all digits sent.			4
Line Busy Tone			←	——	Called line is busy.	60-IPM tone	60-IPM tone	5
Reorder Tone and No Circuit ATB			←	——	All paths are busy. All trunks are busy. Indicates blockage in equipment. Indicates incomplete registration of digits.	120-IPM tone	120-IPM tone	2, 5

Fig. 1—Signals Required in Dialing Through the Network

NAME OF SIGNAL	ON-HOOK	OFF-HOOK	DIRECTION CALLING END	DIRECTION 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 (Timed Wink)	√		⟶		Recalls operator forward to the connection.		Steady or flashing lamp	7
Ringback (Untimed)	√		⟵		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.			
ABC Tone			⟵		Indicates that caller may dial billing number.	60 ms of 941 + 1477 Hz (number tone) and 940 ms of 440 + 350 Hz (dial tone). This signal decays exponentially with a time constant of 200 ms.		
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		
Alerting Tone			⟵		Indicates that an operator has come on the line (emergency interrupt on a busy line — verification call)	440 Hz tone for 2 seconds followed by 1/2 second of tone every 10 seconds.		
Recall (Customer Flashing)	√	√	⟶ ⟵		Manually recalls operator to connection.		Flashing lamp	6

Notes:

1. In cordboard operation, the start-dial, delay-dial, stop, and go signals are sometimes indicated to the operator on the calling cord lamp instead of the start-dial lamp. In Traffic Service Position (TSP) operation, these signals are indicated on KP and ST lamps.
2. It will be observed that conditions producing a 120-IPM tone signal apply to facilities that are relatively liberally engineered; 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 TSP operation, the effect of flashing can depend upon the circumstances, but in most instances, a flashing supervisory lamp will result.
7. No effect, unless inward operator is at terminating end of the connection.

Fig. 1—Signals Required in Dialing Through the Network (Contd)

NAME OF SIGNAL	CALLING STATION	ORIGINATING LOCAL OFFICE (CLASS 5)	ORIGINATING TOLL OFFICE (CLASS 4 OR HIGHER)	THROUGH SWITCHING OFFICE (CLASS 3 OR HIGHER)	TERMINATING TOLL OFFICE (CLASS 4 OR HIGHER)	TERMINATING LOCAL OFFICE (CLASS 5)	CALLED STATION	REMARKS	SEE NOTE
Connect (Seizure)	→	→	→	→					
Disconnect	→	→	→	→	→	→			1
Answer (Off-Hook)			←	←	←	←	←	Used in charging control	1, 5
Hang Up (On-Hook)			←	←	←	←	←		1, 5
Delay-Dial (Delay Pulsing)			←	←	←	←		As required	
Start-Dial (Start Pulsing)			←	←	←	←			
Dial Tone		←							
Wink-Start Pulsing (Wink)			←	←	←	←			3
Stop				←	←	←		As required	7
Go				←	←	←			
Called Station Identity									
TOUCH-TONE	→								
Dial Pulsing (DP)	→	→	→	→	→				2
Multifrequency Pulsing (MFP)		→	→	→	→				2
Calling Station Identity (CAMA)									
Verbal (Interim)	→			Operator Identification } CAMA					
MF Pulsed Digits		→		Automatic Identification } CAMA					
Line Busy						←			
Reorder		←	←	←	←	←			4
No Circuit (NC) (Intertoll)			←	←					4
Ringing						→			
Audible Ringing (Ringing Induction)					←				
Ringing Start				→				As required	
Recorder Warning Tone	→								
Announcements						←			4, 6
See Fig. 42									

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 dial tone is used in some cases but is not satisfactory in ultimate.
4. May originate at any one of the indicated offices.
5. 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.
6. Announcement may be by operator or by machine (recorded announcement).
7. Stop is returned when selector cuts in on the level having trunks which require this signal.

Fig. 2—Use of Signals With Calls Dialed Through the Network

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- and on-hook signals, when not used to convey address information, are often referred to as supervisory signals or simply as "supervision." A sequence of alternating on- and off-hook signals (dial pulses) occurring within a specific time duration is used to convey address information.

2.04 The various on- or off-hook signals are shown in Fig. 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 Fig. 1:

(a) ***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.

(b) ***Relative Time of Occurrence:*** A delay-dial, 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.

CONNECT (SEIZURE)

2.05 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 (ie, simultaneous seizure from both ends), 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 paragraphs 2.25 through 2.44.)

ANSWER (OFF-HOOK)

A. Charge Delay

2.06 When the called customer answers, an off-hook signal is transmitted toward the calling end 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 2 to 5 seconds. The 1975 issue of ***Notes on Distance Dialing*** indicated that the minimum continuous off-hook signal (charge delay feature) that should be considered an answer for charging purposes is 0.6 second. However, study has shown that many spurious off-hook signals last longer than 0.6 second. As a result, the present recommended minimum off-hook signal that should be recognized as an answer signal for charging purposes is 2 seconds.

2.07 Most trunks when idle and all trunks when awaiting the customer's answer transmit an on-hook signal from the called end to the calling end. Most trunks return to the on-hook state when the called station hangs up. Some 1-way loop signaling trunks are arranged to signal off-hook toward the calling end when idle.

B. Answer Signals on Calls to Directory Assistance

2.08 Direct-dialed directory assistance calls to 555-1212 and NPA + 555-1212 trunks originally did not return answer supervision. This prevented the use of Automatic Message Accounting-Centralized Automatic Message Accounting (AMA-CAMA) tape analysis for network completion studies on calls to directory assistance. 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.

2.09 Where operator directory assistance (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.

C. Cross-Office Transfer Time for Answer Signals

2.10 Since individual switching offices contribute directly to network effects, it is important to establish performance objectives which recognize those parameters to which the network is most sensitive. Cross-office delay in transfer of the answer signal is one such parameter. In the recent past, the controlling consideration in placing an objective figure on this function was the desire to avoid a transmission clip at the time of verbal response following call answer. The widespread use of inband single-frequency (SF) signaling on intertoll trunks was the principal factor in causing this clip. Today the growing use of T Carrier and CCIS has shifted this concern, while not eliminating it. It now appears that long-term priorities should seek to avoid undue loss of revenue attributable to slow transfer of the answer signal that governs the start of charging.

2.11 Where little or no penalty is attached to prompt return of an answer signal, it is clear that this task should be performed with dispatch. Figures ranging from 5 to 25 milliseconds are being achieved and are preferred. It is also clear that forward-looking signaling arrangements should seek higher standards. Thus CCIS-to-CCIS connections should tend to produce improved performance. This subject remains under study and further advice may be expected. In the absence of economic options to achieve higher speeds, figures on the order of 50 milliseconds (average) for normal class 4 offices appear acceptable. This is reasonably consistent with the allowed split of class 4 and class 4X offices in the switching hierarchy for which figures in the order of 25 milliseconds per office have been published.

CONTROL OF DISCONNECT

A. Calling Customer Control of Disconnect

2.12 Calling customer control of disconnect, also known as forward control of disconnect, forward disconnect, or calling party control, is the means by which the calling end notifies the called end that the established connection is no longer needed and should be released. Forward disconnect is an on-hook signal which is transmitted toward the called end at the conclusion of the call. As long as the customer remains off-hook, the connection will remain up. When the calling customer goes on-hook for a period longer than the disconnect time, the connection is released. This method allows the calling customer to disconnect at any time by hanging up.

2.13 To distinguish an off-hook signal intended as a disconnect signal from other off-hook signal indications, such as a ring forward signal, the forward disconnect signal should exceed a minimum of 300 to 800 milliseconds for step-by-step trunk circuits and about 150 to 400 milliseconds for other types of trunk circuits. To ensure 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.

2.14 Calling customer control is usually modified by the local central office to prevent connecting the called party to dial tone as soon as the calling party goes on-hook and to prevent locking the called party to the connection as long as the calling party is off-hook. Table A lists disconnect timing that occurs in various types of telephone connections when the ***calling*** party hangs up and the called party remains off-hook. Table B lists similar information for conditions where the ***called*** party hangs up and the calling party remains off-hook.

B. Calling Customer Control of Disconnect With Forced Disconnect

2.15 In addition to the features discussed above, calling customer control of disconnect can include a forced disconnect feature. The addition of a forced disconnect feature is a distinguishing characteristic of all (except No. 5 crossbar) outgoing CAMA (paragraphs 8.26 through 8.30 and 8.36 through 8.39) and Automatic Intercept System (AIS) (paragraph 9.01) local central office trunk circuits. The calling customer may disconnect at any time but is automatically disconnected (winked off*) when an on-hook signal is received from the CAMA or AIS. The timing of partial dial, permanent signal, and other disconnect sequences is performed by the CAMA or AIS trunk. The forced disconnect feature ensures that "dial 1 for slumber" does not hold high revenue earning CAMA trunks out of service. If the terminating end reverts back to off-hook, the outgoing trunk circuit is automatically made busy (reverse make-busy).

* Wink off and winked off are popular terms for a forced disconnect from a CAMA, AIS, or TSPS. Actually the off- to on-hook transition causes the disconnect—not a wink.

TABLE A

DISCONNECT TIMING (NOTE 1)
(CALLING PARTY HANGS UP, CALLED PARTY HOLDS)

TERMINATING CENTRAL OFFICE SWITCHING SYSTEM	TIMED DELAY IN TERMINATING CENTRAL OFFICE FROM INCOMING DISCONNECT TO RESTORAL OF CALLED LINE TO IDLE STATE
No. 1 crossbar	2 to 4 minutes (Note 2)
No. 5 crossbar	13 to 32 seconds (Note 2)
No. 5 crossbar centrex, phases I and II	2 to 5 seconds
No. 5 crossbar centrex, phase III	1.2 to 1.6 seconds
Step-by-step	Immediate—calling party control
No. 1/1A ESS	2 to 3 seconds—ground start
	10 to 11 seconds—loop start
No. 2/2B ESS	10 to 11 seconds
No. 3 ESS	10 to 11 seconds

Notes:

1. Noncoin, direct-dialed calls; no operator handling.
2. Timing of incoming trunk is terminated if the corresponding outgoing trunk is seized by originating office for a new call.

2.16 The forced disconnect described in the previous paragraph is a timed disconnect (Table B) of 13 to 32 seconds in No. 5 crossbar and 10 seconds in No. 4 ESS.

C. Operator Control of Disconnect

2.17 Operator control of disconnect is used on outgoing trunks to the TSPS. (See paragraphs 8.31 through 8.35 and 8.40.) The local central office trunks are designed to have calling customer control of disconnect until the TSPS office returns off-hook supervision (Automatic Number Identification [ANI] request) to the local central office to indicate that the TSPS is ready to receive the calling number. This off-hook signal remains for the duration of the call, locking the calling customer to the TSPS. At the end of the call, the TSPS, recognizing an on-hook from the calling (or called) party, provides necessary timing and then reverts to on-hook toward the local central office. This causes a forced disconnect of the calling customer. If the terminating end reverts back to off-hook, the trunk circuit is automatically made busy.

D. Joint Hold Control of Disconnect

2.18 In situations where recording-completing switchboard trunk circuits are used, joint

TABLE B

DISCONNECT TIMING (NOTE 1)
(CALLED PARTY HANGS UP, CALLING PARTY HOLDS)

ORIGINATING CENTRAL OFFICE SWITCHING SYSTEM	TIMED DELAY IN ORIGINATING CENTRAL OFFICE FROM INCOMING DISCONNECT TO RESTORAL OF CALLING LINE TO IDLE STATE
No. 1 crossbar	2 to 4 minutes (Note 2)
	14 to 29 seconds—LAMA calls (Note 3)
No. 5 crossbar	13 to 32 seconds (Note 4)
Step-by-step	Indefinite—without connector time-out on non-CAMA interoffice calls
	—CAMA calls 13-32 seconds (Note 5)
	12 to 37 seconds—with connector time-out on intraoffice calls
No. 1/1A ESS	Immediate—ground-start outgoing trunk
	10 to 11 seconds—loop-start—non-FX
No. 2/2B ESS	10 to 11 seconds
No. 3 ESS	10 to 11 seconds

Notes:

1. Noncoin, direct-dialed calls; no operator handling.
2. From 1 to 2 minutes in some offices; indefinite on noncharge calls.
3. Plus interval for AMA entry but not more than 2 to 5 seconds additional.
4. Indefinite on noncharge calls; on LAMA calls, additional time is allowed for the AMA entry but not more than 1.7 to 6.7 seconds.
5. Also on calls from step-by-step common control via extended area service-multifrequency outgoing trunk (13 to 19 seconds).

hold is the method of control utilized. This means the customer is not disconnected until both the customer and operator are on-hook. If the calling customer fails to hang up, release is not forced by on-hook supervision from the operator and a permanent signal will remain on the switchboard.

GUARD TIME

2.19 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 calling 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 in paragraph 2.05, the connect signal must be sent immediately.

2.20 The timed interval used to ensure 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 plus round trip signaling time 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. Actual guard times for the various switching systems are as follows:

SWITCHING SYSTEM	MILLISECONDS
Step-by-step	Not available
No. 1 crossbar	Not available
No. 4 crossbar	Not available
No. 5 crossbar	620 to 1650
Crossbar tandem	Not available
No. 1/1A ESS	800 to 1000
No. 2/2B ESS	Not available
No. 3 ESS	Not available
No. 4 ESS	1050 to 1200

2.21 The above guard times are for terrestrial facilities and include delays introduced by trunk and signaling equipment. When satellite facilities (routed through an earth satellite repeater) are used, the round trip time and, consequently, the trunk guard times must be longer. At present, only the No. 4 crossbar system, No. 1/1A ESS, No. 1/1A ESS HILO, and No. 4 ESS have options to operate with satellite facilities. The No. 4 crossbar system uses a guard time of 1050 to 1250 milliseconds. The No. 1/1A ESS and No. 1/1A ESS HILO use a guard time of 1600 to 1800 milliseconds. The No. 4 ESS uses the same guard time for terrestrial or satellite facilities (1050 to 1200 milliseconds).

2.22 The No. 5 crossbar is not presently used in the public network with satellite facilities but can be made compatible for use with satellite facilities and is used in private line applications. In these applications, the guard time is 1050 to 1250 milliseconds; however, this will be changed to 1600 to 1800 milliseconds in the near future.

2.23 An important factor in establishing a compatible guard time is the interval required to restore the incoming trunk circuit to the idle condition (force an on-hook toward the calling end if the called end is still off-hook) after the trunk disconnect timing has elapsed. The electromechanical switching systems, in general, have short intervals that do not change with traffic load. The ESSs, in general, have longer intervals that can become very long for heavy traffic conditions. The time required to restore the trunk circuit to idle after the disconnect timing has elapsed is as follows:

SYSTEM	LIGHT TRAFFIC (MILLISECONDS)	HEAVY TRAFFIC (MILLISECONDS)
No. 4 crossbar	Not available	
No. 5 crossbar	140 to 450	140 to 450
Crossbar tandem	Not available	
No. 1/1A ESS	175 to 275	450
No. 2/2B ESS	Not available	
No. 3 ESS	Not available	
No. 4 ESS	0 to 30	110 to 150

2.24 The delay introduced by various switching systems from receipt of a seizure (connect) signal to the return of a delay-dial or wink-start signal is as follows:

SYSTEM	DELAY IN MILLISECONDS FROM CONNECT SIGNAL TO: WINK	DELAY-DIAL
No. 4 crossbar	Not available	
No. 5 crossbar	100 to 200	10 to 20
Crossbar tandem	Not available	
No. 1/1A ESS	Not available	
No. 2/2B ESS	Not available	
No. 3 ESS	Not available	
No. 4 ESS	Not available	

GLARE

2.25 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 a sustained off-hook signal.

2.26 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.

2.27 Historically, glare on trunks between common control offices was generally handled by lengthy sender or transmitter time-out intervals of up to 40 seconds followed by reorder tone. These long time-out intervals are a disadvantage in that the customer assumes a no-ring, no-answer condition and hangs up before the time-out is completed. The customer satisfaction would not be improved significantly by waiting the full time-out period for a reorder signal to be returned. It is clear that any attempt to salvage the calls now lost in glare conditions must be made within seconds rather than the long historic time-out intervals.

2.28 Dependent upon the types of switching systems involved, various techniques are used in the Bell System to reduce ineffective attempts and long time-out intervals due to glare. The results are as follows:

(a) The No. 1/1A, 2/2B, 3, and 4 ESSs use a method to detect and resolve glare on both wink-start and delay-dial controlled outpulsing conditions that saves both calls. To accomplish this, only one ESS office is required. The office at the opposite end can be either electronic or electromechanical.

(b) The No. 4A and 4M crossbar systems have a glare detection and retrial scheme that saves the call from the No. 4 crossbar office. In a glare condition between two No. 4 crossbar offices, both calls could be saved. When only one No. 4 crossbar office is involved, and the other office is an electromechanical office (other than No. 4 crossbar), only the call from the No. 4 crossbar office would be saved.

(c) The No. 5 crossbar and crossbar tandem systems recognize any off-hook from the far end of the circuit as a glare condition if it occurs within the minimum round trip signaling transit interval for the facility. It is also available for No. 5 crossbar trunk circuits used to provide Common Control Switching Arrangements (CCSAs). However, this feature does not cover the full range of relevant No. 5 crossbar trunk circuits used to provide toll service.

A. Glare Resolution in ESSs

2.29 The ESSs detect glare by timing the incoming wink-start or delay-dial signal. Where the maximum time for the appropriate controlled outpulsing signal is exceeded, glare is assumed. The office detecting the glare condition holds the off-hook toward the other office until the office detecting glare can back out of the connection, attach a register to the connection, and go on-hook toward the other office as a start-dial signal. The call incoming to the office detecting glare will be completed on the original trunk. The call outgoing from the office detecting glare will be retried on another trunk. This method saves both calls as long as one or both ends have ESSs.

2.30 Any wink-start signal over 350 milliseconds should be treated as glare. The actual glare detection times for the various ESSs are as follows:

(a) No. 1/1A ESS, 500 to 600 milliseconds

(b) No. 2/2B ESS, 450 to 550 milliseconds

(c) No. 3 ESS, not available

(d) No. 4 ESS, 350 to 500 milliseconds.

2.31 Delay-dial to start-dial intervals that exceed 4 seconds may be considered glare. The No. 1/1A ESS has two different maximum times for glare detection: 4-second detection time used on trunks shared with the No. 4 crossbar as explained in paragraphs 2.33 through 2.39 and 6-second timing used on trunks with other types of switching systems. The shorter time permits the No. 1/1A ESS to detect and resolve the glare before the No. 4 crossbar can detect the glare. The actual glare detection times when expecting delay-dial for the various ESSs are as follows:

(a) No. 1/1A ESS:

(1) 4 ±0.1 seconds with 4- to 8-second overall timing

(2) 6 ±0.1 seconds with 16- to 20-second overall timing.

(b) No. 2/2B ESS (glare resolution with wink-start only).

(c) No. 3 ESS, not available.

(d) No. 4 ESS:

(1) 4 ±0.1 seconds, intertoll

(2) 5 ±0.1 seconds, toll connect

(3) 10 seconds, second trial, intertoll and toll connect.

In all systems, a failure on a retried call will route the call to reorder.

2.32 Wink-start is the preferred controlled outpulsing method on 2-way trunks where at least one of the offices is an ESS and the second is something other than a No. 4 crossbar. (See Table C.) Wink-start permits less expensive trunk circuits in the ESSs when hardware is used to generate the delay-dial signal and quicker detection of glare for either hardware or software generated delay-dial. Where electromechanical switching systems and ESSs are at opposite ends of a trunk, the electronic system should be optioned to back out of glare situations in favor of the electromechanical system. Where two ESSs are involved, the following protocols should be observed:

(a) The lower ranked office should back out (give up control) of glare situations in favor of the higher ranked office, thereby allowing the greatest chance of completion to a call that has traversed the network and is descending in the hierarchy rather than one which is just starting.

(b) If of equal rank, the A office should be assigned to maintain control of the trunk. The Z office should be assigned to release. The A and Z designations should be determined by using the Common Language Equipment Identification codes.

B. Glare Resolution in No. 4 Crossbar

2.33 The No. 4A and 4M crossbar systems have intertoll trunks and toll connecting trunks that operate differently. Since there are no 2-way toll connecting trunks, this discussion is limited to intertoll trunks.

2.34 Delay-dial is still the required method of controlled outpulsing for outgoing intertoll or 2-way intertoll trunks connected to No. 4A and 4M crossbar offices. The requirements for delay-dial

TABLE C

CONTROLLED OUTPULSING METHODS AVAILABLE IN BELL SYSTEM SWITCHING SYSTEMS

SWITCHING SYSTEM	TYPE OF CALL	DELAY-DIAL		DELAY-DIAL WITH INTEGRITY CHECK	WINK-START	
		EXPECT	SENT	EXPECT	EXPECT	SENT
Step-by-step	Local	—	—	—	—	—
	Toll completing — with integrity check	—	X	—	—	X
	Toll completing — without integrity check	—	—	—	—	—
	Toll connecting — outgoing	—	—	—	—	—
	CAMA — outgoing	—	—	—	—	—
Step-by-step (Common Control)	Local — outgoing	—	—	XX	XX	—
	Local — incoming	—	—	—	—	—
	Toll completing — with integrity check	—	X	—	—	X
	Toll completing — without integrity check	—	—	—	—	—
	Toll connecting — outgoing	—	—	XX	XX	—
	CAMA — outgoing	—	—	XX	XX	—
Step-by-step (CAMA)	Incoming	—	—	—	—	XX
	Outgoing	—	—	XX	—	—
Step-by-step (Toll)	Intertoll — outgoing	XXX	—	—	—	—
	Intertoll — incoming	—	—	—	—	X
	Toll completing — outgoing	XXX	—	—	—	—

LEGEND:

X — Design capability
XX — Always available
XXX — Preferred method

TABLE C (Contd)

CONTROLLED OUTPULSING METHODS AVAILABLE IN BELL SYSTEM SWITCHING SYSTEMS

SWITCHING SYSTEM	TYPE OF CALL	DELAY-DIAL		DELAY-DIAL WITH INTEGRITY CHECK	WINK-START	
		EXPECT	SENT	EXPECT	EXPECT	SENT
No. 1 crossbar	Local — loop outgoing	XX	—	X	X	—
	Local — loop incoming	—	—	—	—	X
	Toll completing — incoming	—	—	—	—	XX
Crossbar tandem	Intertoll	XX	XX	X	X	X
	Toll connecting — incoming	—	XX	—	—	X
	Toll connecting — outgoing	XX	—	X	X	—
	CAMA	—	—	XX	XX	—
No. 4 crossbar	Intertoll	XX	XX	X	—	—
	Toll connecting — incoming	—	XX	—	—	—
	Toll connecting — outgoing	XX	—	X	X	—
	CAMA	—	—	—	—	XX
No. 5 crossbar (Local)	Local — MF	XX	XX	XX	XX	XX
	Local — DP	XX	XX	X	X	X
	Toll completing — incoming	—	XX	—	—	XX
	Line link pulsing — DP outgoing	XX	—	X	X	—
	CAMA — outgoing	—	—	XX	XXX	—

TABLE C (Contd)

CONTROLLED OUTPULSING METHODS AVAILABLE IN BELL SYSTEM SWITCHING SYSTEMS

SWITCHING SYSTEM	TYPE OF CALL	DELAY-DIAL		DELAY-DIAL WITH INTEGRITY CHECK	WINK-START	
		EXPECT	SENT	EXPECT	EXPECT	SENT
No. 5 crossbar (Toll)	Intertoll — DP	XX	XX	X	X	XX
	Intertoll — MF	XX	XX	XX	XX	XX
	CAMA — incoming	—	—	—	—	XX
	Toll connecting — DP outgoing	XX	—	X	X	—
	Toll connecting — MF outgoing	XX	—	XX	XX	—
	Line link pulsing — DP (2-wire, 2-way)	XX	XX	X	X	—
	LUNK — DP (4-wire)	XX	XX	X	X	X
TSPS	Incoming	—	—	—	—	XXX
	Outgoing	—	—	XX	XX	—
No. 1/1A ESS (Local)	Local	—	X	XX	XX	XXX
	Toll connecting — outgoing	—	XX	—	XXX	—
	Toll connecting — incoming	—	—	XX	—	XXX
	CAMA — outgoing	—	—	XX	XX	—
No. 1/1A ESS (Toll)	Intertoll	—	X	XX	XX	XXX
	Toll connecting — incoming	—	X	—	—	XXX
	Toll connecting — outgoing	—	—	XX	XX	—
	CAMA	—	—	XX	XX	—

TABLE C (Contd)

CONTROLLED OUTPULSING METHODS AVAILABLE IN BELL SYSTEM SWITCHING SYSTEMS

SWITCHING SYSTEM	TYPE OF CALL	DELAY-DIAL		DELAY-DIAL WITH INTEGRITY CHECK	WINK-START	
		EXPECT	SENT	EXPECT	EXPECT	SENT
No. 1/1A ESS HILO	Intertoll	—	—	XX	XX	XXX
	Toll connecting — incoming	—	—	—	—	XXX
	Toll connecting — outgoing	—	—	XX	XX	—
	CAMA — incoming	—	—	—	—	XXX
No. 2/2B ESS (Local)	Local — incoming	—	X	—	—	XXX
	Local — outgoing	—	—	XX	XX	—
	Toll connecting — incoming	—	—	—	—	XXX
	Toll connecting — outgoing	—	—	XX	XX	—
	CAMA — outgoing	—	—	XX	XX	—
No. 2/2B ESS (Toll)	Intertoll	—	X	XX	XX	XXX
	CAMA — incoming	—	—	—	—	XXX
No. 3 ESS	Local — incoming	—	—	—	—	XXX
	Local — outgoing	—	—	XX	XX	—
	Toll connecting — incoming	—	—	—	—	XXX
	Toll connecting — outgoing	—	—	XX	XX	—
	CAMA — outgoing	—	—	XX	XX	—
No. 4 ESS	Intertoll	—	—	XX	XX	XXX
	Toll connecting — incoming	—	—	—	—	XXX
	Toll connecting — outgoing	—	—	XX	XX	—
	CAMA	—	—	—	—	XXX

have been modified from the historic requirements by the introduction of retrial features and features to permit operation with trunks using facilities via a synchronous satellite. The changes (if installed) permit the return of the delay-dial signal to be delayed as much as 5 seconds after seizure.

2.35 When either multifrequency (MF) or dial pulsing (DP) address signaling is used with No. 4A and 4M crossbar system intertoll trunks, the terminating office must return a delay-dial signal to the No. 4A or 4M crossbar office. It is not possible to distinguish no sender ahead from glare when delay-dial is used. Therefore, in the following paragraphs on glare resolution when the delay-dial method is used, no sender ahead will be included with glare.

2.36 With retrial features in the No. 4A and 4M crossbar systems, the off-hook, delay-dial signal must be returned within 5 seconds of seizure or the sender will lock out the trunk and retry the call on another trunk. If the office returning the delay-dial signal to the No. 4 crossbar had been incorrectly optioned to return a wink-start signal, a no sender ahead condition would cause the trunk to be falsely locked out. If the delay-dial signal is returned, the start-dial signal must be returned within 5 seconds of the delay-dial signal on first attempt. Today in most No. 4A and 4M crossbar offices, the retrial period is 8 seconds. However, there are some No. 4A and 4M offices which operate with a 20- to 30-second retrial interval. In heavy traffic, retrial is canceled. The sender, register, or link attachment requirements are given in Fig. 3.

2.37 When the start-dial signal is not received in time, the sender causes the trunk to send a signaling sequence which is used to stop outpulsing and return reorder at the distant office. This signaling sequence is a 100- to 200-millisecond on-hook followed by a minimum of 220-millisecond off-hook and then a 750- to 1000-millisecond on-hook signal (trunk guard time) before the trunk circuit can be selected again. This signaling sequence from the No. 4A crossbar would cause the crossbar tandem to retry the call. Usually, the ESSs would not be exposed to this signaling sequence since the electronic offices would time out and resolve the glare before the No. 4A crossbar times out.

2.38 The timer used for the 5- and 8-second timing mentioned above is held to close tolerances. The 5-second time is adjusted to +0.05 -0 second. While age and voltage variations are expected to widen this timing range, it is expected that the timing periods will remain within ±0.5 second throughout the service life of the equipment.

2.39 It is important that any switching system depending on the No. 4 crossbar system for glare detection and resolution delay outpulsing for at least 200 milliseconds. This permits the on-hook, off-hook, on-hook signaling sequence used by the No. 4 crossbar to be recognized as an unexpected stop to block outpulsing or start retrial in the other office.

C. Glare Resolution in No. 5 Crossbar and Crossbar Tandem

2.40 Crossbar tandem systems have a feature that detects some but not all glare conditions. This feature is usable with either the wink-start or delay-dial method of controlled outpulsing. A similar feature is being developed for No. 5 crossbar, but is not available for all applications. The No. 5 crossbar CCSA trunks using wire spring markers and wire spring trunk link connectors have this feature. One intertoll trunk circuit is available with this feature when using wire spring trunk link connectors. However, this feature is not presently available for all 2-way trunk circuits and for flat spring markers and trunk link connectors.

2.41 This feature takes advantage of the fact that the time from the initial seizure signal to the return of the delay-dial or wink-start to the originating office requires a minimum total interval. Any off-hook seen by the originating office from the time of seizure until the minimum time for the return of a delay-dial or wink-start signal must be glare. This method detects many but not all glare situations. In either No. 5 crossbar or crossbar tandem, any off-hook received during the first 100 milliseconds after trunk seizure is detected as glare.

2.42 When glare is detected, the office detecting glare backs out (possibility both offices) of the connection, maintains a delay-dial signal (off-hook) toward the distant office, attaches a signaling receiver to the trunk, and sends a start-dial (on-hook) signal toward the terminating office. The originating office then selects a new trunk for the completion of the call.

			4A AND 4M		4A AND 4M CAMA		CROSSBAR TANDEM (INCL CAMA)	NO. 5 CROSSBAR (INCL CAMA)		SXS CAMA	NO. 1 ESS
			RETRIAL (NOTE 3)	NO RETRIAL (NOTE 1)	RETRIAL (NOTE 3)	NO RETRIAL (NOTE 1)		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	First Trial	5	30-40	5	20-30	20	19	13	19	16
		Second Trial	8 (Note 2)	—	8 (Note 2)	—					
	Heavy Traffic	—	5	5	5	5	3, 5, or 8	4.4	4.4	4.6	4
Line finder in distant office must be attached in less than _ seconds or originating sender in indicated system may time out.	Normal Traffic	—	—	20-30	—	20-30	20	19	—	19	16
	Heavy Traffic	—	—	20-30	—	20-30	3, 5, or 8	4.4	—	4.6	4

Notes:

1. Without the retrial feature, timing starts with sender seizure.
2. Some offices are still operating with a 20- to 30-second retrial interval.
3. With the retrial feature, the sender will wait as long as 5 seconds after seizure for return of the delay-dial signal from the distant office. With the retrial feature, timing starts when the delay-dial signal is returned from the distant office.

Fig. 3—Sender, Register, or Line Finder Attachment Timing Requirements

2.43 To use this method of glare detection, the round trip delay time must be at least 100 milliseconds. The option to use this type of glare detection is sometimes called "option for use with single frequency signaling" because the option can be used with SF signaling but cannot be used with physical facilities or with digital (T) carrier facilities.

D. Trunk Hunting—Method to Minimize Glare

2.44 The strategy of selecting idle trunks, as well as the number of seizures per trunk per unit of time, has an effect on glare. Opposite order trunk hunting gives lowest glare. In this method, one office selects from low- to high-numbered trunks while the other office selects from high- to low-numbered trunks. In this selection method, glare is possible only when all but one trunk in the group is busy. The greater the number of seizures per trunk per unit of time, the greater the glare problem. When glare is a problem, consideration should be given to adding more trunks to the group or to replacing a single group of 2-way trunks with two groups of 1-way trunks.

IMMEDIATE-DIAL

2.45 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 the connect signal. Immediate-dial is used with these trunks and is required for direct-dialed CAMA traffic from nonsenderized step-by-step 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-dial. Some advantage is realized, however, if delay-dial is employed for signaling integrity check purposes.

2.46 Most trunks, in order to direct control switching systems, are ready to receive digits without delay and are normally in the start-dial, on-hook condition. However, senders should delay the first dial pulse a minimum of 150 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-dial or wink-start signal prior to the start-dial indication.

2.47 The minimum delay of 150 milliseconds in the previous paragraph was 70 milliseconds in the 1975 issue of ***Notes on Distance Dialing.*** The 70 milliseconds, given in ***Notes on Distance Dialing,*** provide a 5-millisecond margin for distortion in the signaling and trunk relay equipment. Tests show that the 5-millisecond margin is not nearly large enough. Loop signaling circuits with F-type SF signaling require a minimum of 90 milliseconds sent to guarantee 65 milliseconds at the distant step-by-step selector. When E&M lead signaling and a pulse corrector are used at the step-by-step office, the minimum time increases to 150 milliseconds. When E&M lead signaling is used and there is no pulse corrector at the step-by-step office, the minimum again increases to 150 milliseconds. As a result, the Bell System plans to use 150 milliseconds as a minimum interval between seizure and outpulsing on all immediate-dial circuits. The No. 1/1A ESS has elected to use 170 milliseconds and the No. 4 ESS has elected to use 210 milliseconds as the minimum for this time interval.

SIGNALING INTEGRITY CHECK

2.48 Signaling integrity check is a per-call test made by a common control office during the initial call setup. 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 using carrier derived facilities whenever possible.

2.49 The exact nature of the check varies from switching system to switching system. However, there are two general types of signaling integrity checks. The first and most complete check requires a signaling response from the incoming office in the form of a delay-dial or wink-start signal. This check is known as integrity check.

The second check requires circuit continuity and the correct polarity on the tip and ring of the trunk which is known as continuity and polarity check.

2.50 The No. 4 crossbar, No. 5 crossbar, crossbar tandem, step-by-step CAMA, No. 4 ESS, and No. 1/1A ESS provide the continuity and polarity test check 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 (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 signal that meets the requirements for either delay-dial or wink-start operation. As a result, the originating office can use either delay-dial or wink-start expected. The signal sent is called wink-start by some and delay-dial by others.

2.51 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.

2.52 The No. 4 crossbar, crossbar tandem, No. 5 crossbar, step-by-step CAMA, No. 4 ESS, and No. 1/1A 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 lead 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.

FLASHING

2.53 Flashing signals were once transmitted between offices in the 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 toll calls, tone was added to the flash signal to provide both the customer and operator with identifiable signals. Every effort should be made to eliminate flashing signals between offices where they still exist.

REVERSE MAKE-BUSY (OFF-HOOK MAKE-BUSY)

2.54 Outgoing trunk make-busy by means of off-hook supervision received from the terminating end is a feature of outgoing CAMA, TSPS, and AIS trunks in all local switching systems. Other types of outgoing trunks, especially loop signaling trunks with customer control of disconnect, require an applique circuit to automatically make the trunk appear busy when idle and while receiving off-hook supervision from the terminating end.

2.55 Provisions for off-hook make-busy for trunks other than operator, TSPS, and AIS when an outgoing trunk circuit is used, or other techniques that accomplish the same result with or without an outgoing trunk circuit, are summarized for the various switching systems in Table D.

3. CONTROLLED OUTPULSING

3.01 Controlled outpulsing, which is used between common control offices and between operators and common control offices, requires less common equipment than if immediate-dial operation is used. Controlled outpulsing permits the use of slower links and results in a more efficient use of registers. With controlled outpulsing, the originating office seizes the trunk and sends a connect signal to the terminating office just as in immediate-dial outpulsing. However, if the idle state of the called office is an on-hook indication, the terminating office returns an immediate off-hook signal (or is off-hook idle) followed by an on-hook signal to the originating office. The exact timing of the on-hook, off-hook, on-hook (or off-hook, on-hook) signaling sequence constitutes the differences between the delay-dial and wink-start methods of controlled outpulsing. These differences are described in paragraphs 3.06 through 3.26. Whether delay-dial or wink-start, the originating office will wait a short period after receiving the on-hook, off-hook, on-hook (or off-hook, on-hook) signaling sequence and then begin outpulsing. Either dial pulse or MF address signaling can use controlled outpulsing. There are many applications where a common control office uses controlled outpulsing with dial pulse signaling to step-by-step offices to obtain the maintenance advantages of integrity check. (See paragraph 2.48.)

TABLE D

OFF-HOOK MAKE-BUSY PROVISIONS
(For trunks other than operator, TSPS, and AIS)

OFFICE	SUPERVISION	OFF-HOOK MAKE-BUSY	PROVISION
Step-by-step	Loop, E&M	No	None available
No. 1 crossbar	Loop	No	None available
No. 1 crossbar (MF)	Loop	No	Make-busy circuit
No. 4 crossbar	Loop, E&M	Yes	Some 1-way outgoing intertoll
No. 5 crossbar	Loop	No	Make-busy circuit
	E&M	No	Substitute 2-way trunk circuit
Crossbar tandem	Loop	No	Make-busy circuit
	E&M	No	Substitute way trunk circuit
No. 1/1A ESS	Loop	No	None available
	E&M	No	Substitute 2-way trunk circuit
No. 2/2B ESS	Loop	No	Substitute 2-way trunk circuit
	E&M	No	
No. 3 ESS	E&M	Yes	
No. 4 ESS	E&M	No	Substitute 2-way trunk circuit

3.02 Originally, the only method of controlled outpulsing was delay-dial. Switchboards and the No. 4 crossbar system have used this method of controlled outpulsing since the start of toll dialing. Consequently, the vast majority of intertoll trunks were arranged for the delay-dial method of controlled outpulsing. However, the introduction of the No. 1/1A ESS, No. 1/1A ESS HILO, and No. 4 ESS as toll switching systems and the TSPS that all use the wink-start method of controlled outpulsing have greatly reduced the number of intertoll trunks that require the delay-dial method of controlled outpulsing. Essentially all new trunks being added to the network that require controlled outpulsing use the wink-start signal. (Many other new trunks use CCIS.)

3.03 The No. 4 crossbar design was modified to provide the maintenance advantages of integrity check (paragraph 2.48) on both toll connecting (1-way outgoing) trunks and on intertoll trunks. In addition, it permits the use of intertoll trunks over synchronous satellite-derived facilities. The signal delay inherent in synchronous satellite-derived facilities precludes the use of the historic delay-dial operation with these facilities. With these changes, toll connecting trunks will accept either a delay-dial or wink-start signal from the terminating office. No. 4 crossbar intertoll trunks expect a delay-dial signal from the terminating office. The delay-dial signal, rather than a wink-start signal, is necessary for the proper operation of the No. 4 crossbar retrial feature described in paragraph 2.36.

3.04 The No. 5 crossbar and crossbar tandem systems also have design changes to permit wink-start operation. However, it should be remembered that the No. 4 crossbar, No. 5 crossbar, and crossbar tandem systems originally were designed for delay-dial operation. The design changes to permit wink-start operation may or may not be present in a given office. On the other hand, the ability to use delay-dial operation is always present in these offices.

3.05 To properly describe the operation of the various switching systems for signaling compatibility purposes, it is necessary to define the signal ***sent*** by the terminating office and the signal ***expected*** by the originating office. Generally, the signal ***sent*** by the terminating office is the same as the signal ***expected*** by the originating office. However, this may not always be the case. In addition, in specific situations, there are advantages in not having the ***sent*** and ***expected*** signals identical. For example, glare resolution in the No. 1/1A ESS (paragraphs 2.29 through 2.32) uses different ***sent*** and ***expected*** signals to resolve the glare in the "wink-start mode." When two No. 1/1A ESS offices interconnect, both can ***send*** wink-start but both do not ***expect*** wink-start. The office selected to back out of the connection (glare situation) ***expects*** a wink-start signal and, therefore, times the wink. Any wink-start signal over 500 milliseconds is detected as glare. The office selected to remain on the trunk ***expects*** delay-dial and does not time the signal received (other than the 18- to 20-second overall timing) and, therefore, remains in control of the trunk. Another factor is the difference in the definition used by the various systems for delay-dial and wink-start. A No. 4 crossbar can send a delay-dial signal and the No. 5 crossbar originating office can expect a wink-start signal with compatible operation. Table C covers the design capabilities of the various systems and their ability to use the various methods and the preferred method of controlled outpulsing for each of the Bell System switching systems.

DELAY-DIAL WITHOUT SIGNALING INTEGRITY CHECK

3.06 Delay-dial without signaling integrity check is the oldest method of controlled outpulsing. It is also the most unsatisfactory method from a maintenance standpoint. Consequently, it should be used only when wink-start or delay-dial with integrity check is not available.

3.07 In the delay-dial without signaling integrity check method, the originating office seizes the trunk circuit which sends a connect signal toward the called office. After a timing interval of at least 300 milliseconds on some trunks and 75 milliseconds on others, the calling office then looks at the supervision from the called office. If the supervision is on-hook, the originating office starts the outpulsing procedure. If the supervision is off-hook, the calling office will wait until the supervision from the called office goes on-hook (start-dial) and then start the outpulsing procedure. The called office sends a delay-dial (off-hook) signal from the incoming trunk circuit as soon as the connect signal is recognized. In Bell System electromechanical switching systems, the delay-dial signal is generated by the individual incoming trunk circuit. In electronic switching systems, such as the No. 4 ESS, the delay-dial signal is generated by common control equipment which controls the trunk circuit. The trunk circuit sends the delay-dial signal. The delay-dial signal is maintained until a register is attached to the incoming trunk. When the register is attached and ready to receive pulses, the start-dial (on-hook) signal is sent to the calling office.

3.08 In this method of controlled outpulsing, there is no minimum time requirement for the delay-dial (off-hook) signal. In fact, no delay-dial signal is needed if the called office is ready to receive pulses.

3.09 If the called office is not ready to receive pulses, the speed with which the called office returns the delay-dial signal is especially important in the delay-dial method of operation. Where signaling integrity check is not used, the failure to receive a delay-dial signal may permit the sender to outpulse before the register or sender is attached at the called end. This can cause the call to be routed to reorder or left high and dry depending on the exact conditions involved.

3.10 The trunk circuits that use E&M leads for signaling in the delay-dial method of operation are on-hook at both ends when in the idle condition. E&M lead signaling trunks should receive the delay-dial signal less than 300 milliseconds after seizure; otherwise, the originating end will interpret the on-hook signal (or lack of off-hook signal) as a start-dial signal and begin outpulsing prematurely. The 300 milliseconds must include all signaling delays in signaling units and transmission delays as well as the delay within the terminating trunk circuit. These conditions obviously preclude using transmission facilities derived from a synchronous satellite which has a round trip transmission time of over 300 milliseconds.

3.11 Some loop signaling trunks using the delay-dial 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-dial 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. The off-hook when idle trunk circuits could be used with synchronous satellite-derived facilities; however, the use of such trunks on satellite-derived facilities is remote since the 2-wire loop trunk circuits are generally used for toll connecting and there is no suitable signaling unit to interface with the 4-wire loop trunk circuits.

3.12 When the originating office ***expects*** a delay-dial signal (without integrity check), the terminating office must ***send*** a delay-dial signal. The No. 4 crossbar, No. 5 crossbar, and crossbar tandem systems may ***expect*** a delay-dial signal (without integrity check). The No. 4 crossbar, No. 5 crossbar, crossbar tandem, No. 1/1A ESS, No. 1/1A ESS HILO, No. 2/2B ESS, No. 4 ESS, step-by-step (common control), and step-by-step (with integrity check) systems can ***send*** a delay-dial signal. The No. 3 ESS and TSPS ***cannot send*** a delay-dial signal. The No. 1/1A ESS, No. 1/1A ESS HILO, No. 2/2B ESS, No. 3 ESS, No. 4 ESS, and TSPS never operate in the ***expect*** delay-dial (without integrity check) mode.

3.13 Delay-dial is often referred to as an off-hook, on-hook signaling sequence. The delay-dial signal is the off-hook interval and the start-dial is the on-hook interval. Bell System switching systems do not check for an on-hook before the delay-dial signal.

DELAY-DIAL WITH INTEGRITY CHECK

3.14 With integrity check, the originating office will not outpulse until a delay-dial (off-hook) signal followed by a start-dial (on-hook) signal has been recorded at the originating office. This method is very much like wink-start operation. In fact, with No. 4 crossbar toll connecting, crossbar tandem, and No. 5 crossbar trunks, delay-dial ***expected*** and wink-start ***expected*** are identical. No. 4 crossbar intertoll trunks always ***expect*** delay-dial as explained in paragraphs 2.34 through 2.39. The ESSs do have differences between delay-dial ***expected*** and wink-start ***expected*** which will be explained in paragraph 3.26.

3.15 In the delay-dial with integrity check method of controlled outpulsing, seizure of the trunk by the originating office causes the distant office to return a delay-dial signal. However, the delay-dial signal does not have to be returned within a given interval (ie, 300 milliseconds). It can be delayed for a longer period since the originating office will not begin outpulsing until it has received an off-hook (delay-dial) signal followed by an on-hook (start-dial) signal. It is the performance of this positive signaling sequence from on-hook to off-hook to on-hook that verifies the "integrity" of the trunk.

3.16 The delay-dial signal in this method of controlled outpulsing must meet the following requirements:

(a) The off-hook must be a minimum of 140 milliseconds in duration.

(b) The off-hook to on-hook transition (start-dial) must not occur until:

(1) 210 milliseconds after the connect signal is received, and

(2) The register or sender is attached and ready to receive pulses.

It is desirable to minimize the post dialing delay by sending the off-hook to on-hook transition as soon as possible after the above requirements are met. 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-dial signal.

3.17 The 210-millisecond delay from the reception of the connect signal at the terminating office to the sending of the start-dial signal (by the terminating office) was not included in the 1975 issue of ***Notes on Distance Dialing.*** It was not necessary to specify this delay because it was inherent to the operation of the electromechanical switching systems and to the No. 1 ESS. However, with the advent of faster ESSs, it would be possible to complete sending the 140-millisecond minimum delay-dial signal before the originating office was in a position to receive the delay-dial signal. For example, to minimize glare (paragraphs 2.25 through 2.44) in electromechanical switching systems, the marker causes the trunk to send a connect signal to the terminating office before a sender is attached. With a short delay signaling system such as used in T Carrier, the minimum delay-dial signal could be over before the sender is attached and ready to receive a delay-dial signal. In the No. 5 crossbar system, the sequence of sending the connect signal to attaching a sender and detecting a wink-start or delay-dial signal is between 100 and 210 milliseconds. A minimum length delay-dial or wink-start signal (140 milliseconds) can be missed if the start-dial signal reaches the originating No. 5 crossbar office less than 210 milliseconds after the connect signal. In addition, there is a period of time after the No. 1/1A ESS sends the connect signal forward on a 1- or 2-way trunk that the system is blind to signaling from the far end. A start-dial signal occurring within 210 milliseconds of the connect signal can be missed.

3.18 All Bell System common control switching systems, as well as the step-by-step system (with integrity check), can ***send*** signals that will meet the requirements for delay-dial with integrity check. In many cases, the signal ***sent*** also meets the requirements for wink-start and is actually called wink-start by the terminating office.

3.19 The majority of No. 4 crossbar, crossbar tandem, and No. 5 crossbar switching systems can ***expect*** delay-dial with integrity check. As indicated above, it is identical to wink-start ***expected*** in No. 5 crossbar and crossbar tandem. The No. 4 crossbar using delay-dial with signaling integrity check will consider any delay-dial signal over 5 seconds to be glare (paragraphs 2.25 through 2.44) on 2-way trunks.

3.20 At least one No. 5 crossbar 2-way Line Link Pulsing (LLP) circuit fails if the delay-dial or wink-start signal is received within 100 milliseconds of seizure. A complete survey of circuits has not been made; therefore, other LLP or trunk circuits may have the same operating characteristics. Whenever a long delay signaling system such as SF signaling is used, the necessary delay is provided in the signaling system.

3.21 All the electronic switching systems (No. 1/1A ESS, No. 1/1A ESS HILO, No. 2/2B ESS, No. 3 ESS, and No. 4 ESS) can ***expect*** delay-dial with integrity check. Unlike the electromechanical systems, there is a difference between ***expect*** wink-start and ***expect*** delay-dial with integrity check. ***Expect*** delay-dial with integrity check operation has no time limit in most systems for the delay-dial signal except a 4-second limit when glare detection is used (paragraphs 2.25 through 2.44), while wink-start has a shorter time-out interval of 500 to 600 milliseconds for No. 1/1A ESSs. See paragraph 2.30 for the time-out interval for other systems. The No. 2/2B ESS times

8 seconds (±10 percent) for an off-hook and after the off-hook is received up to 16 seconds (±10 percent) for an on-hook.

3.22 Delay-dial with integrity check can be an on-hook, off-hook, on-hook like wink-start or an off-hook, on-hook signaling sequence like delay-dial. All E&M lead trunks are on-hook when idle. The loop trunks can be off- or on-hook when idle per paragraph 3.11. The originating office would have to restrict interconnection to on-hook, off-hook, on-hook sequence trunks to make use of all three signaling intervals. However, Bell System offices do not detect the original on-hook.

WINK-START

3.23 With wink-start 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-dial) 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 a wink-start signal is sent by the called office. The wink-start signal is an off-hook signal that must meet the following requirements:

(a) The off-hook must be a minimum of 140 milliseconds and a maximum of 290 milliseconds in duration.

(b) The off-hook to on-hook transition (start-dial) must not occur until 210 milliseconds after the connect signal is received.

It is desirable to minimize the post dialing delay by sending the off-hook transition as soon as possible after the above requirements are met. The nominal wink-start signal is about 200 milliseconds for electromechanical offices, 150 milliseconds for No. 1/1A ESS offices, and 250 milliseconds for No. 4 ESS offices. Electromechanical and No. 1/1A ESS offices delay returning the wink-start signal for slightly more than 100 milliseconds. This is the minimum time required to attach a register/receiver to the incoming trunk after the connect signal is received. The No. 4 ESS usually returns the wink-start signal within a few milliseconds of the receipt of the connect signal. The transitions from on-hook to off-hook to on-hook, with the duration of off-hook constrained as indicated, constitute the wink.

3.24 The signal transmission system will generally distort the wink-start as it is transmitted between offices. As a result, the calling office must recognize an off-hook signal in the range of 100 to 350 milliseconds as a wink-start signal. Off-hook signals exceeding 350 milliseconds can be treated as glare on 2-way, wink-start trunks (paragraphs 2.25 through 2.44). All wink-start trunks operate in the same manner, whether E&M lead or loop reverse battery signaling.

3.25 The 210-millisecond minimum delay between reception of the connect signal and completion of the wink-start signal was not included in the 1975 issue of ***Notes on Distance Dialing***. It was not necessary to specify this delay because it was inherent to the operation of the electromechanical switching systems and to the No. 1 ESS. Additional details concerning this subject are provided in paragraph 3.17.

3.26 The capability of various switching systems to ***expect*** or ***send*** wink-start is covered in Table C. In the case of ***expect*** wink-start, the ESSs time the received off-hook signal. On No. 1/1A ESS 2-way trunks, an off-hook, wink-start signal longer than 500 to 600 milliseconds is interpreted as a glare condition and initiates the start of the glare resolution sequence. On No. 1/1A ESS 1-way trunks, a 500- to 600-millisecond, wink-start signal causes the call to be routed to reorder and maintenance activity started. All present CAMA systems and TSPSs ***send*** wink-start.

FALSE OFF-HOOK

3.27 The No. 5 crossbar system is known to generate a false off-hook that can cause pumping on a 2-way LLP circuit with either delay-dial or wink-start operation. When a 2-wire No. 5 crossbar 2-way LLP circuit is used on a call originating in a PBX and the call is abandoned by the PBX party before the completion of dialing (call abandoned in the originating register), a false off-hook pulse is sent back toward the PBX. The false off-hook pulse can start any time from 200 to 570 milliseconds after receipt of on-hook from the PBX. The duration of the false pulse is 160 to 250 milliseconds.

START-DIAL (START-PULSING)

3.28 Start-dial 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 after receipt of the start-dial signal 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-dial signal to prevent the registration of a false reflected pulse. In the No. 5 crossbar offices, dial pulsing is delayed 55 milliseconds instead of the recommended 70 milliseconds. Good practice also suggests that dial pulse registration circuits at the called end be disabled (desensitized) for a minimum of 30 milliseconds and a maximum of 70 milliseconds after the start-dial signal is sent. In the No. 4A crossbar system, a nominal 200-millisecond delay is introduced after receipt of the start-dial signal and before MF outpulsing. This delay was introduced to prevent false stop-dial signals occurring with the use of the older type SF signaling equipment. It also facilitates proper sender retrial operation (when such features are provided) during simultaneous seizures of 2-way intertoll trunks. There is no standard delay between the start-dial signal and MF outpulsing. The delay can be 0 to 200 milliseconds depending on the MF sender used in the various switching systems.

3.29 Experimental data indicate that the start-dial signal generates transient noise at the sending central office that lasts for about 50 milliseconds in electromechanical offices and about 20 milliseconds in electronic offices. This transient can mask the KP signal long enough to prevent recognition by the MF receiver, thereby causing a call failure. No Bell System switching system will accept an MF-pulsed address signal unless it starts with KP (and ends with ST [start]). The nominal transmitted KP signal is from 90 to 120 milliseconds and the MF receiver will recognize a KP signal of 55 milliseconds minimum. It is easy to see that call failures could occur on MF-pulsed calls between electromechanical offices. As a result, design changes are being introduced in the crossbar tandem system to provide a 50-millisecond delay between the reception of the start-dial signal and the transmission of the KP signal. Similar changes are being considered for the No. 5 crossbar system. It is good practice to introduce a minimum delay of 50 milliseconds between the receipt of the start-dial signal and the beginning of outpulsing to permit the transients associated with the start-dial signal to dissipate before the first MF pulse is sent. Actual delays introduced between the reception of the start-dial signal and the beginning of the KP signal are as follows:

SYSTEM	DELAY (MILLISECONDS)
No. 1 crossbar	Not available
No. 4 crossbar	200
No. 5 crossbar:	
MF senders	0
DP senders	55
DP senders converted to MF operation	55
No. 1/1A ESS	100 - 150
No. 2/2B ESS	Not available
No. 3 ESS	Not available
No. 4 ESS	20, 80, or 200 (selectable per trunk group)

STOP-GO

3.30 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 Community Dial Office (CDO) not equipped for immediate-dial. The originating common control office dial pulses the address information. An off-hook signal returned to the originating office within the interdigital interval stops outpulsing until the supervisory condition returns to on-hook. The off-hook signal 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.

3.31 In stop-go operation, the step-by-step intertoll office uses one, two, or three digits 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 of about 330 milliseconds.

3.32 The terminating office sends a delay-dial signal on stop-go trunks as soon as it receives the initial seizure signal or off-hook. The delay-dial 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-dial, 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 normally equipped to return a stop signal.

UNEXPECTED STOP

3.33 An unexpected stop is a spurious off-hook (stop) signal detected by the sender before or during outpulsing. It can be an off-hook (stop) signal on a circuit not arranged for stop-go operation or a second off-hook signal on a circuit arranged for stop-go operation. The detection of an unexpected stop signal is used as a trouble condition. However, prudent use of this test is required because it is possible for many circuits to produce unexpected stop signals when there is no trouble. To prevent taking unnecessary trouble records and falsely sending calls to reorder, the various Bell System switching machines use different methods to avoid detecting nonproductive unexpected stop signals.

3.34 Toll switching systems can look for unexpected stops during MF outpulsing on intertoll circuits. However, no Bell System switching system looks for unexpected stops after outpulsing is completed, ie, after the last dial pulse when dial pulsing or after the ST pulse when MF pulsing. The No. 5 crossbar system, for example, often produces a short off-hook signal in the process of transferring call control from the incoming register back to the trunk circuit. This off-hook signal would be detected as an unexpected stop if a switching system looked for unexpected stops after outpulsing was completed. The step-by-step and No. 1 crossbar systems are known to produce short off-hook signals during and after the units digit. Consequently, Bell System switching systems do not look for unexpected stops after the start of the units digit on toll completing or local calls.

3.35 The Bell System switching systems test for unexpected stops during MF outpulsing as follows:

(a) The crossbar tandem system looks for an unexpected stop during MF outpulsing until the completion of the ST pulse on 2-way trunks and until outpulsing the tens digit on 1-way trunks.

(b) The No. 4 crossbar system looks for an unexpected stop during MF outpulsing until the completion of the ST pulse on intertoll trunks and until outpulsing the units digit on toll connecting trunks.

(c) The No. 5 crossbar system looks for an unexpected stop during DP outpulsing in the interdigital intervals until after outpulsing the tens digit on intertoll, toll connecting, and local trunks. The No. 5 crossbar system looks for an unexpected stop during MF outpulsing from the start of the KP signal until the end of the tens digit on intertoll, toll connecting, and local trunks.

(d) The No. 1/1A ESS looks for an unexpected stop before MF outpulsing and in an interval between the tens and units digits on intertoll, toll connecting, and local trunks.

(e) The No. 4 ESS looks for an unexpected stop after receipt of the start-dial indication to the completion of the ST pulse on intertoll calls and on toll connecting calls before MF outpulsing starts to the hundreds digit for 10-digit outpulsing, to the ST pulse on 7-digit outpulsing, to the tens digit on 5-digit outpulsing, and to the units digit on 4-digit outpulsing.

SENDER TIMING

3.36 Normally in a No. 4 crossbar or crossbar tandem switching system, senders wait as long as 20 to 40 seconds for a sender to be attached in the distant office. If a distant sender cannot be attached within this time interval, the "home" sender times out and routes the call to an overload announcement. When all "home" senders in the same sender group become busy, the time-out interval is automatically reduced from 20 to 40 seconds to 5 to 8 seconds. There are instances when this short sender timing interval may not be appropriate and network management personnel may elect to cancel it and return the sender waiting time to the regular 20- to 40-second interval. For this reason, an indication is given to network management when short sender timing is in effect so that manual cancellation can be activated if desired. These signal indications are a part of the Dynamic Overload Control (DOC) equipment.

3.37 The DOC equipment is also available for use in ESS offices and is used to send signals to distant offices, requesting that they limit the amount of traffic sent to the ESS office. The DOC signals are sent from ESS offices because of a shortage of real time, a shortage of receivers, or a lack of capability to switch calls. The DOC control console at the ESS office contains various lamps indicating the type signals being sent. It is also Network Management's practice to limit traffic in expected overload situations (eg, Mother's Day).

4. DIAL PULSING

4.01 Dial pulsing is a means of transmitting digital information from a customer'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 release 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 central 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.

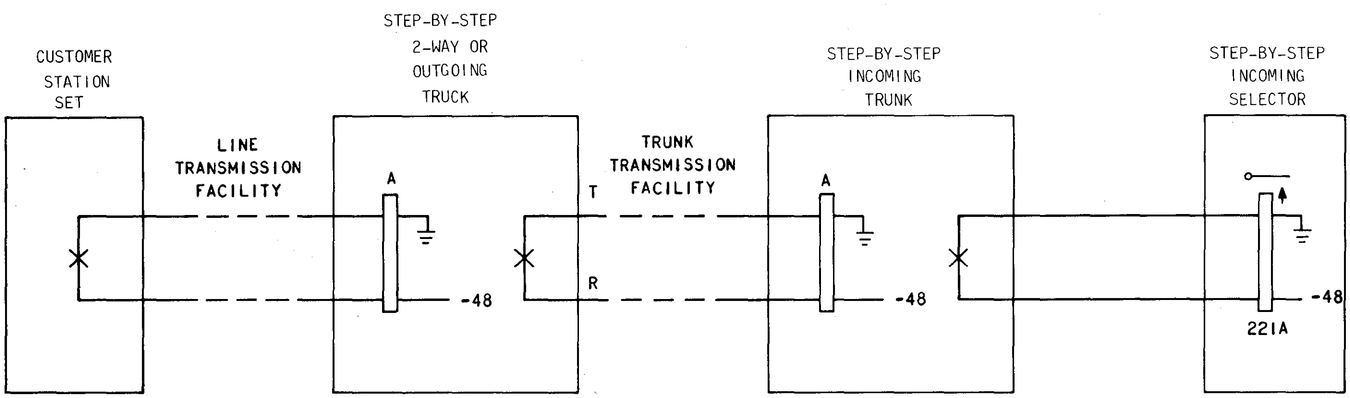
4.02 With dial pulsing, the numerical value of each digit is represented by the number of on-hook intervals in a train of pulses. The on-hook intervals of each digit are separated by short off-hook intervals while the digits themselves are separated by relatively long off-hook intervals. The on-hook signals are not interpreted as disconnect signals since they are considerably less than the minimum disconnect times given in Tables A and B. 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.

4.03 Dial pulse signaling in the Bell System is originated at a "pulsing speed" of approximately 10 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.

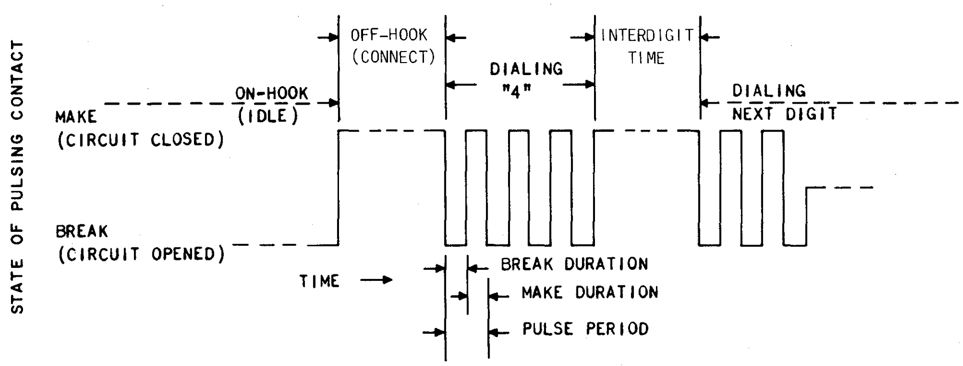
4.04 Figure 4 illustrates dial pulsing. Figure 4(A) shows typical pulsing contacts (which may be the cam-operated contact in a rotary dial or the "make" contact of a pulse-repeating relay in a signaling circuit as shown); these contacts open and close a dc circuit a number of times equal to the digit being dialed together with relays which are intended to respond accordingly. Figure 4(B) illustrates some of the terms employed in describing dial pulse signaling circuits.

LOOP AND LEAK

4.05 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 of adding series resistance is the same as increasing the percent break at the pulsing 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 the signaling voltage. The net effect of adding shunt capacitance or shunt resistance is the same as decreasing the percent break at the pulsing contact.



(A) DIAL PULSING CIRCUITS

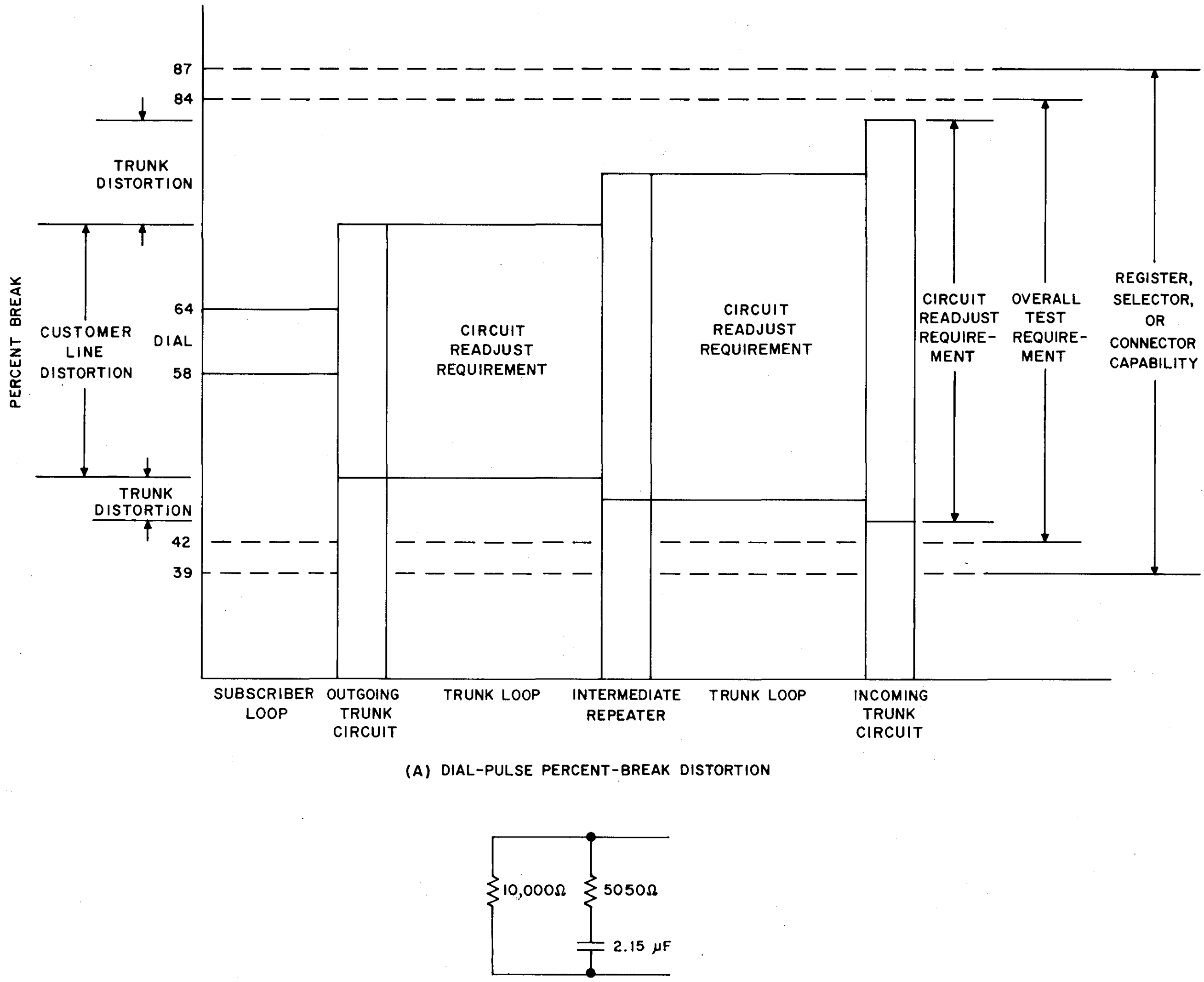


PULSING PERIOD = BREAK DURATION + MAKE DURATION (MILLISECONDS)
PULSING SPEED = PULSES PER SECOND = 1000 ÷ PULSING PERIOD (MILLISECONDS)
PERCENT BREAK = 100 X BREAK RATIO
= 100 X BREAK DURATION ÷ PULSING PERIOD

(B) DIAL PULSING DEFINITIONS

Fig. 4—Dial Pulse Signaling

4.06 In certain pulsing tests, series resistance is added to roughly simulate 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 D1,*** etc. Figure 5(B) shows the circuit of the ***leak A*** condition.



(A) DIAL-PULSE PERCENT-BREAK DISTORTION

(B) LEAK A

Fig. 5—Circuit Requirements for Loop Conditions

4.07 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, relays cannot exactly translate change of current in their windings into changes of state of their own contacts. The important consideration, however, is the state of the contact upon which all subsequent activity in the circuit depends. For this reason, the terms and definitions in Fig. 4 refer to states of the pulsing contact and not to current flow or any other feature of the circuit. 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.

4.08 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 solely 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 relay in the signaling circuit for which it is substituted.

4.09 Modern customer dials are designed to a break ratio of 58 to 64 percent, manufactured with an objective accuracy of 10 ±0.5 PPS, and operated under normal service conditions between 8 and 11 PPS 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.

DIAL PULSING LIMITS

4.10 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 20-PPS dials is 17 to 21 PPS, 62 to 66 percent BK. While present applications of 20-PPS dials will continue, no new circuits will be designed for 20 PPS. There will be no requirement to operate with 20-PPS dials. Some existing Bell System switching systems are not compatible with a 20-PPS dial, eg, No. 2/2B ESS and No. 10A Remote Switching System.

The objective output for modern senders is:

E&M pulsing	10±0.2 PPS	60.0±2 percent BK
Loop pulsing	10±0.2 PPS	60.0±2 percent BK
Battery and ground	10±0.2 PPS	60.0±2 percent BK

The majority of senders in service will outpulse within the following limits:

E&M pulsing	10±1 PPS	56.0 to 60.0 percent BK
Loop pulsing	10±1 PPS	59.5 to 67.5 percent BK
Battery and ground	10±1 PPS	48.5 to 66.0 percent BK

4.11 The nominal dial pulsing speed in the various signaling, trunk, and pulse repeater circuits used in network dialing is 10 PPS. Percent break requirements for these circuits differ since the percent break may be shifted in passing through various circuits.

4.12 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 or loop sender operates at 64 percent BK because the connected trunk circuit works best with this break ratio on its input loop; however, the composite (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 receives 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.

4.13 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 E. These examples are illustrative only and are not meant to be all-inclusive. For types not listed, other literature should be consulted.

4.14 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. However, short on-hook signals are generated by Bell System switching systems that could be mistaken for dial pulses. These short on-hook signals occur before the start of pulsing, during the interdigital interval, and shortly after the completion of outpulsing. As a result, it is recommended that dial pulse receivers ignore on-hook signals shorter than 10 milliseconds and accept on-hook signals greater than 25 milliseconds.

4.15 Figure 5 shows the limiting conditions on loop pulsing. The circuit diagram for this arrangement is shown in Fig. 4. The percent break limits for a dial are shown on the left in Fig. 5. The distortion these pulses experience from the customer's line, the originating office, the intermediate office, and the terminating office is 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

TABLE E

PERCENT BREAK SHIFT IN OUTGOING TRUNKS

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.

to drive a register, selector, or connector. However, when pulse distortion exceeds the capability of the register, selector, or connector, pulse correction must be provided, usually at the terminating office. The percent break ranges shown in Fig. 5 are for pulsing over a customer's loop of 1500 ohms and no ***leak*** in one test and pulsing with ***leak A*** and no ***loop*** in another.

4.16 The 1500-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 percent 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 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.

4.17 The ***leak*** test represents a test on a customer's line with zero loop resistance, maximum number of ringers, and maximum permissible leakage. The percent breaks shown in Fig. 5 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. A 221A relay is used for this purpose in the Bell System. The tests are made at the highest dial pulsing speed (12 PPS) encountered in practice because the higher the pulsing speed, the higher the distortion.

INTERDIGITAL TIME

4.18 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, or equivalent device, 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. 4.)

4.19 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:

(a) Three hundred milliseconds when pulsing into senders or registers of systems other than step-by-step.

(b) 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 recommended. However, the maximum time for selector action can be as high as 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.

4.20 A breakdown of the interdigital interval in step-by-step offices is as follows:

TIME IN MILLISECONDS			
MINIMUM	AVERAGE	MAXIMUM	
58	100	155	Release C relay
250	325	400	Hunt 10 terminals
40	57	75	Operate D relay
8	10	15	Operate A relay
15	22	30	Operate B relay
20	20	20	Soak B
391	534	695	Total Interdigital Time in Milliseconds

4.21 The No. 5 crossbar system, No. 1/1A ESS, No. 2/2B ESS, and No. 3 ESS have always had the ability to transmit a 700-millisecond interdigital interval. The ability to use a 700-millisecond interdigital interval has been added to the No. 4 crossbar system, the crossbar tandem system, and the No. 4 ESS. These offices may or may not have added the necessary changes to use the increased interval. The No. 1/1A ESS has an office option for an interdigital interval of 600 to 1000 milliseconds. The default value is 600 milliseconds.

4.22 Although senders and registers are capable of recognizing interdigital intervals as short as 300 milliseconds, Bell System senders have not in the past used interdigital intervals of less than 500 milliseconds when outpulsing; shorter intervals approaching the 300-millisecond minimum may be used in the future. An accuracy of ±5 percent is considered satisfactory for timing this interval.

4.23 In step-by-step systems, three functions must be completed during the interdigital interval as follows:

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

(b) Trunk-hunt over as many as ten terminals.

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

4.24 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-dial 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:

(a) The delay due to transit time before an off-hook is seen at the source of the stop-dial

(b) The reaction time required to generate a stop-dial

(c) The delay due to transit time before the stop-dial 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.

5. LOOP SIGNALING

5.01 The basic loop signaling circuit is a series circuit such as illustrated in Fig. 4(A). 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

5.02 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 loop signaling method. Figure 6 shows a typical application of reverse battery signaling in a common control office. In the idle or on-hook condition, all relays are unoperated and the SW contacts are open. Upon seizure of the outgoing trunk by the calling office (trunk group selection based on the office code dialed by the calling customer), the following will occur:

(a) SW2 contacts close, thereby closing loop to called office and causing the A relay to operate.

(b) Operation of the A relay signals off-hook (seizure) indication to called office.

(c) Upon completion of pulsing between offices, the called customer is alerted. When the called customer answers, the S2 relay is operated.

(d) Operation of the S2 relay operates the T relay which reverses the voltage polarity on the loop to the calling end.

(e) The voltage polarity causes the CS relay to operate, transmitting an off-hook (answer) signal to the calling end.

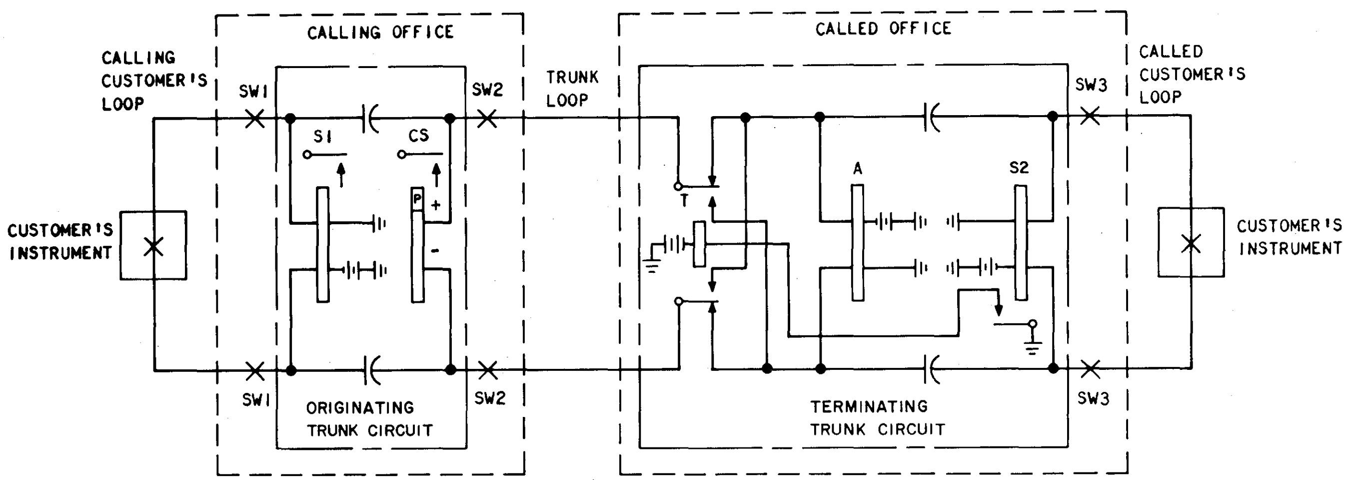


Fig. 6—Reverse Battery Signaling

5.03 When the calling party hangs up, disconnect timing per paragraph 2.13 (150 to 400 milliseconds) is started. After the timing is completed, SW1 and SW2 contacts are released in the calling office. This (1) opens the loop to the A relay in the called office and (2) releases the calling party. (The calling party is free to place another call.) The disconnect timing per paragraph 2.13 (150 to 400 milliseconds) is started in the called office as soon as the A relay releases. When the disconnect timing is completed, the following will occur:

(a) If the called party has returned to on-hook, SW3 contacts will release. The called party is free to place another call.

(b) If the called party is still off-hook, disconnect timing per Table A is started in the called office. On the completion of the timed interval, SW3 contacts will open. The called customer will be returned to dial tone. If the circuit is seized again from the calling office during the disconnect timing, the disconnect timing is terminated and the called party is returned to dial tone. The new call would be completed without interference from the previous call.

5.04 When the called party hangs up, the CS relay in the calling office releases. Then the following occurs:

(a) If the calling party has also hung up, disconnection takes place as described in the paragraph above.

(b) If the calling party is still off-hook, disconnect timing per Table B is started. On the completion of the disconnect timing, SW1 and SW2 contacts are opened. This returns the calling party to dial tone and releases the A relay in the called office. The calling party is free to place a new call at this time. After the disconnect timing per paragraph 2.13 (150 to 400 milliseconds), the SW3 contacts are released which releases the called party. The called party can place a new call at this time.

(c) If the calling office is a step-by-step office, the disconnect timing for called party on-hook and/or calling party off-hook is made in the called office. The times in Table B apply. After the disconnect interval is completed, the called party is free to place a new call.

5.05 Figure 7 illustrates repeated reverse battery signaling at a tandem office. The slow release D relay is used to hold the connection through the tandem switches.

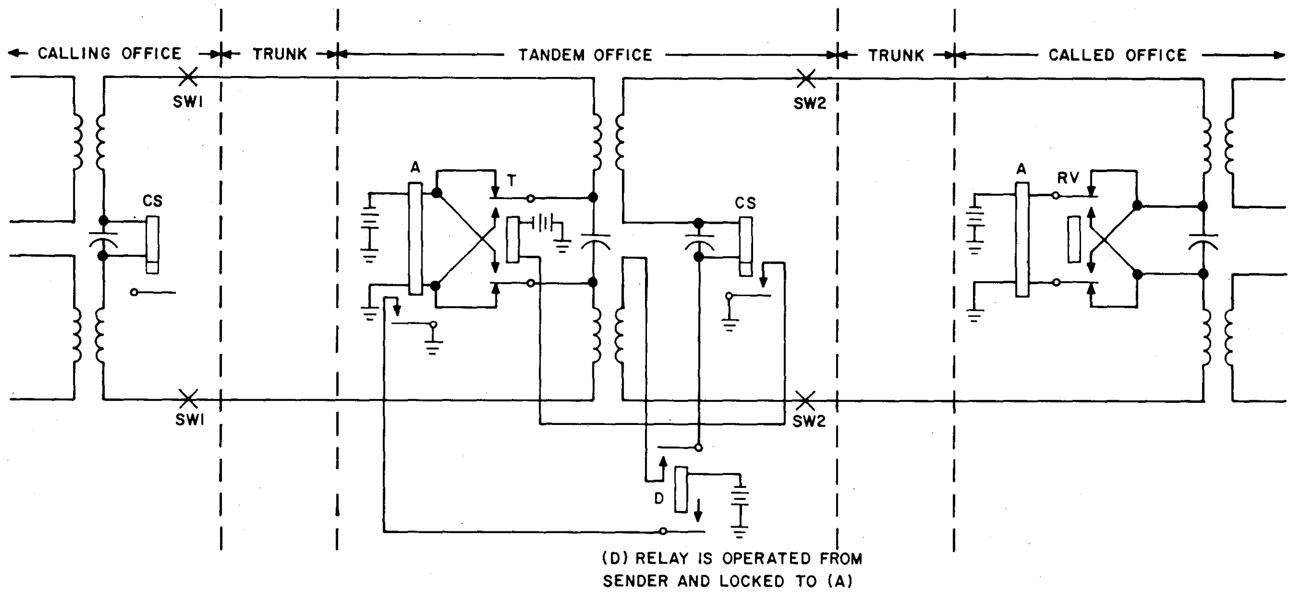


Fig. 7—Repeated Reverse Battery Signaling

BATTERY AND GROUND SIGNALING

5.06 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 voltage available for signaling. Means are provided to open and close both conductors at the originating end to furnish forward on- 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 8 shows a circuit using battery and ground pulsing with loop holding.

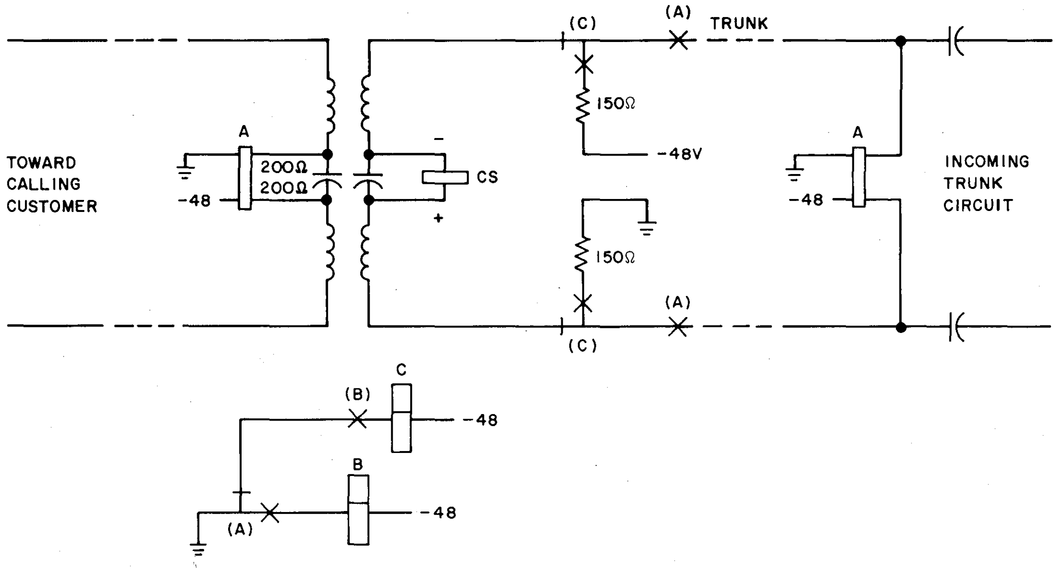


Fig. 8—Battery and Ground Pulsing with Loop Supervision

HIGH-LOW SIGNALING

5.07 In high-low signaling, 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. 9. 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 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.

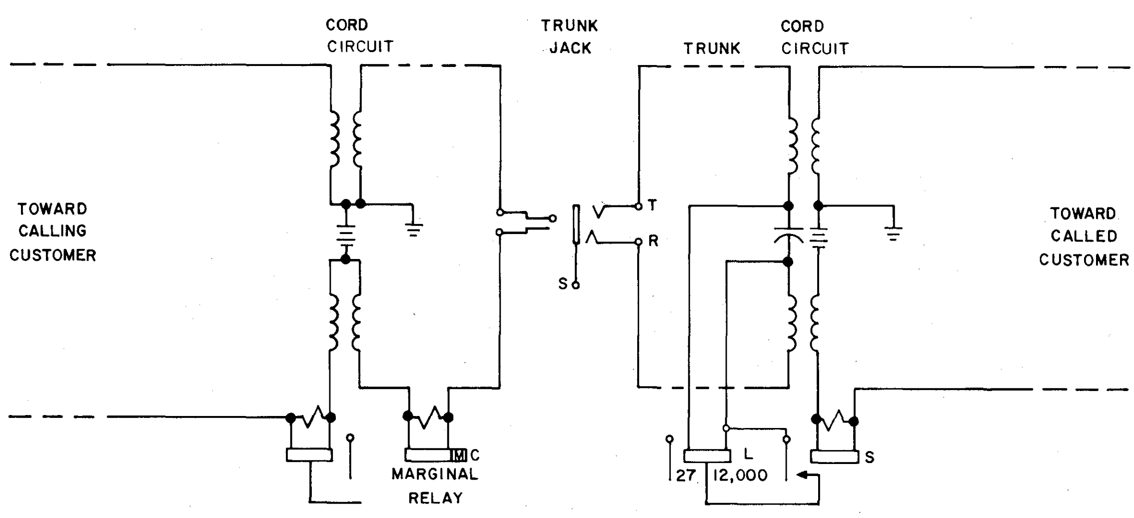


Fig. 9—High-Low Signaling

5.08 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 other signaling schemes, such as reverse battery, applied at the terminating end.

A. High-Low, Reverse Battery Signaling

5.09 CAMA and TSPS trunks have the capability for being made busy from the terminating end. Figure 10 shows such a trunk originating in a step-by-step local office. These trunks are reverse battery trunks, as described in paragraph 5.02, 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.

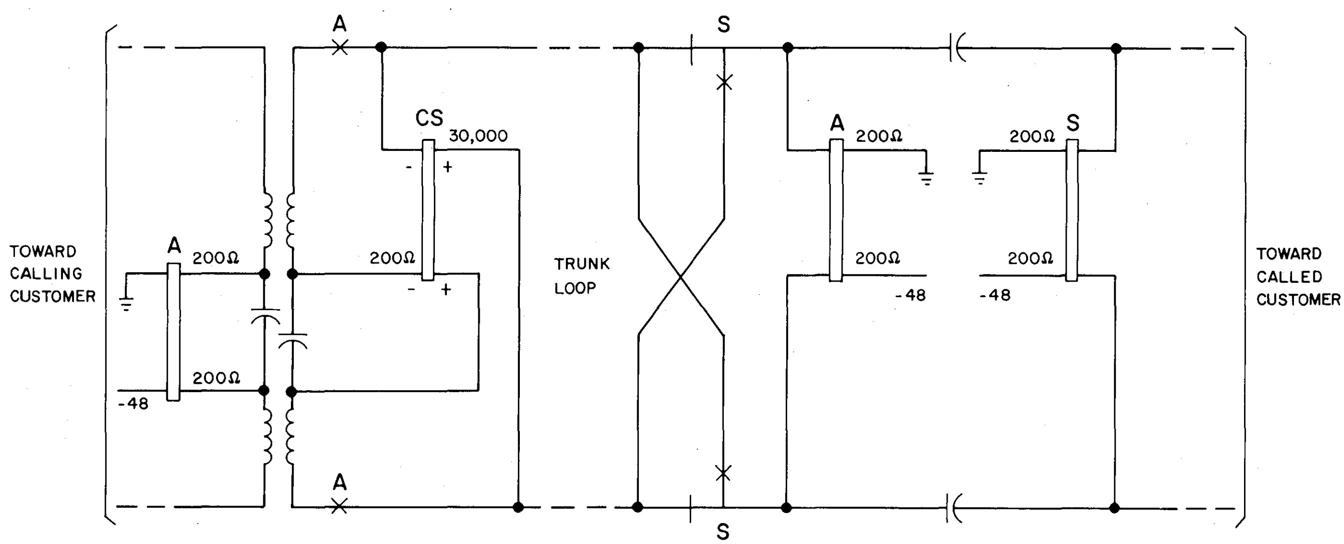


Fig. 10—High-Low, Reverse Battery Signaling

B. Reverse Battery, High-Low Signaling

5.10 This signaling arrangement is used between a local central office and an operator at a switchboard. As shown in Fig. 11, the switchboard responds to reverse battery and the local central office to high-low supervision. When the customer is connected, the A relay operates, reversing the battery; but the reverse 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."

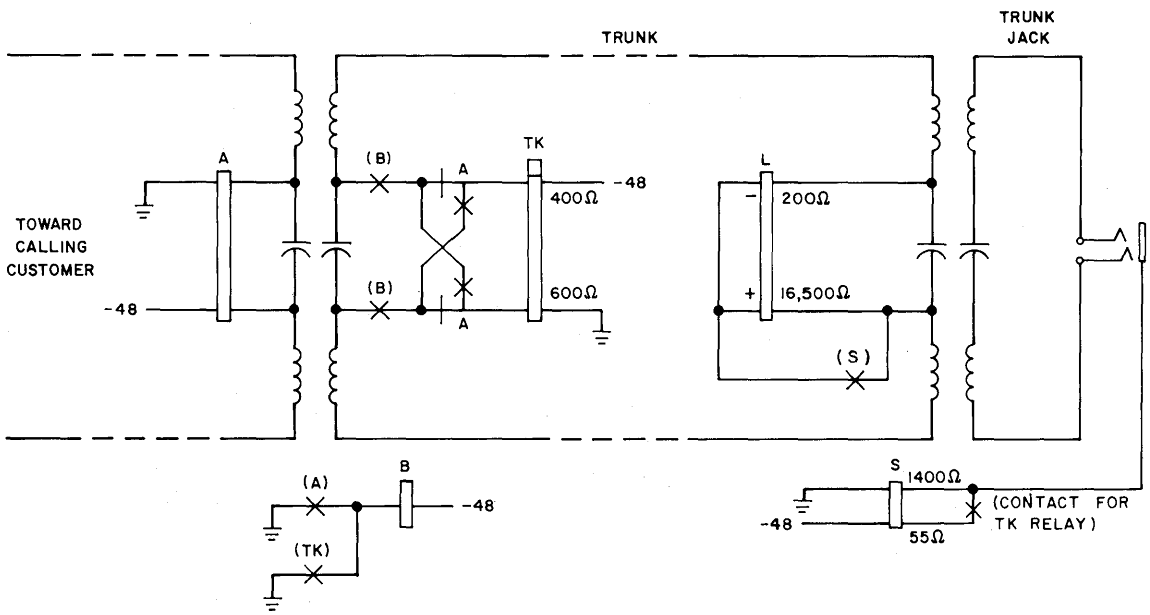


Fig. 11—Reverse Battery, High-Low Signaling

5.11 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 the customer has hung up. (See paragraphs 2.12 through 2.18.)

WET-DRY

5.12 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. 12, 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.

5.13 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 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.

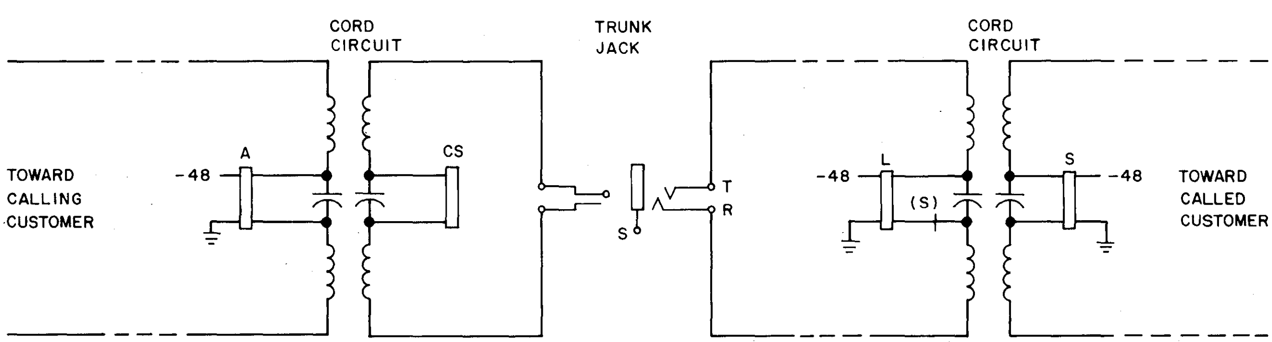


Fig. 12—Wet-Dry Signaling

IDLE CIRCUIT TERMINATIONS AND TRUNK CAPACITANCE

5.14 Idle circuit terminations do not affect signaling on E&M trunks because the T&R leads are not in the dc signaling path. Idle circuit terminations, such as the ideal transmission value of 2.16 μF in series with 900 ohms, may therefore be used. However, idle circuit terminations connected to signaling leads have a substantial effect on signaling.

5.15 In the idle condition, the termination toward the called end presented by an outgoing trunk circuit or an incoming trunk signaling or channel unit using loop signaling should not exceed 0.5 μF capacitance. This capacitance limit includes all shunt capacitances including transmission capacitors, contact network capacitors, and idle circuit termination network capacitors.

5.16 The total trunk capacitance in the on-hook state, including the idle circuit termination in the outgoing loop trunk circuit, the cable capacitance, the capacitance of any transmission repeaters, and the on-hook capacitance of an on-hook terminating channel unit, should not exceed 2 μF for trunks with a specified 2000-ohm conductor range and 4 μF for trunks with a specified 4000-ohm conductor range.

6. E&M LEAD SIGNALING

INTERFACE REQUIREMENTS

A. General

6.01 Most signaling systems, other than loop signaling, are separate from the trunk equipment and functionally are normally located between the trunk equipment and the line facility. The E&M lead signaling systems derive their name from historical designations of the signaling leads on the circuit drawings covering these systems. Traditionally, the E&M lead signaling interface consisted of two leads between the switching (trunk) equipment and the signaling equipment: the M lead which carries signals from the switching (trunk) equipment to the signaling equipment and the E lead which carries signals from signaling equipment to the switching (trunk) 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. 13.

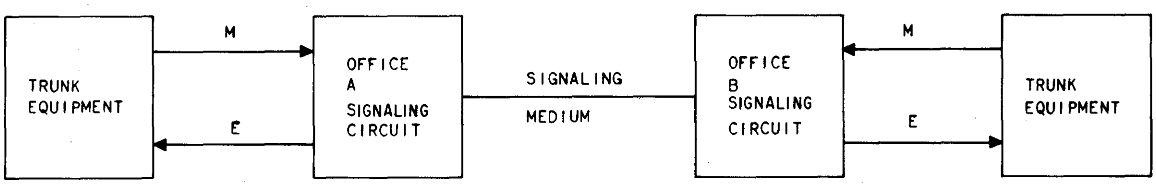


Fig. 13—E&M Lead Control Status

6.02 Historically, E&M lead signaling circuits have used only one lead for each direction of transmission with a common ground return. This means that the signaling leads have a greater noise influence than if the leads were balanced (2-wire) as are transmission circuits. While the E&M lead signaling circuits operated satisfactorily in electromechanical systems, they were not satisfactory for electronic systems. As a result, several new E&M lead interfaces have been introduced. These are described below.

B. Type I Interface

6.03 The Type I interface (Fig. 14) is the original E&M lead signaling arrangement. Signaling from the trunk circuit to the signaling facility is over the M lead using nominal -48 volts for off-hook and local ground for on-hook. Signaling in the other direction is over the E lead using local signaling facility ground for off-hook and open for on-hook. The trunk circuit sensor on the E lead should use nominal -48 volts, and essentially the full voltage should appear on the E lead during the on-hook state.

6.04 The battery supply to the M lead for the off-hook state may be applied through a current limiter to prevent blowing of fuses or circuit damage in case the M lead is accidentally grounded (not a rare event). In any case, the voltage should not drop more than 5 volts with 85 milliamperes in the M lead. In the on-hook state, the potential drop from M lead to ground at the trunk circuit should not exceed 1 volt when an external -50 volt source is connected to the M lead through 1000 ohms.

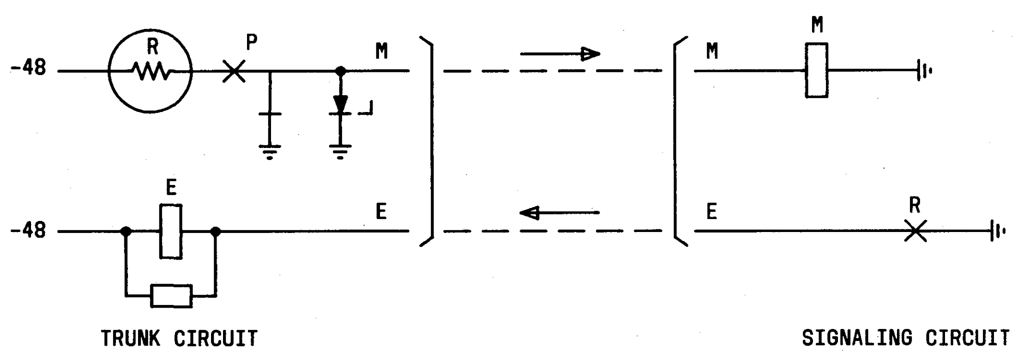


Fig. 14—Type I Interface

C. Type II Interface

6.05 The Type II interface (Fig. 15) is a 4-wire, fully looped but nonsymmetrical arrangement. Signaling from the trunk circuit to the signaling facility is by means of opens and closures across the M and SB pair of leads for on-hook and off-hook, respectively. Since the signaling facility supplies nominal -48 volts to the SB lead, the effect is to signal on the M lead with battery for off-hook and open for on-hook. Signaling in the reverse direction is by means of opens and closures across the E and SG leads for on-hook and off-hook, respectively. Since the trunk circuit grounds the SG lead, the effect is to signal on the E lead with open for on-hook and ground for off-hook. The signaling facility should supply nominal -48 volts to the SB lead through a current limiting device. Refer to paragraphs 6.34 through 6.38 for the requirements for this current limiter.

6.06 The trunk circuit sensor on the E lead should be biased with nominal -48 volts, except that if considerable loss of compatibility with test equipment can be tolerated, the voltage may be as low as -21 volts. In any case, in the on-hook state, essentially the full sensor voltage should be present on the E lead.

6.07 The sensor on the M lead in the signaling facility may be biased with a voltage in the range of +10 volts to -24 volts. When a negative bias or reference is used, it is desirable that a blocking diode be used to prevent the voltage from appearing on the M lead during the on-hook state. This is required if the voltage is more negative than -24 volts.

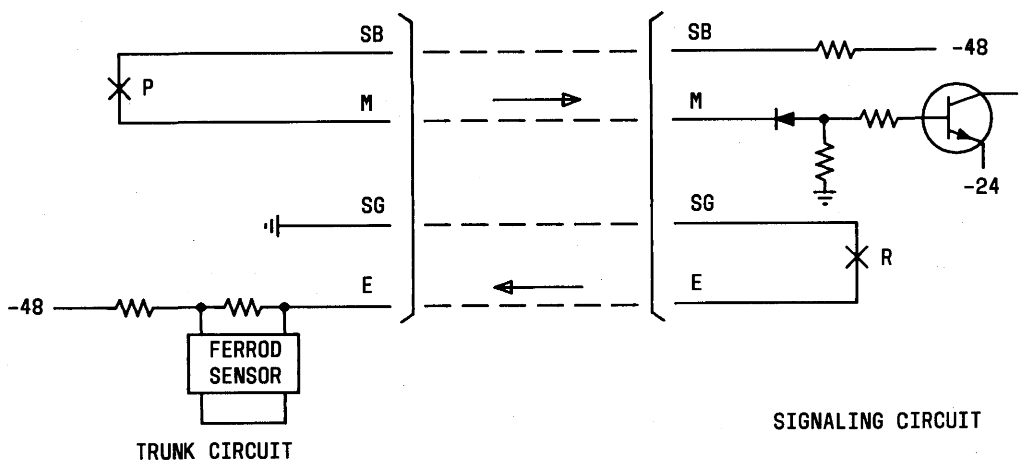


Fig. 15—Type II Interface

D. Type III Interface

6.08 The Type III interface (Fig. 16) is a compromise, partially looped, 4-wire E&M lead arrangement. It is essentially the same as the Type I interface except that the battery and ground for signaling on the M lead are supplied by the signaling facility over the SB and SG leads, respectively. The E lead in all its characteristics and requirements is identical to the Type I interface E lead except that the expected E lead current is significantly lower.

6.09 The signaling facility should supply its local ground to the SG lead and should supply nominal -48 volts to the SB lead through a current limiter. Refer to paragraph 6.39 for requirements for this limiter. The M lead sensor should meet the same requirements as in the Type II interface except that the blocking diode may be omitted.

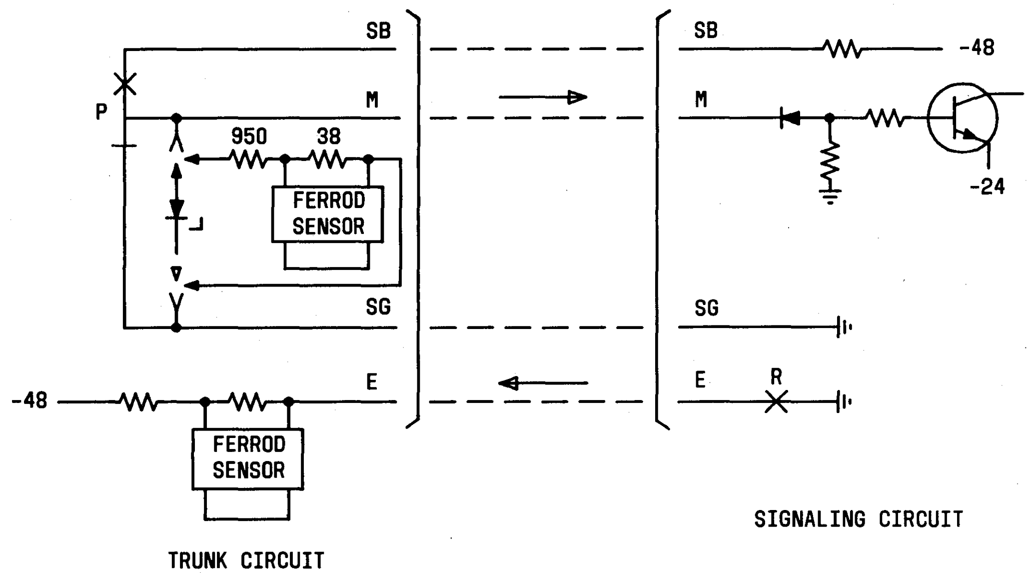


Fig. 16—Type III Interface

E. Type IV Interface

6.10 The Type IV interface (Fig. 17) is a symmetrical, 4-wire looped E&M lead arrangement. Signaling from the trunk circuit to the signaling facility is by means of opens and closures across the M and SB leads for on-hook and off-hook, respectively. Signaling in the reverse direction is identical except that it is across the E and SG leads. Since the trunk circuit grounds the SG lead and the signaling facility grounds the SB lead, the signaling over both the E&M leads is by open for on-hook and ground for off-hook.

6.11 The Type II interface in trunk circuits is identical to the Type IV interface. The requirements for both trunk circuits and signaling facilities are identical. The requirements are the same as for the trunk circuit with the Type II interface except for some modest deviations described in paragraph 6.57.

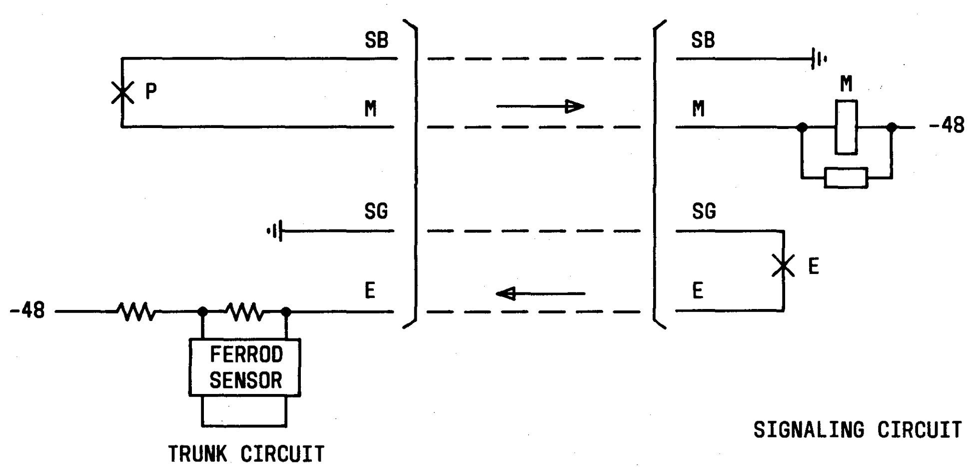


Fig. 17—Type IV Interface

F. Type V Interface

6.12 The Type V interface (Fig. 18) is a symmetrical, 2-wire E&M lead arrangement that signals in both directions by means of open for on-hook and ground for off-hook. Signaling from the trunk circuit to the signaling facility is over the M lead; signaling in the reverse direction is over the E lead. This interface is essentially the unbalanced version of the Type IV interface in which local ground is used for off-hook instead of the ground obtained over the SB or SG lead.

6.13 The Type V interface is nearly the worldwide standard outside North America. A variety of other lead designations are in use besides E&M. The known corresponding sets E, SZ1, Sa and SR, and M, SZ2, Sb and SS. "Type V interface" is a Bell System nomenclature not presently in use elsewhere.

6.14 There is a limited amount of information on any circuit requirements in use by other companies; but with the possible exception of current maximums, the requirements proposed herein for Bell System standardization should provide for complete functional compatibility with other systems. At present, the Bell System is setting an upper limit of 50 milliamperes in the E or M leads for new designs. It is hoped this will become a more widespread requirement as well as the use of "Type V" nomenclature.

6.15 The E&M lead sensors should be biased with nominal -48 volts and, in the on-hook state, essentially the full voltage should appear on the E&M leads. The sensor resistance should be high enough to limit the signaling lead currents to 50 milliamperes.

6.16 Most of the E&M lead test sets used in North America are not fully compatible with either the Type IV or V interface. The use of -48 volts on the E&M lead sensors will help in the standardizing of future test sets.

G. Signaling State Summary

6.17 Table F summarizes the signaling states with respect to the sending end. It should be noted that a bridged examination of all E leads will show essentially nominal -48 volts (or -21 volts for No. 4 ESS) on the leads during the on-hook state. For M leads, any voltage between +10 and -52.5 volts for either on- or off-hook states may be found. Table F indicates the sent signal, not what a bridged measurement might indicate.

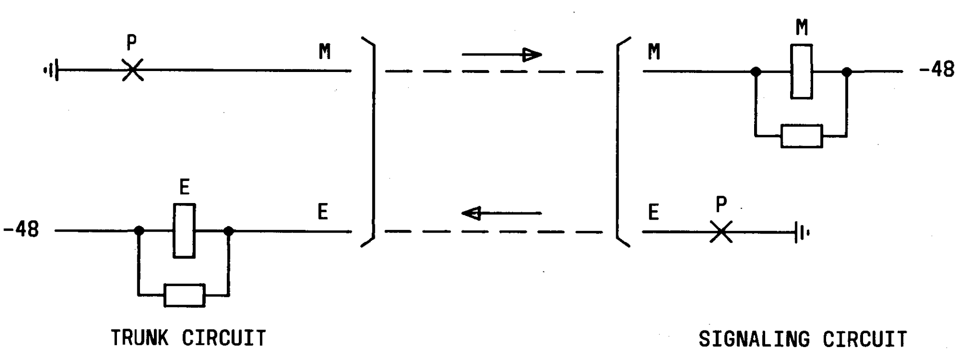


Fig. 18—Type V Interface

TABLE F

SENT SIGNAL STATES

TYPE	TRUNK TO SIGNALING CIRCUIT			SIGNALING TO TRUNK CIRCUIT		
	LEAD	ON-HOOK	OFF-HOOK	LEAD	ON-HOOK	OFF-HOOK
I	M	Ground	Battery	E	Open	Ground
II	M	Open	Battery	E	Open	Ground
III	M	Ground	Battery	E	Open	Ground
IV	M	Open	Ground	E	Open	Ground
V	M	Open	Ground	E	Open	Ground

H. Switching Means

Relay Contacts

6.18 The simplest switching means for E&M lead signaling is a relay contact. Transfer contacts are required for sending on the Type I and III M leads. To lengthen contact life and reduce current surges, a break-before-make transfer should be used and is desirable to keep the open interval during transfer to a maximum of 1 or 2 milliseconds. A transfer time in excess of 1 or 2 milliseconds may introduce distortion (increase in percent break) to dial pulsing with certain signaling facilities.

Solid-State Switches

6.19 In spite of the small size and relatively low price of modern mercury-wetted sealed contact relays, some circuit designers prefer to use solid-state switches. To maintain signaling compatibility and compatibility with the probable variety of E&M lead test equipment, the following requirements should be met:

(a) ***Type I M Lead:*** Complete requirements have not been developed specifically for this transfer switch. In the on-hook state, the potential drop from M lead to local ground should not exceed 1 volt when -50 volts through 1000 ohms is connected externally to the M lead.

(b) ***Type II M Lead:*** If the switch is polarized, reversing means should be provided. In the off-hook state, the potential drop from the M lead to SB lead should not exceed 2 volts with 50 milliamperes in the M lead. The current in the SB lead should be equal to the M lead current ±10 percent. Any difference between the two lead currents implies incomplete separation of signaling and trunk circuit power systems, a condition which is contrary to the intent of the Type II interface arrangement. Unless opto-isolators (or equivalent) are used, it appears that perfect separation cannot be achieved, hence the ±10 percent allowance given above. In the on-hook state, very little leakage is permitted. If the M lead is grounded, the M lead current should not exceed 100 μA whether the SB lead is open or connected to -50 volts. If a grounded source of ±12 volts is connected to the M lead while the SB lead is open, the M lead current should not exceed 24 μA.

The switch should operate properly when connected to a signaling facility applying nominal +12 or -42.5 to -52.5 volts on the SB lead. The switch should be reversible if it is polarized since sometimes the battery may be supplied on the M lead instead of the SB lead. Normal M lead current is well under 50 milliamperes, but it is not uncommon for the M lead to be accidentally grounded. Three types of current limiters are in use on the SB leads, leading to three fault current characteristics. Most commonly, a resistor will limit the current to a steady maximum of 175 milliamperes. Another limiter, a Positive Temperature Coefficient (PTC) thermistor, will permit a maximum current of 1.7 amperes, which drops 75 percent within about 0.5 second and stabilizes at about 30 milliamperes. The third limiter, a 13A resistance lamp or equivalent, will permit a peak of 3 to 4 amperes which will drop to 0.8 ampere within 10 milliseconds and stabilize at a maximum of about 360 milliamperes within 50 milliseconds. Additional details concerning fault currents are provided in paragraphs 6.34 through 6.38.

(c) ***Type III M Lead:*** Complete requirements have not been developed specifically for this switch. The requirements will be similar to those for the Type II M lead switch, except +12 volts will not be found on the SB lead and the leakage requirements for the on-hook state will not apply. When -50 volts through 1000 ohms is connected externally to the M lead, the potential drop between the M and SG leads should not exceed 1 volt in the on-hook state.

(d) ***Type IV M Lead:*** The Type IV and II interfaces appear to be identical in trunk circuits when relay contacts are used. The difference is in the signaling facility in that it supplies battery to the SB lead for Type II operation or ground for Type IV operation. The M lead signaling formats are battery and open for Type II and ground and open for Type IV. The significance of switch leakage in the on-hook states is different. For Type II, the requirements given in (b) are for effective switch leakage to battery or ground to be at least 500 KOHM. For Type IV operation only, the leakage to ground may be as low as 100 KOHM in the on-hook state. Also, there are no expected fault currents for the Type IV M lead. Therefore, if a trunk circuit is to be used exclusively for Type IV, the switch requirements are relaxed. If the trunk circuit may be used optionally for either Type II or IV, the switch should be designed to meet the Type II requirements.

(e) ***Type V M Lead:*** The requirements for the Type V switch are the same as those for the strictly Type IV switch, with additional provisional requirements that the M lead current should be no greater than 50 milliamperes.

(f) ***Type I E Lead:*** The Type I E lead switch should supply local ground to the E lead in the off-hook state which should not exceed 2 volts potential drop across the switch when the E lead current is 250 milliamperes. The potential supplied to the switch will be between -42.5 and -52.5 volts in the on-hook state. In the off-hook state, the E lead current is commonly about 50 milliamperes; there have been no limits on the current and it may be as high as 250 milliamperes. The effective resistance of the switch in the on-hook state should be at least 100 KOHM.

(g) ***Type II E Lead:*** The Type II switch should supply a closure across the E and SG leads for off-hook. The potential drop across the switch should not exceed 2 volts with 50 milliamperes in the E lead. In the on-hook state, the effective resistance of the switch should be at least 500 KOHM. If the switch is polarized, a reversing means is required. The voltage supplied to the switch on the E lead is in the range of -21 to -52.5 volts and the SG lead is grounded. In some trunk configurations, the battery may be supplied on the SG lead and the E lead may connect to resistance ground or a voltage in the range of +10 to -24 volts.

When the SG lead connects to nominal -50 volts in the connecting circuit, it is possible for a fault ground on the E lead (not an uncommon event) to cause a surge of up to 1.7 amperes which will reduce to about 175 milliamperes within 1 second and stabilize at about 30 milliamperes after many seconds, or the fault may cause a steady current of up to 175 milliamperes. Normal E lead currents are well under 50 milliamperes. Refer to paragraphs 6.34 through 6.38 for additional details concerning current limiters.

(h) ***Type III E Lead:*** The requirements for the Type III E lead switch are the same as those for the Type I switch, except that the maximum current should not exceed 50 milliamperes. The 2-volt potential drop limit is at 50 milliamperes instead of 250 milliamperes.

(i) ***Type IV E Lead:*** Since the Type IV arrangement is symmetrical, the requirements for the E lead switch are identical to purely Type IV M lead switch requirements.

(j) ***Type V E Lead:*** Since the Type V arrangement is symmetrical, the switch requirements are the same for both E&M leads. [See (e) above.]

I. Transient Suppression

6.20 Under certain circumstances, surge or transient suppression circuitry is required. This circuitry should be provided as discussed in the following paragraphs.

Type I and III M Leads

6.21 Although it appears abnormal, tradition requires the surge suppression for Type I and III M leads be supplied by the trunk circuit. In early circuits, this was done by wiring a 1000-ohm resistor from the M lead to ground in the trunk circuit. High wattage resistors are required since they dissipate about 2.5 watts during the off-hook state. More recently, it has been recommended that a zener diode in series with a 1000-ohm 1/2-watt resistor be used as a general replacement for the higher power resistor. Tests have shown, however, that the resistor may be omitted. The present requirement is that the trunk circuit should include a 65-volt ±10 percent zener diode between the M lead and ground with the anode connected to the M lead. The diode should be able to dissipate at least 500 mW.

All E Leads

6.22 In all interface types, if the E lead sensor is inductive, the sensor should be equipped with some means of transient suppression. The requirements for it are that, when the E lead changes from off-hook to on-hook, the voltage rise should not exceed 300 volts and the rate of rise should not exceed 1 volt per microsecond. The voltage surge should not exceed 80 volts for more than 10 milliseconds. For normal relays with at least 500-ohm windings, a 185A network (470 ohms in series with 0.13 μF) will be satisfactory.

6.23 It is permissible for the signaling facility to also provide the equivalent of the 185A network across its E lead switch. Accordingly, the design of the E lead sensor should tolerate this capacitance in addition to its own capacitance and E lead capacitance.

Type II, IV, and V M Leads

6.24 If the M lead sensor (except the Type I and III interfaces) is inductive, it should be provided with a means of transient suppression. The suppressor should limit the voltage rise rate to not over 1 volt per microsecond and the peak to not over 300 volts and the voltage should not be above 80 volts for more than 10 milliseconds. For normal relays with at least 500-ohm windings, a 185A network is satisfactory (470 ohms in series with 0.13 μF).

6.25 In Type II and IV interfaces, it is ***not*** permissible to also provide a capacitor type transient suppressor across the M lead switch in the trunk circuit. If the switch requires greater protection than given by the signaling facilities, it must be by other than a capacitor network. An exception to this requirement is permitted if the trunk circuit never sends dial pulses or any other pulses with timing requirements equivalent to those of dial pulses.

J. E&M Lead Current Limits

6.26 In no case is there a lower limit set for off-hook currents in E or M leads. From a practical standpoint, the lowest usable currents are approximately 1 or 2 milliamperes. If sensor resistance is higher, the resistance-capacitance time constant will cause excessive distortion. Since there is no lower limit for currents, it is not permissible to use current sensors in any E or M lead except for the one at the end of the lead.

6.27 In the past, no upper limits were established for E or M lead currents. The maximum known M lead current to signaling facilities is approximately 85 milliamperes into E-type SF units, with the next highest being about 55 milliamperes into duplex (DX) signaling circuits. See paragraphs 6.29 through 6.39 for M lead fault currents. The highest known E lead current is into No. 5 crossbar circuits where it may reach 250 milliamperes or slightly over this amount. Most electromechanical systems use relays with currents in the 50-milliampere range. Electronic systems usually draw much lower currents.

6.28 Type V E&M leads should be equipped with sensors that limit the currents to a maximum of 50 milliamperes. It is desirable that all E&M lead currents be limited to a maximum of 50 milliamperes in new circuit designs for normal circuit operation.

K. Current Limiters

6.29 For all E leads and Type IV and V M leads, the current limits are established very simply by the supply voltage and the sensor resistance. In the case of Type I, II, and III M leads, the current limiting is done at both ends of the leads. Having to supply battery to a signaling lead is a major defect in these three interfaces. The following paragraphs discuss limiters in the battery feed to M leads or SB leads.

Type I M Lead

6.30 The trunk circuit signals off-hook by supplying nominal -48 volts to the M lead. It is not uncommon for the M lead to be accidentally grounded. In order to avoid blowing fuses or damaging the switch in such a case, it is necessary to provide some means of current limiting which will still allow normal circuit operation. In the earlier E&M lead circuits, a 13A or 19A resistance lamp was provided in the battery feed to the M lead switch. These lamps are perfectly satisfactory in most respects and are still recommended.

6.31 Several attempts to avoid the use of the resistance lamps have been made; some have been satisfactory and some have lead to incompatibilities. One design simply used one fuse per M lead. Some circuits have used PTC thermistors. Another circuit uses a 1000-ohm resistor. If thermistors or resistors are used, the resulting circuit should meet the Type I interface requirements.

6.32 Recent tests have shown that the "stiffness" of the battery supply as provided by the 13A or 19A lamp can be relaxed slightly. Under the worst known operating conditions (sending to E-type SF units), it is permissible for the current limiter to be as high as 60 ohms and for the M lead resistance to be as high as 50 ohms if the zener diode is used for transient suppression.

6.33 The new requirement for Type I M lead current limiters is that the potential drop in the trunk circuit should not exceed 5 volts at 85 milliamperes of M lead current plus any internal current.

Type II SB Lead

6.34 The signaling circuit with the Type II interface supplies battery, usually -48 volts, to the SB lead. As in the Type I interface, some means of current limiting is necessary in this battery feed. Presently three types of limiters are used in Bell System circuits: 13A resistance lamp or equivalent, 74A PTC thermistor, and fixed resistors. These devices limit the current in case the SB or M lead is accidentally grounded. A current limiter in one circuit protects the M lead switch in a different circuit, the two circuits almost always being designed by different departments or even two different companies. Some coordination of design effort and circuit requirements is clearly needed.

6.35 The known fixed resistor limiters are in the range of nominal 316 to 1000 ohms. The worst case fault current is a steady 175 milliamperes. To maintain maximum compatibility, the resistor should not exceed 1000 ohms; if the circuit may optionally provide a Type III interface, the resistor should not exceed 500 ohms. Resistors under 316 ohms may be used, but they will have to be large power types. The resistor should never be under 150 ohms.

6.36 Half of an 11B resistance lamp, the equivalent of a 13A or 19A lamp, is used in a DX circuit to limit the SB lead current. A worst case ground fault on the SB or M lead can cause a current peak of 3 to 4 amperes which drops to 800 milliamperes within 10 milliseconds and stabilizes at about 360 milliamperes within 50 milliseconds.

6.37 The third limiter is a 74A PTC thermistor used in the G-type SF signaling units. The cold resistance range is 40 to 90 ohms. Until the thermistor reaches about 50°C, it exhibits a small negative temperature coefficient. Thereafter, the coefficient becomes positive at and above the switching or Curie temperature. The detailed characteristics of this device have not been well determined nor published. The highest initial fault current will be about 1.6 amperes which may rise slightly for approximately 100 milliseconds and then decay to a few hundred milliamperes within 0.5 to 1 second. Eventually, the current will stabilize under 50 milliamperes if there is little or no series resistance to the ground fault. Series resistance limits the peak current and slows the decay after the device switches.

6.38 It is clear that existing current limiters need to be better characterized. Once this has been done, new circuits should not use limiters that create worse fault currents in M lead switching devices.

Type III SB Lead

6.39 The same current limiters are used for Type III SB leads as for Type II, except that there are three circuits known to use the resistance lamp, two DX circuits and the E&M applique. All the problems and requirements are the same as for the Type II interface, except that during normal service, the resistance of the limiter should not exceed 500 ohms if the signaling circuit or signaling interface converter circuit both furnishes the SB lead and detects the M lead signal. Where the SB lead is furnished by one circuit and the M lead detector is in another circuit, as is the case in a Type III to Type I signaling interface conversion (Fig. 19), the current limiter for the SB lead must not cause a voltage drop of more than 5 volts with 85 milliamperes flowing. Many trunk circuits with the Type III interface use 975-ohm surge suppression resistors from the M lead to the SG lead; the resultant voltage divider effect will reduce the M lead voltage to such a low value that some common test sets cannot detect the off-hook state if over 500 ohms is used in the SB lead.

L. Compatibility

6.40 When trunk and signaling circuits are designed to conform to the requirements for standard E&M lead interface types, there will be completely functional dc signaling compatibility between any trunk circuit and any signaling circuit as long as both have the same interface type. Except for any options to provide the particular interface type, no other options are required for this assured compatibility.

6.41 The requirements for the Type I interface also assure compatibility with all known E&M lead testing equipment and status indicators. The absence of ground for on-hook makes the Type II M lead incompatible with several status indicators and test sets. The low voltage for off-hook on Type III M leads when the trunk circuit uses resistance surge suppression causes incompatibility with some indicators and test equipment. The use of other than nominal -48 volts for SB leads or sensors on E leads may lead to moderate or even complete incompatibility with E&M lead test facilities. Therefore, even where the interface requirements permit using other than nominal -48 volts, there should be a very serious reason for doing it.

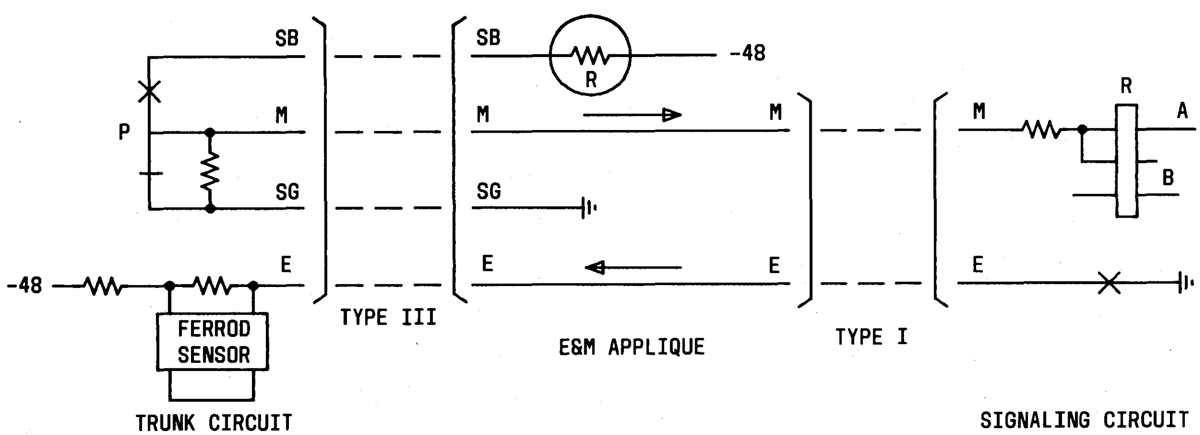


Fig. 19—Type III to Type I Conversion (Normal Range)

M. Interface Conversion

6.42 It is common to use older signaling facilities having only the Type I interface with trunk circuits having the Type II or III interface. This connection requires the use of an intermediary conversion circuit. The Bell System circuit for this is the E&M applique. This circuit has options for converting Type II or Type III to Type I; recently, an option to convert from Type II to Type V was added. Figures 19, 20, 21, and 22 show these conversions.

N. Back-to-Back Connections

6.43 Sometimes it is desirable to connect a trunk circuit of one switching system to a trunk circuit of another system in the same building. Built-up trunks sometimes make use of signaling facilities interconnected within the same building. These back-to-back connections can sometimes be made directly; otherwise, they are made through auxiliary link circuits, depending upon the interface type.

6.44 Circuits with Type I or III interfaces must use an auxiliary link for back-to-back connections as shown in Fig. 23 and 24. Circuits with Type II, IV, or V interfaces may be interconnected metallically by connecting leads SB, M, SG, and E of one to leads SG, E, SB, and M, respectively, of the other. (Omit the SB and SG leads for Type V.) If the mismatch of leads is a problem, the interconnection may be made through the E&M applique which has a lead crossover figure for this purpose only. Back-to-back connections are shown in Fig. 25, 26, and 27.

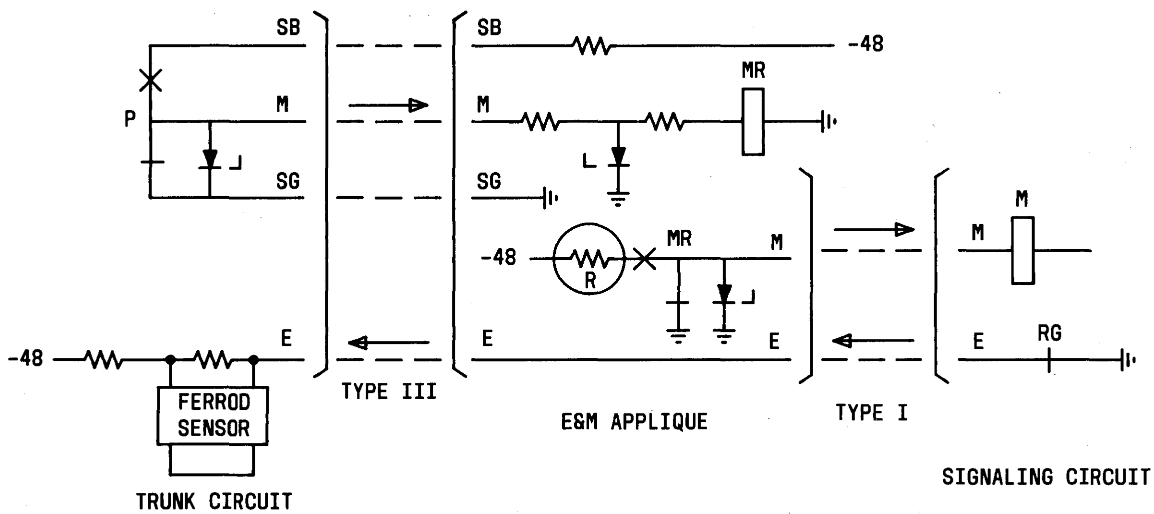


Fig. 20—Type III to Type I Conversion (Long Range)

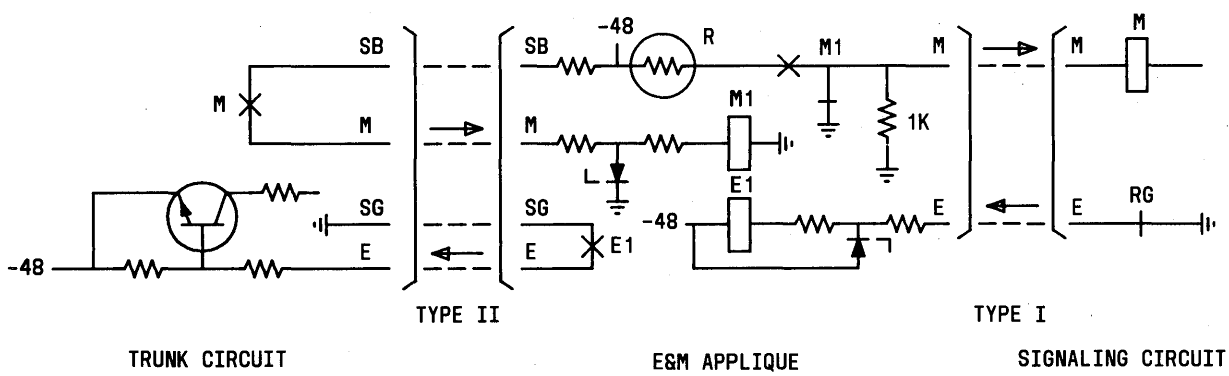


Fig. 21—Type II to Type I Conversion

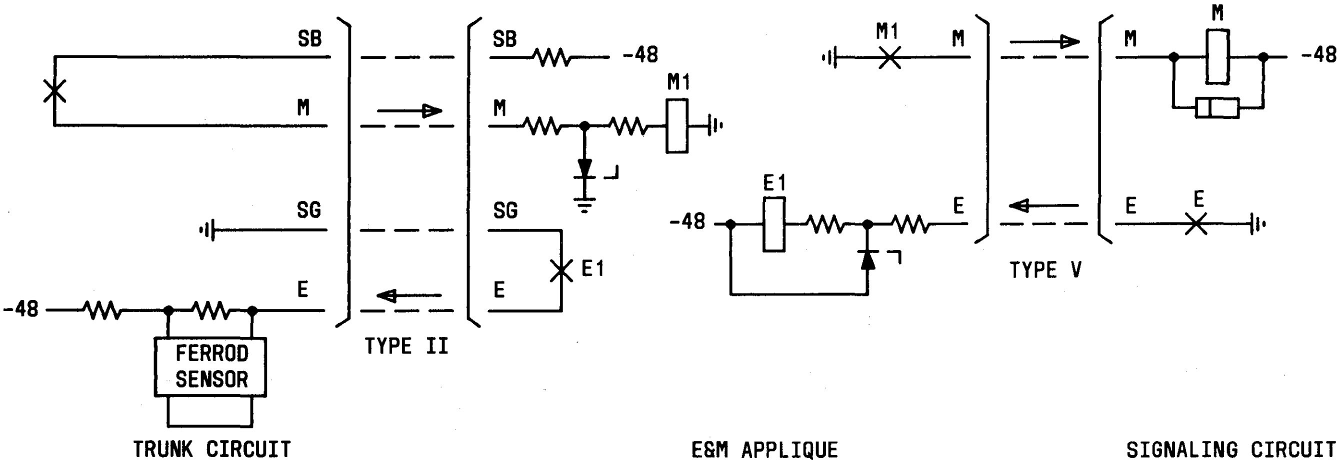


Fig. 22—Type II to Type V Conversion

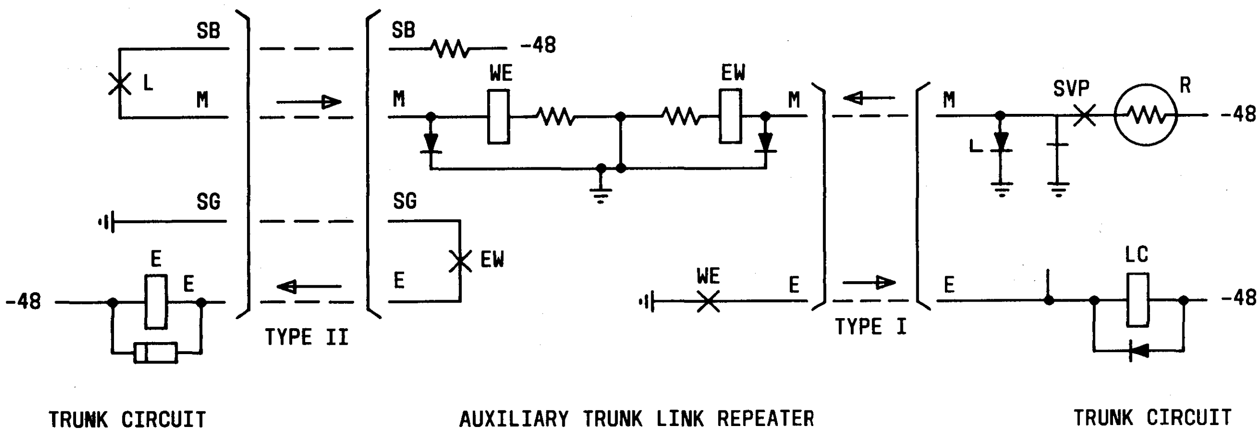


Fig. 23—Trunk Circuit to Trunk Circuit Via Auxiliary Trunk Link Repeater

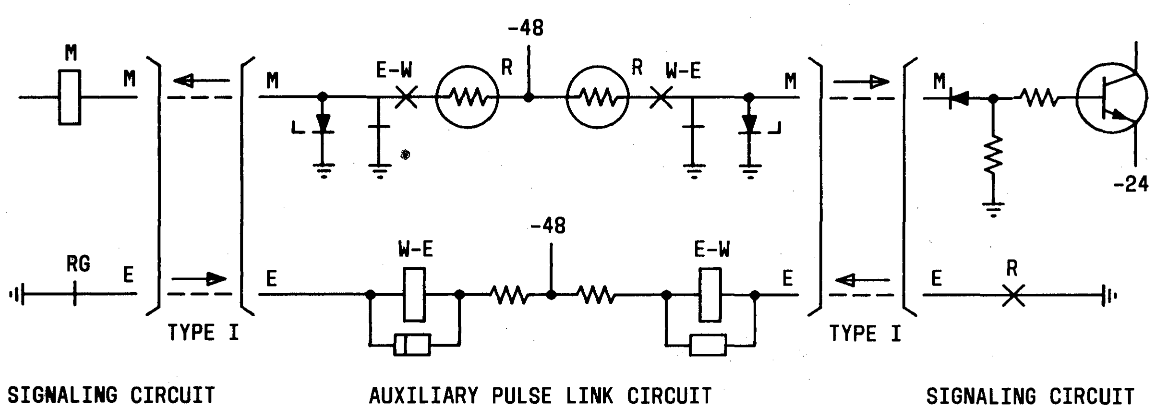


Fig. 24—Signaling Circuit to Signaling Circuit Via Auxiliary Pulse Link Circuit

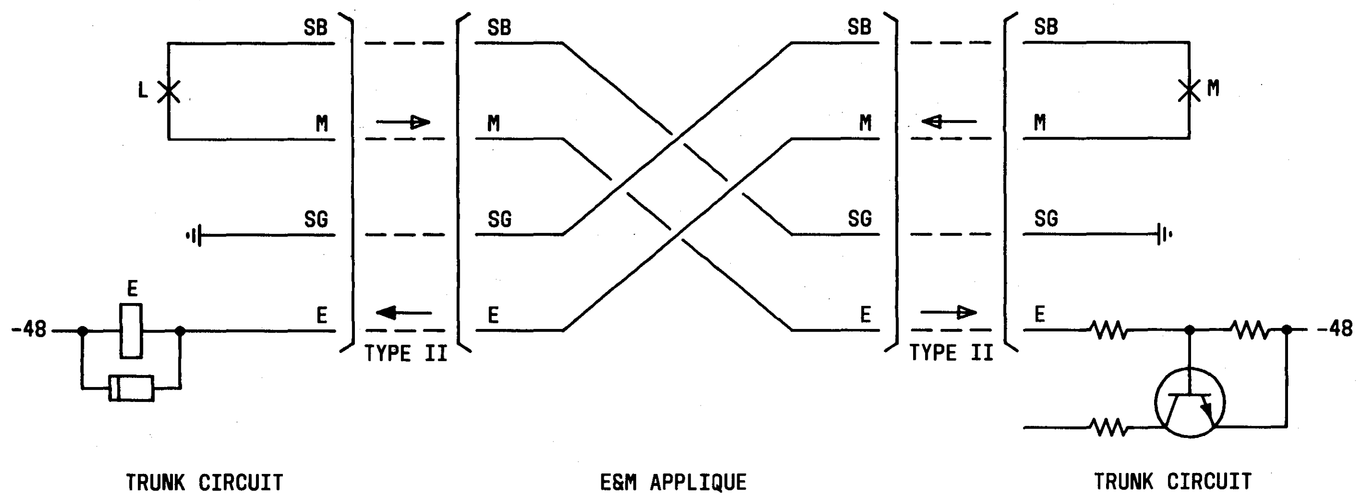


Fig. 25—Trunk Circuits Back to Back—Type II

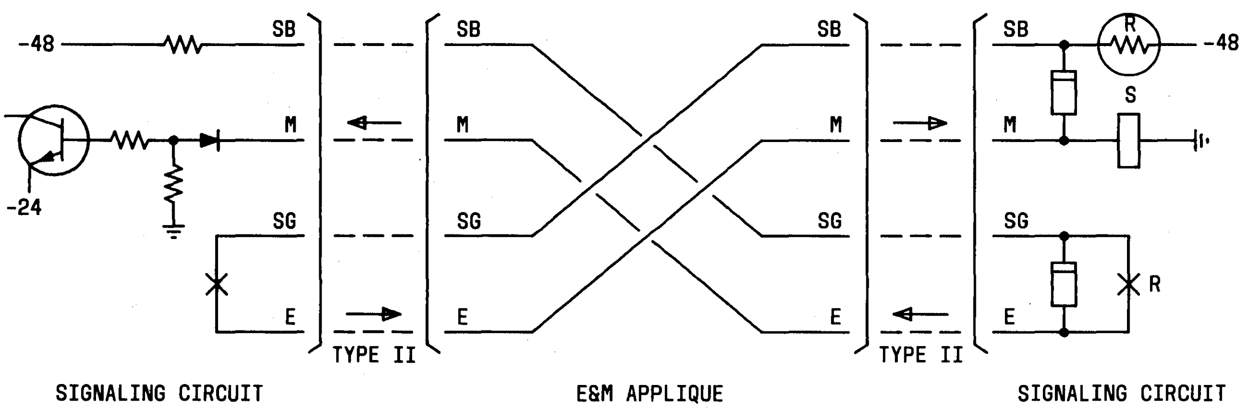
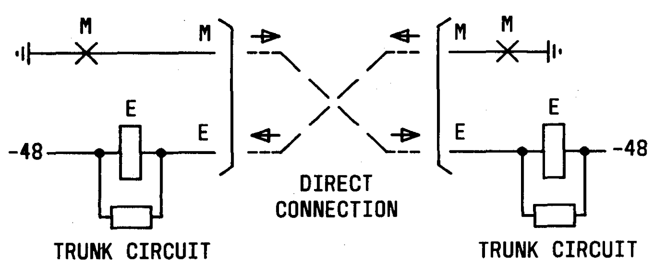


Fig. 26—Signaling Circuits Back to Back—Type II



NOTE: THE FIGURE SHOWS SIGNALING CIRCUITS BACK-TO-BACK IF ALL E&M DESIGNATIONS ARE REVERSED.

Fig. 27—Trunk Circuits Back to Back—Type V

6.45 It should be noted that, when like circuits with the Type II interface are connected back-to-back, they form a symmetrical arrangement with battery and open signaling states for both directions when signaling circuits are interconnected or ground and open states when trunk circuits are interconnected. Most E&M lead test facilities are made for the usual nonsymmetrical interfaces; therefore, some improvising is necessary to do some of the testing. If this is considered to be a serious problem, the trunk circuits may be interconnected by using an auxiliary circuit. However, no similar Bell System circuit is known for interconnecting Type II signaling circuits.

O. 60-Hz Immunity Requirements

6.46 E&M leads should remain within one building or, at most, pass between adjacent buildings. They are, therefore, not exposed to 60-Hz induction or lightning and thus have no requirements in this regard.

P. Working Range

6.47 The sensors on the E&M leads should be sensitive enough to permit each conductor, including SB and SG leads, to have at least 150 ohms. This means at least 300 ohms on a loop basis where applicable. The sensitivity should be low enough that -50 volts or ground through 20,000 ohms bridged onto either M or E leads, respectively, will not be seen as an off-hook state. Not all existing circuits meet these requirements, but new circuits should do so. The sensor on the Type III M lead should be designed to accommodate a 900-ohm surge suppression resistor from the M lead to the SG lead in the trunk circuit.

Q. Lead Designations

6.48 For Type I, II, III, and IV interfaces, the M lead is used for signaling from the trunk circuit, the E lead is used for signaling to the trunk circuit, the SB lead is used to supply battery (Types II and III) or ground (Type IV) to the trunk circuit for signaling on the M lead, and the SG lead is used to supply ground to the trunk circuit for signaling on the Type III M lead or ground to signaling circuit for signaling on the E lead (Types II and IV). When multiple sets of signaling leads are used, it is permissible to add appropriate suffixes to identify the sets.

6.49 The use of EA, EB, MA, and MB instead of E, SG, M, and SB, respectively, was started on some circuits, mostly No. 4 ESS or connecting circuits. However, just before the first cutover, it was agreed that only E, SG, M, and SB designations would be used. However, there are standard circuits that continue to use EA, EB, MA, and MB designations.

6.50 For the Type V interface, lead designations should be identical to the Type I leads in the Bell System. For interfacing with non-Bell System circuits, particularly outside North America, the E lead may also be designated SZ1, Sa, or SR and the M lead may also be designated SZ2, Sb, or SS.

R. Relative Merits

Type I Interface

6.51 In the Type I interface, battery is supplied at the trunk circuit for both the E and M leads. This causes high return current through the office grounding system. In some offices where the trunk circuits are on one floor and the signaling facilities are on another floor, special equalizing jumpers had to be added between the ground systems of the two floors to maintain the required 0.5-volt maximum potential between the two floors. This only occurs when large numbers of E&M leads are used.

6.52 The unbalanced signaling (single lead) is thought to be a potential source of interference in some electronic environments, particularly if the current exceeds 50 milliamperes. The battery feed to the M lead is probably the biggest problem with Type I as has been discussed in paragraphs 6.30 through 6.33.

Type II Interface

6.53 The Type II interface provides complete (nearly complete when some solid-state switches are used) separation between switching and signaling power systems. It is least likely (along with Type IV) to cause interference to other circuits in sensitive environments. Metallic back-to-back interconnection of like circuits is possible.

6.54 On the negative side, when a trunk circuit connects to a signaling facility having only the Type I or V interface, the interface conversion circuit will add to the installed cost of the trunk.

Type III Interface

6.55 The Type III interface is the most widely used arrangement in No. 1/1A, 2/2B, and 3 ESS offices. It provides complete separation of power systems for the M lead and allows the trunk circuit to establish and control the level of E lead current. There is no evidence that the unbalanced E lead has caused any interference problems. The conversion to Type I is much cheaper than from Type II to Type I.

6.56 The only known drawback to the Type III interface is its inability to use simple back-to-back interconnection of like circuits.

Type IV Interface

6.57 The Type IV interface has all the advantages of the Type II interface and, in addition, has no battery feed problems. It is the ideal E&M lead interface where single lead signaling is considered a hazard or where separation of power systems may be required. Its only negative feature is the lack of common E&M lead status indicators and pulsing test sets in North America.

Type V Interface

6.58 The Type V interface is a 2-wire E&M lead interface. It has no battery feed problems; although it does not provide separation of power systems, there tends to be no return ground currents between power systems. It is the worldwide standard outside North America.

S. E&M Lead Connection to Testboards

6.59 When the signaling leads of the Type I, II, III, IV, or V interface appear on jacks at testboards, only the E&M leads appear on jacks for testing. The E lead is on the tip and the M lead is on the ring of the jack.

T. List of Service Trunks

6.60 A list of service trunks using the E&M lead signaling and the various loop signaling arrangements is in Fig. 28.

U. Pulse Links and Converters

6.61 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 lead 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 lead signaling and vice versa.

6.62 Because of the time delay inherent in SF signaling, two signaling sections of SF signaling should not be used in applications where delay is important such as delay-dial or stop-go operation. See paragraphs 3.06 and 3.32 and the following paragraphs.

DC SIGNALING SYSTEMS

A. Composite (CX) and Duplex (DX) Signaling

6.63 CX, as well as DX, signaling arrangements were developed to provide means for dc signaling and dial pulsing beyond the range of loop signaling methods. DX and CX signaling arrangements are duplex in operation; ie, 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.

FUNCTION	TYPE OF EQUIPMENT	LOCATION	DIRECTION	SUPERVISION	START	ADDRESS OF CALLED PARTY	ADDRESS OF CALLING PARTY	COIN CONTROL (NOTE 1)	RINGING (NOTE 2)	OTHER SIGNALS
Recording-Completing— Special Service (Dial 0) Coin	3C-Type Switchboard or Equivalent	Remote Building	To Switchboard	E&M	None	None	None	Inband	Inband (Note 3)	None
				Loop Reverse Battery, High-Low	None	None	None	Tip and Ring	Tip and Ring	None
								Inband	Inband	None
		Same Building	To Switchboard	Sleeve Lead	None	None	None	Tip and Ring	Tip and Ring	None
Recording-Completing— Special Service (Dial 0) Noncoin	3C-Type Switchboard or Equivalent	Remote Building	To Switchboard	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 Switchboard	Sleeve Lead	None	None	None	None	Tip and Ring	Emergency Ringback
Recording-Completing— Special Service Coin and Noncoin Combined	3C-Type Switchboard or Equivalent	Remote Building	To Switchboard	Same as Recording-Completing Coin	None	None	None	Same as Recording-Completing Coin	Same as Recording-Completing Coin	Class-of-Service Tone to Operator, Emergency Ring-back
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 (Note 4)	MF (Note 4)	Inband or Polar Marginal	Inband or Polar Marginal	ANI Request Signal from TSP, Reverse Make-Busy
					Wink	MF (Note 4)	MF (Note 4)	Multiwink or EIS	Multiwink or EIS	
				E&M	Wink	MF (Note 4)	MF (Note 4)	Inband	Inband	ANI Request Signal from TSP, Reverse Make-Busy
					Wink	MF (Note 4)	MF (Note 4)	Multiwink or EIS	Multiwink or EIS	

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 N, O, P, and Q and paragraph 8.17.)
5. Also operator-attached and operator-released signals when multiwink or expanded inband signaling is used.

Fig. 28—Service Trunks

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 (Note 1)	MF (Note 1)	None	Inband— Wink Only	ANI Request Signal from TSP, Reverse Make-Busy
				E&M	Wink	MF (Note 1)	MF (Note 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 (Note 1)	MF (Note 1)	Inband or Polar Marginal	Inband or Polar Marginal	ANI Request Signal from TSPS, Reverse Make-Busy (Note 2)
					Wink	MF (Note 1)	MF (Note 1)	Multiwink or EIS	Multiwink or EIS	
				E&M	Wink	MF (Note 1)	MF (Note 1)	Inband	Inband	ANI Request Signal from TSPS, Reverse Make-Busy (Note 2)
					Wink	MF (Note 1)	MF (Note 1)	Multiwink or EIS	Multiwink or EIS	
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 (Note 1)	MF (Note 1)	None	Inband— Wink Only	ANI Request Signal from TSPS, Reverse Make-Busy
				E&M	Wink	MF (Note 1)	MF (Note 1)	None	Inband— Wink Only and Wink and MF Tone	ANI Request Signal 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 (Note 1)	MF (Note 1)	Inband or Polar Marginal	Inband or Polar Marginal	ANI Request Signal from TSPS, Reverse Make-Busy (Note 2)
					Wink	MF (Note 1)	MF (Note 1)	Multiwink or EIS	Multiwink or EIS	
				E&M	Wink	MF (Note 1)	MF (Note 1)	Inband	Inband	ANI Request Signal from TSPS, Reverse Make-Busy (Note 2)
					Wink	MF (Note 1)	MF (Note 1)	Multiwink or EIS	Multiwink or EIS	
Toll Switch Noncoin	3C-Type Switchboard or Equivalent	Remote Building	From Switchboard	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 Switchboard	Sleeve Lead	Delay-Dial	MF and Dial Pulse	None	None	Tip and Ring	None

Notes:

1. Special format. (See Tables N, O, P, and Q and paragraph 8.17.)
2. Also operator-attached and operator-released signals when multiwink or expanded inband signaling is used.

Fig. 28—Service Trunks (Contd)

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 Switchboard or Equivalent	Remote Building	From Switchboard	Same as Toll Switch Noncoin	Delay-Dial	Same as Toll Switch Noncoin	None	None	Same as Toll Switch Noncoin	Controlled Ring Signal from Operator
Toll Switching Coin	3C-Type Switchboard or Equivalent	Remote Building	From Switchboard	Same as Remote Building Toll Switch Noncoin	Delay-Dial	Same as Toll Switch Noncoin	None	Inband and Polar Marginal	Inband and Polar Marginal	None
		Same Building	From Switchboard	Sleeve Lead	Delay-Dial	MF and Dial Pulse	None	Third Wire	Tip and Ring	None
Intercept Operator (Regular)	3C-Type Switchboard or Equivalent or No. 23C Operating Room Desk	Same or Remote Building	To Equipment	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 Announcement System	Same or Remote Building	To System	Loop Reverse Battery, High-Low	None	None	None	None	None	Signal to Announcement System Accompanying Seizure to Indicate Regular, Trouble, and Machine
Combined (Regular, Trouble, and Machine)	Automatic Intercept Center (AIC)	Same or Remote Building	To System	Loop Reverse Battery, High-Low	Wink	MF (Note)	None	None	None	Reverse Make-Busy
				E&M	Wink	MF (Note)	None	None	None	Reverse Make-Busy
Repair Service	Repair Service Desk No. 2, 1C	Same or Remote Building	To Repair Service Desk	Loop High-Low, Reverse Battery	None	None	None	None	None	Make-Busy Indication from Repair Desk (RSB)
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 Dial Pulse	None	None	None	Test Signals from Test Desk (See Section 8.)

Note: Special format. (See Tables N, O, P, and Q and paragraph 8.17.)

Fig. 28—Service Trunks (Contd)

6.64 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. 29 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 independent of the voice channels with which they are physically associated because of the isolation provided by the CX sets.

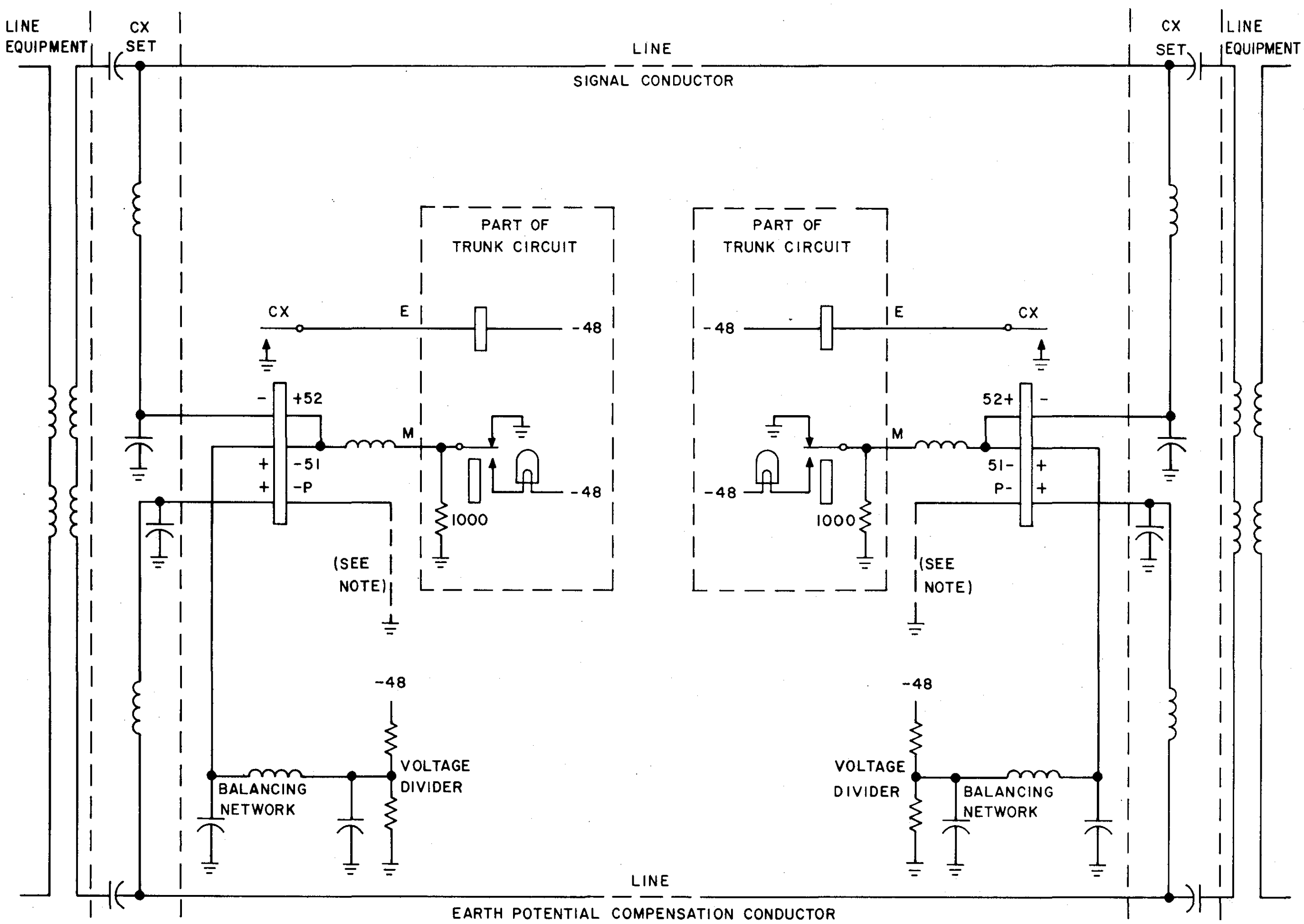


Fig. 29—Composite Signaling for One Voice Channel

6.65 Three types of CX sets are used in the Bell System and are coded as follows:

(a) ***Type C:*** Used for CX signaling on open wire and cable. This set can be used at intermediate and terminal points.

(b) ***Type D:*** Used for CX signaling on open wire and cable but only at terminal points and cannot be used for intertoll trunks. This set is similar to type C but less expensive.

(c) ***Type E:*** Used for CX signaling on cable circuits only. This set can be used at intermediate and terminal points like type C but uses less expensive components.

6.66 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:

(a) ***Short Haul:*** Maximum of 4800 ohms loop resistance on cable circuits or 90 to 100 miles of open wire.

(b) ***Long Haul:*** Maximum of 12,000 ohms loop resistance. Such circuits usually include one intervening voice repeater around which the signals are bypassed.

6.67 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, 1.5 to 4.5 volts difference in earth potential usually requires compensation. Under some conditions, filters may be required to overcome the effect of induced longitudinal ac voltages.

6.68 Dial pulsing on CX signaling circuits is normally at a rate of 10 PPS. Tests for dial pulse distortion, however, are made at 12 PPS 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.

6.69 Under normal service conditions, the input to CX signaling equipment should be limited to the range of 47 to 67 percent BK or a more narrow range under unfavorable conditions. When testing at 12 PPS, 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 BK.

6.70 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 signaling section, and a CX signaling section in tandem. The total round trip signaling delay for terrestrial facilities should not exceed 300 milliseconds for a connect plus delay-dial signal. In the case of delay-dial without integrity check, the 300 milliseconds also include time for the far-end switching system to return delay-dial.

6.71 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 in length. 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 signaling equipment and an auxiliary pulse link may be provided or bypass equipment must be used to provide a signaling path around the repeater.

6.72 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 CX set. Figure 30 shows a trunk embodying the DX signaling features.

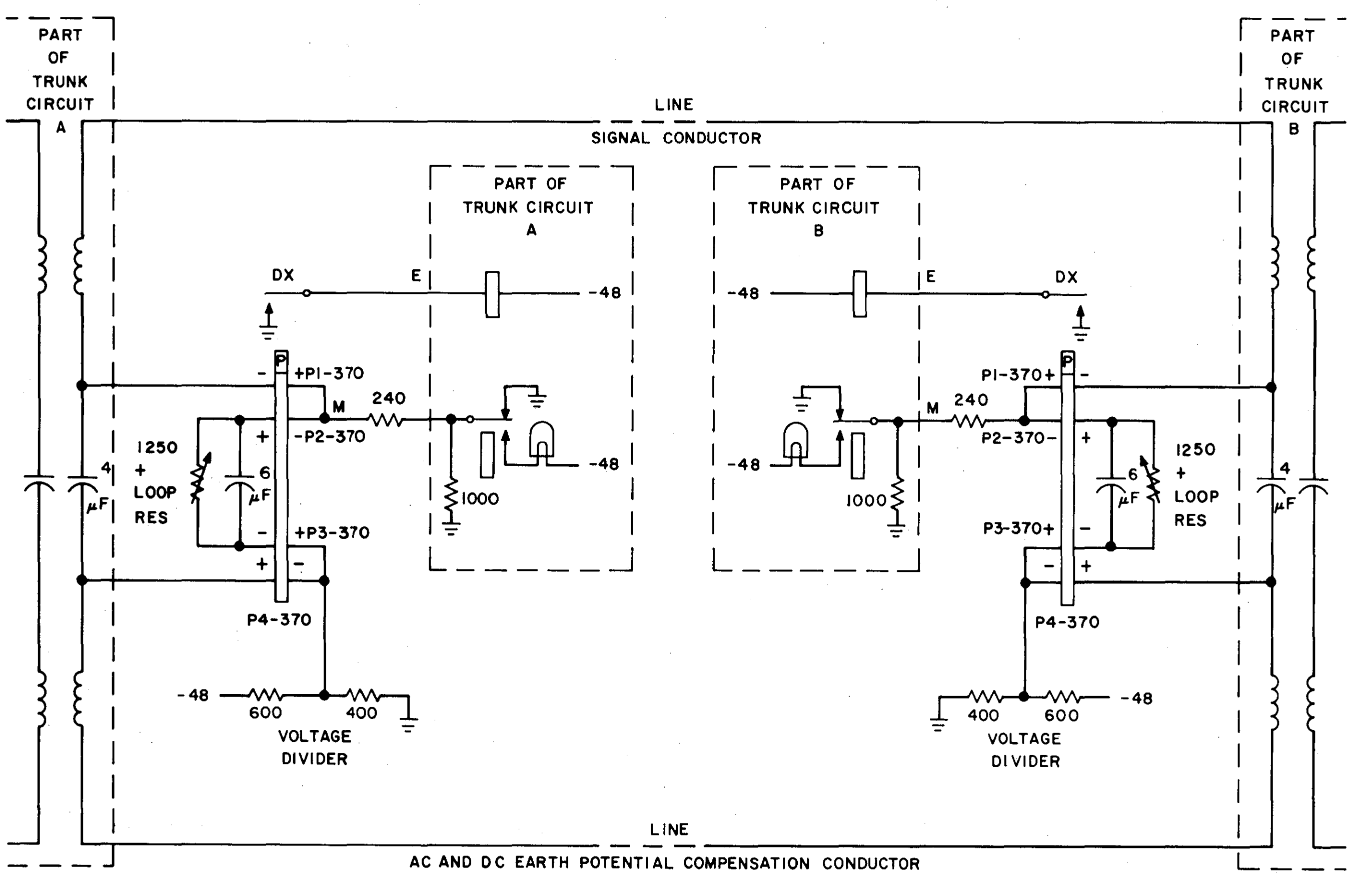


Fig. 30—DX Signaling Circuit

6.73 A DX signaling circuit uses the same conductors as the talking path and does not require a CX set or filter to separate the signaling frequencies from the voice transmission. One conductor in the DX signaling 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.

6.74 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 PPS of 58 percent BK with a distortion not exceeding ±4 percent BK. 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 simplex (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.

6.75 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 signaling circuits can be used in tandem for one trunk. As presently designed, Bell System DX signaling 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.

6.76 Sometimes it 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.

6.77 Three different types of DX signaling units are used interchangeably in the Bell System: the first employs the 280-type polar relay, the second employs the mercury polar relay, and the latest employs solid-state detectors instead of the polar relay.

6.78 All types of DX signaling equipment must be balanced for proper operation. A static or dc balance is required as well as a transient balance. The dc balance is achieved by adjusting a resistor in the balancing network of the DX1 or DX2 to 1250 ohms plus the resistance of the loop.

6.79 To obtain a perfect transient balance of the R relay, it would be necessary to provide an elaborate balancing network with characteristics which exactly matched the distributed line characteristics and its capacitors. In practice, a simple balancing network consisting of the line balancing resistance shunted by an experimentally determined value of capacitance provides a satisfactory balance. This occurs because the electrical and mechanical inertia of the relay prevents response to the unbalanced portions of the transient.

6.80 In the past, optional values of 1.3, 2, 4, or 6 μF were used in the balancing network. However, all trunk arrangements can be balanced using 6 μF in the balancing network if 4 μF is used at the repeat coil midpoints of a 2-wire line or if 4 μF is used across the simplexes of a 4-wire line. This is now the recommended method of operation for DX signaling circuits.

6.81 The capacitance required in the balancing network is essentially unaffected by the value of midpoint capacitance used at the distant end of the line. Thus satisfactory operation could be obtained with a 4-μF midpoint capacitor at one end and 1 μF at the other. However, as described in the previous paragraph, 4 μF is recommended for the midpoint capacitor with 6 μF in the balancing network to assure proper transient balance.

6.82 When a change of signaling state is sent over a DX signaling facility, the time it takes that signal to arrive at the terminating circuit ranges between 2 and 25 milliseconds. This delay time is primarily dependent on the total trunk capacitance including the repeat coil midpoint capacitor, cable capacitance, and capacitance of E-type repeaters. The effect of an E-type repeater is equivalent to 0.5 μF being placed across the line. The conductor resistance is significant only insofar as it represents greater mileage and, therefore, more cable capacitance. The battery voltage and balancing network capacitor are not significant factors. The delay times are plotted in Fig. 31 for the 280 relay and mercury relay circuits, respectively. The major difference between these two circuits is the type of relay used. The mercury relay, being slightly faster than the 280 relay, provides slightly shorter delay times. The effect of cable gauge and loop resistance upon the delay times is also shown in Fig. 31.

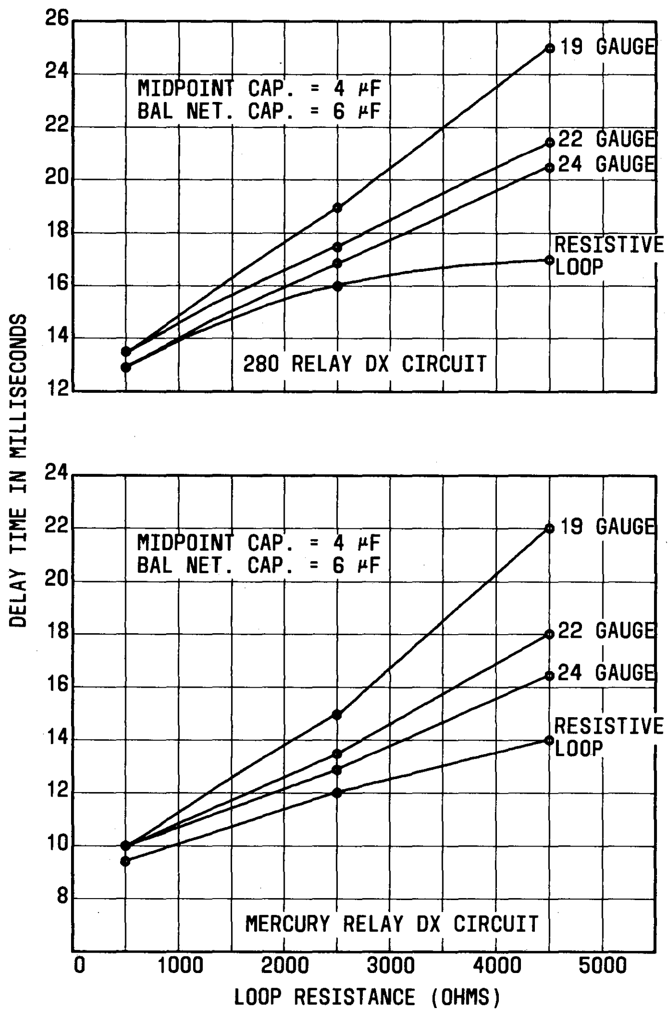


Fig. 31—Effect of Cable Gauge and Loop Resistance Upon Delay Times of DX Circuits

B. Simplex (SX) Signaling

6.83 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 1-way signaling scheme suitable for intraoffice use or the SX legs may be connected to full DX signaling circuits which function like the CX signaling circuits with E&M lead control. The DX signaling circuits provide 1- or 2-way full duplex operation.

6.84 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 SX leg. SX signaling has been largely superseded for new work by the DX signaling system previously described.

7. AC SIGNALING SYSTEMS

7.01 The ac signaling systems have been designed to convey the basic trunk supervision and pulsing functions required by switching systems. They are used over network trunks where dc signaling is not feasible or economical such as long- and short-haul circuits derived from carrier systems. Two-state ac signaling can handle trunk supervision and dialing where the latter is coded by dial pulsing. Three-state ac signaling has been designed to handle foreign exchange (FX) lines. Multistate ac signaling, in the form of MF pulses, is used for addressing only and must be coordinated with 2-state signaling systems, either alternating current or direct current for supervision.

7.02 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. 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.

7.03 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 paragraphs 7.38 through 7.42.

7.04 One of the chief problems with inband signaling is the prevention of the mutual interference between voice transmission and signaling. Voice-frequency signals are audible and, consequently, signaling should not take place during the time the channel is used for conversation. Since signal receiving equipment must remain on the channel during conversation to be ready to respond to incoming signals, it may 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.

(a) Signal tones of a character not likely to occur in normal speech may be used.

(b) Timing requirements for sustained signaling tones may be used to prevent false operation due to voice frequencies occurring in the signaling band.

(c) Voice-frequency energy, other than the signaling frequency, may be detected and used to prevent the operation of the signaling receiver.

SINGLE-FREQUENCY (SF) SIGNALING

7.05 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.

7.06 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.

7.07 Former SF signaling units, designed only for E&M signaling circuits, were able to use 1600, 2000, and 2400 Hz for signaling as well as 2600 Hz. In some instances, they were arranged to operate at one frequency (eg, 2600 Hz) in one direction and at another frequency (eg, 2400 Hz) in the other direction and could, therefore, be used on 2-wire physical 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 physical facilities no longer exists; therefore, SF units for 2-wire facilities have been discontinued.

7.08 The original and some subsequent designs of SF signaling circuits employed electron tubes. Current designs, however, use solid-state devices exclusively. The on- 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

7.09 Since the SF signaling system uses voice-frequency signals on the 4-wire voice path, the characteristics of SF signaling systems are quite different from those of dc signaling systems. The major differences are as follows:

(a) SF signaling systems have longer delay in signaling time as compared to the dc signaling systems.

(b) SF signaling systems have smaller pulsing speed range and percent break range than the dc signaling systems unless pulse correction is used.

(c) SF signaling systems interrupt the voice path during and after transitions between on- and off-hook.

(d) Continuous tones can cause an SF signaling system to malfunction.

E-, F-, AND G-TYPE SIGNALING

7.10 The Bell System is presently using three types of SF signaling: E-, F-, and G-type. The basic principles of all three types are the same. The differences are primarily in the packaging of the components and the design technology. All three families provide for 2- and 4-wire E&M lead trunk signaling, 2-wire loop trunk signaling, and 2- and 4-wire FX line signaling.

7.11 The E-type family is no longer manufactured but is still widely used in the Bell System. All the E-type units for trunk and FX line signaling are single-module units except for the ground-start FX line signaling units which are double-module units.

7.12 The F-type family is still being manufactured and is also widely used in the Bell System. The F-type units are basically double-module units. One module transmits and receives SF tone. This module is called a signaling converter. The other module contains the transmission equipment and the signaling equipment to convert from the dc signaling to signaling used in the other (SF) module. This module is called an auxiliary signaling unit. The single-module units are limited to 4-wire E&M lead units.

7.13 The G-type family is the latest design and uses single-module units with the signaling converter and SF tone (transmit and receive) functions in a single module.

7.14 The characteristics of the E-, F-, and G-type units are covered in Table G. The explanation that follows will be based on the E-type E&M lead units; however, the explanation also covers the F- and G-type signaling E&M lead units. The same basic principles also apply for the E-, F-, and G-type loop signaling units. Figure 32 is a simplified schematic illustrating the major features of the E-type transistorized 2600-Hz SF signaling system. A simplified diagram of the F-type SF module (FUA) is shown in Fig. 33 and the auxiliary module in Fig. 34. The G-type unit is not shown but is similar in function to the F-type unit.

A. SF Transmitter

7.15 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.

7.16 The E-type SF signaling units will accept and transmit dial pulses at speeds from 8 to 12 PPS with from 56 to 69 percent BK. If the range of percent break presented to the M lead is outside these limits, means must be provided to bring the range within these limits. 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 overcome by the use of units incorporating a built-in transmitting pulse corrector.

7.17 There are three types of F-type E&M lead signaling units: MF only, sender dial pulse or MF, and pulse-correcting dial pulse. To date, only a pulse-correcting, E&M lead G-type unit is available. All E-, F-, and G-type loop units contain a pulse corrector. The input and output signals for all Bell System SF units, including the M-lead pulse corrector used as an auxiliary to E-type E&M lead units, are shown in Table G, Section I, Transmitter.

7.18 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.

7.19 The pulse correction used with SF units lengthens the short pulses and ensures 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.

TABLE G

CHARACTERISTICS OF SF SIGNALING UNITS

	E&M LEAD					LOOP					
	E-TYPE	F-TYPE			G-TYPE	E-TYPE		F-TYPE		G-TYPE	
	SENDER	MF ONLY	SENDER	PULSE CORRECTION	PULSE CORRECTION	ORIGINATING	TERMINATING	ORIGINATING	TERMINATING	ORIGINATING	TERMINATING
I. TRANSMITTER											
A. Minimum detected input:											
(1) On-hook — Break		55	21	19				18		20	20
(2) Off-hook — Make.		60	21	2						14	14
B. Minimum output:											
(1) On-hook — Break		55 ±4	21 ±2	49.5 ±3.5				51 ±4		51 ±3	51 ±3
(2) Off-hook — Make.		60 ±4	21 ±2	26 ±4						26 ±2	26 ±2
C. Maximum input lengthened by pulse corrector:											
(1) On-hook — Break				50				52		51	51
(2) Off-hook — Make.										26	26
D. Distortion for inputs not lengthened by pulse corrector:											
(1) On-hook — Break		±4	±2	±3				±2		±2	±2
(2) Off-hook — Make.		±4	±2							±2	±2
E. Signal delay:											
(1) Off-hook to on-hook			13-21	17-21				13-18	19-35	19 Typical	19 Typical
(2) On-hook to off-hook.			13-21	17-21				14-19	19-35	19 Typical	19 Typical
F. Pulsing range accepted as input — Expressed as percent break:											
(1) 7.5 PPS			16-84	19-90				13.5-86			
(2) 10 PPS			21-79	20-90				18-81			
(3) 12.5 PPS.			26-74	25-90				22.5-77			
G. Transmit cut:											
(1) When both ends are on-hook	Yes	Yes	Yes	Yes				Yes	Yes		
(2) When near end is on-hook	No	No	No	No				Yes	No		
(3) Cut delay			5-13	5-15					5-15		
(4) Effective pre-cut											
(5) Near-end cut:											
(a) Both ends are on-hook:											
1. Near end goes off-hook.	80-175	105-155	80-160	106-180				94-176	110-195		
2. Far end goes off-hook, near end is off-hook.	350-750	46-55	560-860	545-780				Yes	530-760		
(b) Far end is on-hook:											
1. Near end goes on-hook.	Yes	Yes	Yes	Yes				Yes			
2. Far end goes off-hook: near end is on-hook.	No	No	No	No				No			
(c) Far end is off-hook:											
1. Near end goes off-hook.	80-175	105-155	80-160	106-180					110-195		
2. Far end goes on-hook.	Yes	Yes	Yes	Yes				Yes			
(d) Both ends are off-hook:											
1. Near end goes on-hook.	350-750	330-475	500-790	500-725					500-725		
2. Far end goes on-hook.											
H. Transmit Tone:											
(1) Normal tone level dBm0	20 ±1	20 ±0.5	20 ±0.5	20 ±0.5							
(2) High tone:											
(a) Level dBm0	8 ±1	8 ±0.5	8 ±0.5	8 ±0.5							
(b) Duration.											

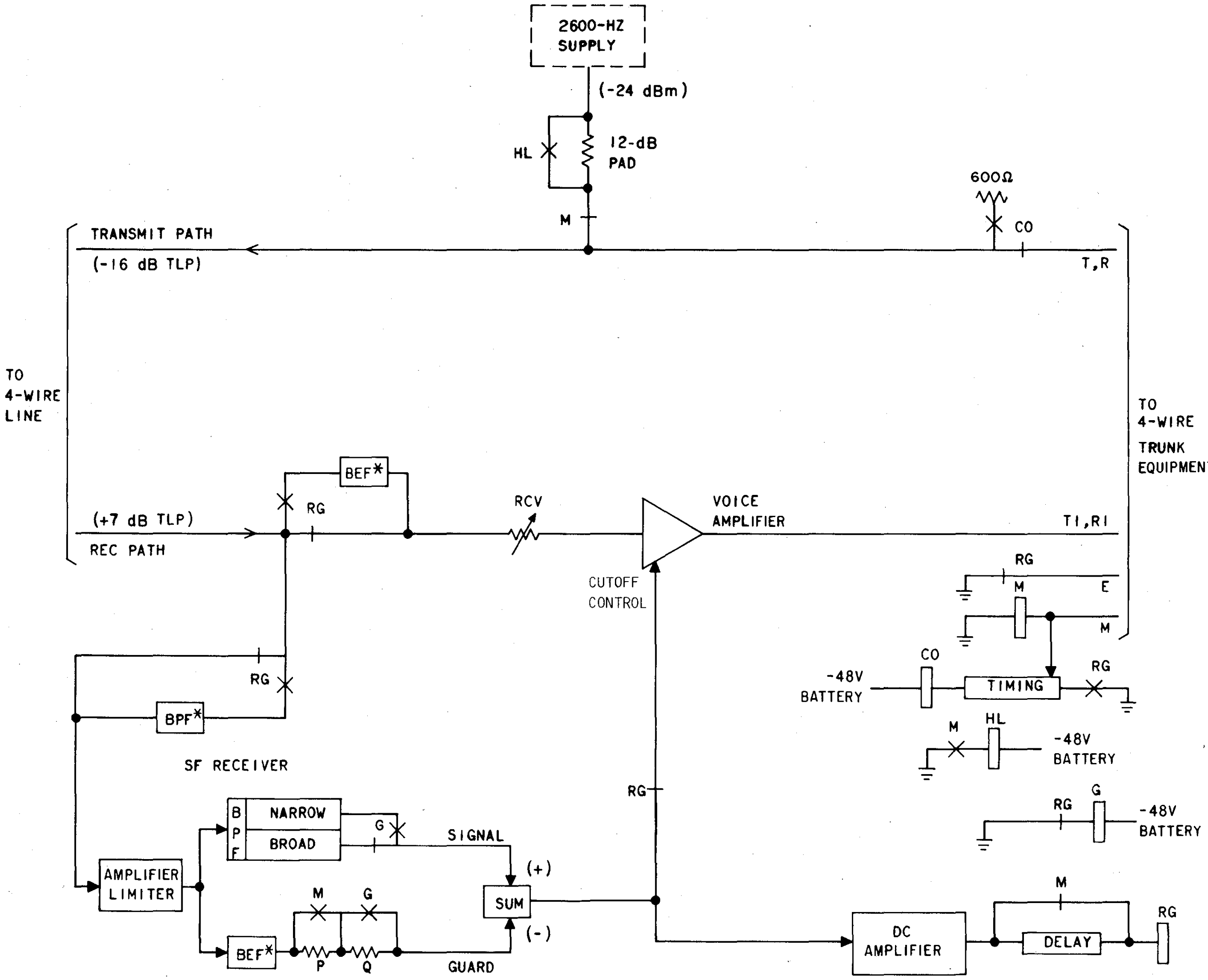
Note: All values are in milliseconds unless otherwise indicated.

TABLE G (Contd)

CHARACTERISTICS OF SF SIGNALING UNITS

	E&M LEAD					LOOP					
	E-TYPE	F-TYPE			G-TYPE	E-TYPE		F-TYPE		G-TYPE	
	SENDER	MF ONLY	SENDER	PULSE CORRECTION	PULSE CORRECTION	ORIGINATING	TERMINATING	ORIGINATING	TERMINATING	ORIGINATING	TERMINATING
II. RECEIVER											
A. Minimum detected input:											
(1) On-hook — Break		55	38	38					35	43	36
(2) Off-hook — Make:											
(a) Narrowband										18	11
(b) Broadband.		55								23	59
B. Minimum output:											
(1) On-hook — Break		55 ±4	51 ±3.5	50 ±3					49 ±3	68.5 ±1.5	56.5 ±1.5
(2) Off-hook — Make:											
(a) Narrowband											
(b) Broadband.											
C. Maximum input lengthened by pulse corrector:											
(1) On-hook — Break			60	60					60		56.5
(2) Off-hook — Make:											
(a) Narrowband											
(b) Broadband.											
D. Distortion for inputs not lengthened by pulse corrector:											
(1) On-hook — Break		±4	±2	±2				±2		±2	
(2) Off-hook — Make:											
(a) Narrowband											
(b) Broadband.											
E. Signal delay:											
(1) Off-hook to on-hook		47-53	48-52	33-37				45-52	33-37	43 Typical	90 Typical
(2) On-hook to off-hook:											
(a) Narrowband											
(b) Broadband.			48-54	47-55				42-48	47-55		55 Typical
F. Pulsing range accepted as input — Expressed as percent break:											
(1) 7.5 PPS			28-90	28-90					26-90		
(2) 10 PPS			38-85	38-85					35-85		
(3) 12.5 PPS.			47-80	47-80					42-80		
G. Detector:											
(1) Bandwidth			75 Hz								
(2) Initial tolerance			±5 Hz								
(3) Aging effect			±8 Hz								
(4) Center frequency			±0.3%								
(5) Signal-guard ratio			10 dB								
(6) Sensitivity:											
(a) Minimum			-25 ±1 dBm								
(b) Maximum.			+8 ±1 dBm								
H. Filter/cut operation:											
(1) Transmission path cut:											
(a) Cut time											
(b) Cut duration.											
(2) Filter insertion:											
(a) Insertion time			13 ±7								
(b) Duration.			225 ±50								
I. "G" function activation.	150-250		225 ±50								

Note: All values are in milliseconds unless otherwise indicated.



*BEF = BAND ELIMINATION FILTER
BPF = BYPASS FILTER

Fig. 32—Simplified Diagram of the E&M 4-Wire E-Type 2600-Hz SF Signaling System Connection to a 4-Wire Transmission Channel

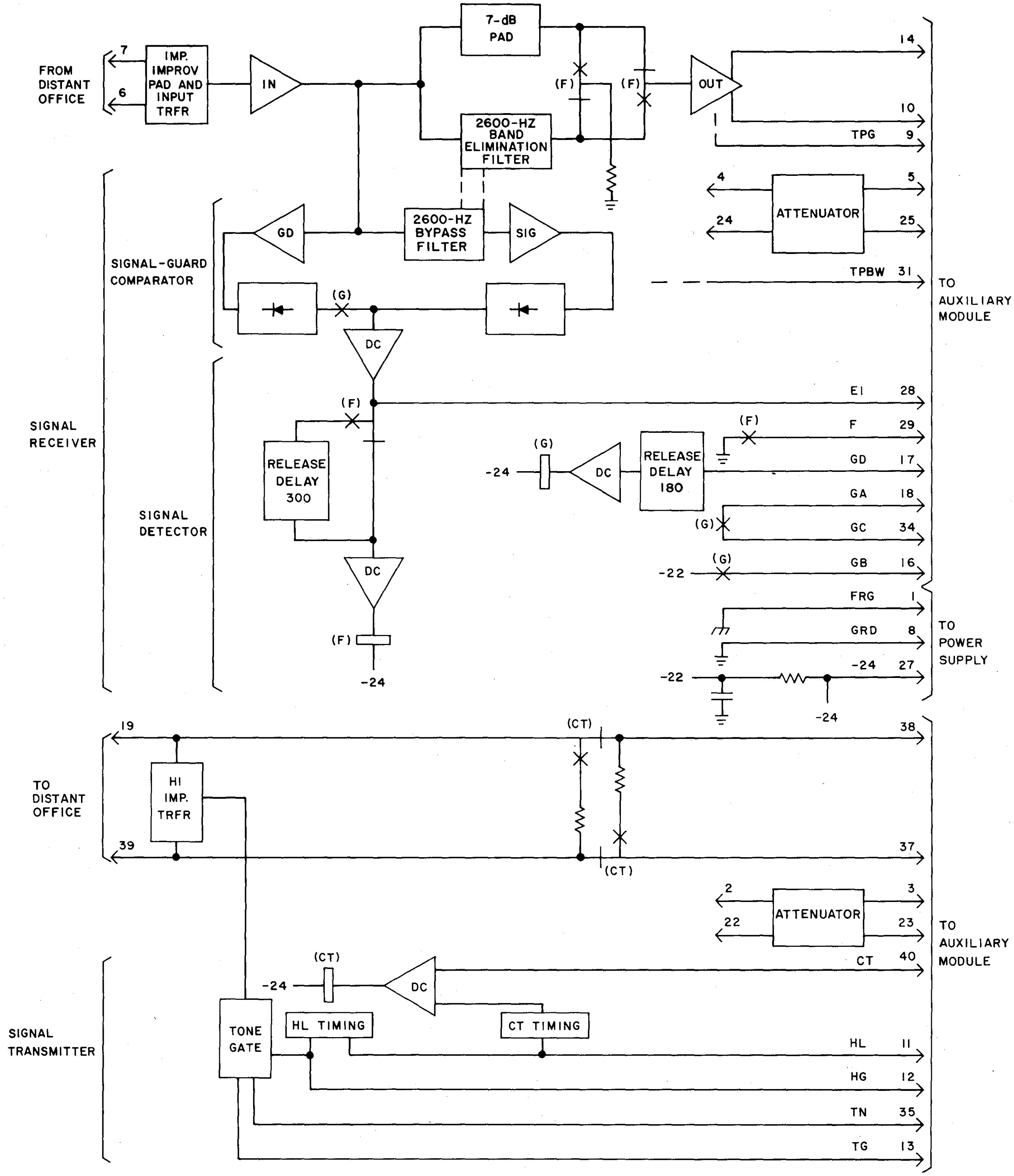


Fig. 33—FUA Signaling Converter

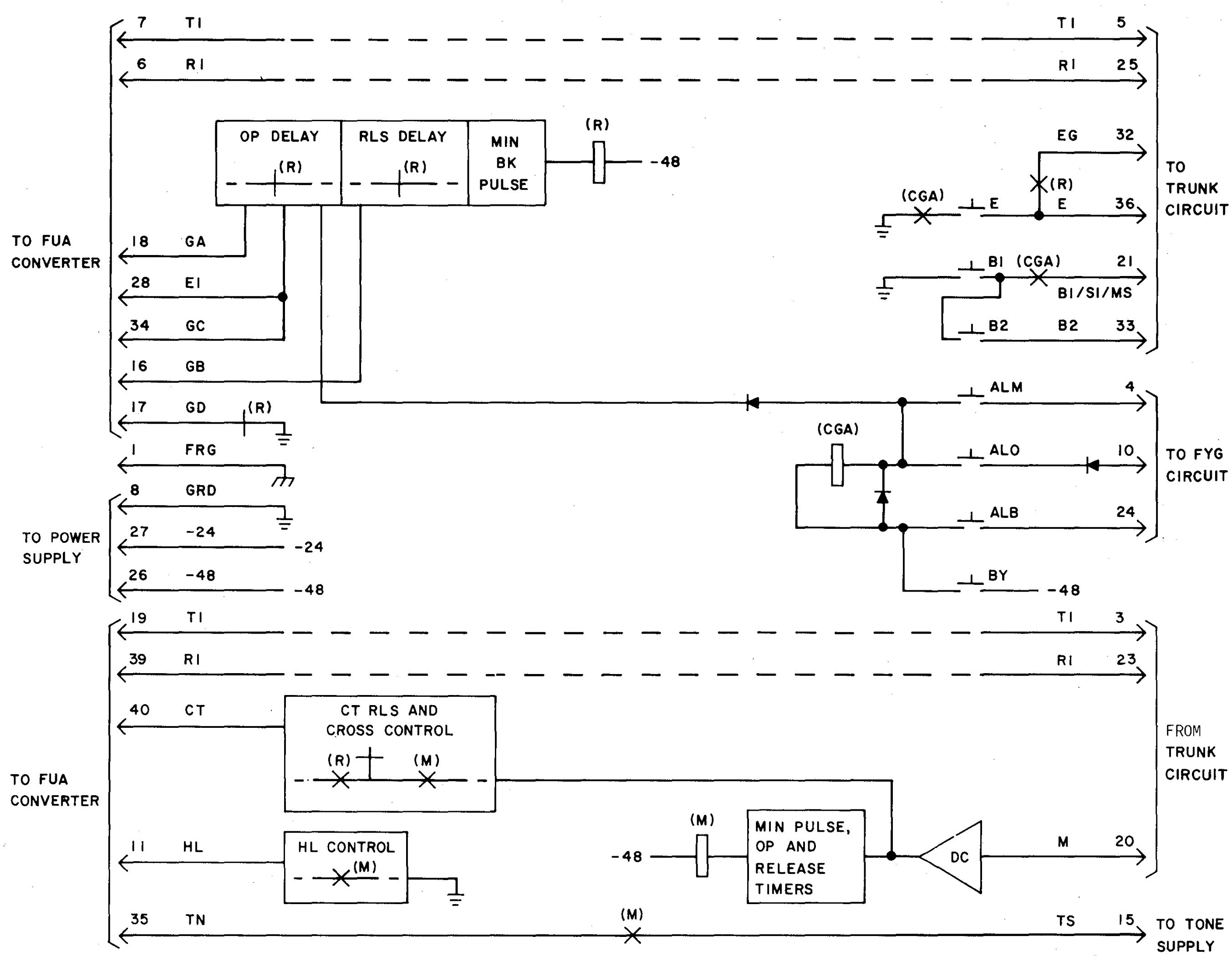


Fig. 34—FBB Signaling Auxiliary Module

B. SF Receiver

7.20 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 signaling 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. The characteristics of the signaling receiver portion of the E-, F-, and G-type SF signaling units are shown in Table G, Section II, Receiver. Typical transmission characteristics of an F-type E&M lead signaling unit, a G-type loop originating signaling unit, and a G-type loop terminating signaling unit are shown in Tables H, I, and J, respectively.

7.21 The receiver sensitivity is -29 dBm at the zero transmission level point for 4-wire line facilities. F- and G-type units are more sensitive than this. 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 conditions to secure optimum overall operation.

7.22 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 for E-type units, 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. 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 for E-type units. 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. This slow release of the G relay and the resultant reduction in talk-off is known as the G function. Timing of the G function for E-, F-, and G-type SF units is shown in Table G, Section II, Receiver. E-type units can only receive dial pulsing when sending on-hook back to originating end. F- and G-type units can receive dial pulsing regardless of supervisory state.

C. Voice Path Cuts and 2600-Hz Band Elimination Filter Insertion

7.23 The E-, F-, and G-type SF signaling units interrupt the transmit voice path to improve signaling margins. Paragraphs 7.25 through 7.27 give examples when the cuts occur and the cut intervals for F-type SF signaling units. Table G, Section I, Part G, Transmit Cut, contains the cut times for typical E-, F-, and G-type SF signaling units.

7.24 A 2600-Hz band elimination filter is inserted in the receive path whenever the E-, F-, or G-type SF signaling unit receives 2600-Hz tone. The filter blocks the tone but permits audible ring, busy, and other call progress signals to be heard by the calling party without the superimposed 2600-Hz signal. In addition, the filter prevents the SF tone from entering the next signaling link. The filter insertion times are given in Table G, Section II, Part H, Filter/Cut Operation. Both the F- and G-type SF signaling units use only the filter to limit the duration of the 2600-Hz tone that can enter the next signaling link. An electronic switch is used to insert the filter over a period of time. The gradual insertion nearly eliminates any thump that would be associated with the filter insertion. The E-type units, on the other hand, must use a relay to insert the filter. The E-type units delay inserting the filter for about 100 milliseconds. To prevent excessive SF tone from entering the next link, E-type units employ an electronic cut (in the voice amplifier) in the receive path. The electronic cut limits the SF tone leak to a maximum of about 30 milliseconds. The sequence for E-type units is to operate the electronic voiceband cut, insert the filter, and restore the

TABLE H

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 μs
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 minimum
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

TABLE I

TYPICAL TRANSMISSION CHARACTERISTICS OF G-TYPE, 2-WIRE LOOP ORIGINATING UNIT

Line Receive Port	
Nominal Level	+7 dB TLP
Nominal Impedance	600 ohms
Return Loss (ERL)	35 dB minimum
Longitudinal Balance	
250 to 3000 Hz	
IEEE STD 455-1976	85 dB typical, 60 dB minimum
Line Transmit Port	
Nominal Level	−16 dB TLP
Maximum Output (10 dB Overload)	−6 dB TLP
Nominal Impedance	600 ohms
Return Loss (ERL)	30 dB minimum
Longitudinal Balance	
250 to 3000 Hz	
IEEE STD 455-1976	85 dB typical, 60 dB minimum
Harmonic Distortion	−50 dB minimum (second harmonic)
at −26 dBm output	−60 dB minimum (third harmonic)
SF Tone Levels	
High	−24 ±1.1 dBm
Low	−36 ±1 dBm
Off	−86 dBm maximum
Equipment Transmit Port	
Nominal Impedance	900 ohms + 2.15 μF.
Return Loss	
ERL	35 dB minimum
SRL	30 dB minimum
SRL-HI	30 dB minimum
Longitudinal Balance	
250 to 3000 Hz, 40 mA dc	
IEEE STD 455-1976	60 dB minimum
Harmonic Distortion	−50 dB minimum (second harmonic)
−3 dBm at Line Receive	−60 dB minimum (third harmonic)
	−49 dB typical THD
Port-to-Port Transmission	
Insertion Loss 600:600 ohm	
with 0 dB Attenuator Settings	
1 kHz	4.2 ±0.4 dB (Ref)
1 kHz (Transmit Cut)	Ref +69 dB minimum
200 Hz	Ref +0.75 ±0.4 dB
2600 Hz (Receive Filter In)	Ref +40 dB minimum
2600 Hz	Ref ±0.3 dB
3000 Hz	Ref ±0.3 dB
Delay Distortion (Typical)	
500 to 3000 Hz	180 μs
500	182
700	85
1000	38
1500	14
2500	2
3000	0
Transhybrid Loss at 1 kHz	
Line Receive to Line Transmit with	
0 Attenuator Settings and Equipment	
Transmit Terminated in	
900 ohms + 2.15 μF	47 dB minimum
Level Setting Attenuators	
Range	0 to 16.5 dB
Steps	0.1 dB
Accuracy (16.5 dB)	±0.1 dB

TABLE J

TYPICAL TRANSMISSION CHARACTERISTICS OF G-TYPE, 2-WIRE LOOP TERMINATING UNIT

Line Receive Port	
Nominal Level	+7 dB TLP
Nominal Impedance	600 ohms
Return Loss (ERL)	35 dB minimum
Longitudinal Balance	
250 to 3000 Hz	
IEEE STD 455-1976	85 dB typical, 60 dB minimum
Line Transmit Port	
Nominal Level	−16 dB TLP
Maximum Output (10-dB Overload)	−6 dB TLP
Nominal Impedance	600 ohms
Return Loss (ERL)	30 dB minimum
Longitudinal Balance	
250 to 3000 Hz	
IEEE STD 455-1976	85 dB typical, 60 dB minimum
Harmonic Distortion	
at −26 dBm Output	−50 dB minimum (second harmonic) −60 dB minimum (third harmonic)
SF Tone Levels	
High	−24 ±1.1 dBm
Low	−36 ±1 dBm
Off	−86 dBm maximum
Equipment Transmit Port	
Nominal Impedance	900 ohms +2.15 μF
Return Loss	
ERL	35 dB minimum
SRL	30 dB minimum
SRL-HI	30 dB minimum
Longitudinal Balance	
250 to 3000 Hz, 40 mA dc	
IEEE STD 455-1976	60 dB minimum
Harmonic Distortion	
−3 dBm at Line Receive	−50 dB minimum (second harmonic) −60 dB minimum (third harmonic) −49 dB typical THD
Port-to-Port Transmission	
Insertion Loss 600:600 ohm	
with 0 dB Attenuator Settings	
1 kHz	4.2 ±0.4 dB (Ref)
1 kHz (Transmit Cut)	Ref +69 dB minimum
200 Hz	Ref +0.75 ±0.4 dB
2600 Hz (Receive Filter In)	Ref +40 dB minimum
2600 Hz	Ref ±0.3 dB
3000 Hz	Ref ±0.3 dB
Delay Distortion (Typical)	
500 to 3000 Hz	180 μs
500	182
700	85
1000	38
1500	14
2500	2
3000	0
Transhybrid Loss at 1 kHz Line Receive to Line Transmit with 0 Attenuator Settings and Equipment Transmit Terminated in 900 ohms +2.15 μF	47 dB minimum
Level Setting Attenuators	
Range	0 to 16.5 dB
Steps	0.1 dB
Accuracy (16.5 dB)	±0.1 dB

receive voice path. The electronic cut must be carefully controlled to minimize the thump; however, it may still be heard by persons using the facility.

7.25 Cut circuits within the signaling units used to improve signaling margins are used to cut and terminate the transmitting transmission path when both ends are on-hook for all units and also momentarily after any change in signaling state in E-type units and after most changes in F- and G-type units. The duration of this cut must be considered when tones are sent from the switching equipment after a change in signaling state.

7.26 The E-, F-, and G-type signaling units do not have identical cut time, but the following is a typical example of the transmission cut timing in an F-type sender dial pulse or MF pulse 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 80 to 160 milliseconds. At the far end, the transmitting transmission path is reestablished in 560 to 860 milliseconds. If the far end goes off-hook during this interval, the cut timing is changed to the shorter 80- to 160-millisecond interval.

7.27 If both ends are off-hook and the near end goes on-hook, the transmitting transmission path is cut and then reestablished in 560 to 860 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- or G-type signaling. In E-type signaling, tone and flash are mutually interfering. Flashing signals are no longer used. (See paragraph 2.53.)

7.28 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.

D. Signaling Delay

7.29 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.

7.30 The transmission delay is the 1-way delay of the transmission facilities between two network locations. This delay applies to either a forward or return signal. It depends on the transmission facility types, their lengths, and any multiplexing delays. Average delays are about 1.17 milliseconds per pair of A channel banks, 0.0062 millisecond per route mile of carrier facility (which includes cross-connections but excludes channel banks), and 0.082 millisecond per route mile of voice-frequency facility. This type delay is very short compared with other system delays. For an extreme case of 3000 carrier miles, three pairs of channel banks and 15 loop miles at each end, the total transmission delay is about 25 milliseconds. The transmission facility delays of most trunks are much less than this.

7.31 Digital transmission facilities also have associated 1-way transmission delays as follows:

(a) A pair of D channel banks have a delay of ____milliseconds.

(b) The T Carrier line has a delay of ____milliseconds (including repeaters) per mile.

(c) The No. 4 ESS has a 1-way transmission delay of ____milliseconds.

(d) The echo suppressor terminal associated with the No. 4 ESS has a 1-way transmission delay of ____milliseconds.

7.32 With F-type E&M lead 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 13 to 21 milliseconds from the time the M lead is changed from ground to battery until signaling tone is removed plus the transit time of the facility plus 48 to 54 milliseconds for recognition of tone removal and grounding the E lead (a total of 61 to 75 milliseconds plus transit time).

7.33 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 13 to 21 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 of 61 to 73 milliseconds plus transit time).

7.34 The delay times for E-, F-, and G-type signaling, including those in paragraphs 7.32 and 7.33, are shown in Table K.

TABLE K

SIGNAL DELAY (IN MILLISECONDS) FOR SF SIGNALING

	SEIZURE	START-DIAL	DELAY-DIAL OR ANSWER	DISCONNECT	
				ORIGINATING TO TERMINATING	TERMINATING TO ORIGINATING
I. E-Type:					
A. E&M Lead:					
(1) Sender Operation:					
Minimum	26	59	41	44	
Maximum.	78	99	96	99	
(2) Pulse Correction:					
Minimum	35	68	50	43	
Maximum.	94	114	111	114	
B. Loop-Pulse Correction:					
Minimum					
Maximum.					
II. F-Type:					
A. E&M Lead:					
(1) MF Only:					
Minimum	46				47
Maximum.	51				53
(2) Sender Operation:					
Minimum	61				48
Maximum.	75				73
(3) Sender Type Unit With Pulse Corrector:					
Minimum	70				57
Maximum.	90				87
(4) Pulse Correction:					
Minimum	59				50
Maximum.	76				58
B. Loop-Pulse Correction:					
Minimum	50				61
Maximum.	73				83
C. E&M to Loop or Loop to E&M:					
Minimum	60				47
Maximum.	90				87
III. G-Type:					
A. E&M Lead Pulse Correction:					
Minimum					
Maximum.					
B. Loop-Pulse Correction:					
Minimum					
Maximum					
Typical.	74			119	62

E. No Charge Calls

7.35 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. Continuous Tones

7.36 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.

7.37 Most signaling units have the cut circuits, described in paragraphs 7.23 through 7.27, that permit use with continuous tones. 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 SIGNALING

7.38 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 manner similar to that already described for E-, F-, and G-type signaling systems in paragraph 7.08. Since the signaling frequency is outside 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.

7.39 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.

7.40 The 3700-Hz signaling system referred to above is normally modulated from direct current to tone and demodulated from 3700 Hz to direct current 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.

7.41 The channel units of time division multiplex transmission systems using PCM (T Carrier Transmission 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 eighth bit may be used exclusively for signaling or only every sixth frame depending on the type of channel bank.) 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. The signaling delay is shown in Table L. Signaling distortion is never larger than ±5 milliseconds. The signaling range is 9 to 12 PPS at 10 to 90 percent BK.

TABLE L

END-TO-END SIGNALING DELAY TIMES FOR T CARRIER

SIGNAL		CHANNEL BANK			
		D1	D2	D3	D4
Seizure	— E&M — Loop				
Start-Dial	— E&M — Loop				
Answer	— E&M — Loop				
Disconnect	— E&M — Loop				

Notes:

1. All times are given in milliseconds
2. Transit time of the facility is not included.

7.42 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.

MULTIFREQUENCY (MF) PULSING

7.43 The MF pulsing 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.

7.44 The MF system transmits only numerical information; hence, another signaling system (eg, 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. Figure 35 shows the digits or other usages, the associated frequencies, and the explanation for the 6-tone MF keypulsing code.

7.45 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.

FREQUENCIES IN HZ	SIGNALS			
	DIGIT AND CONTROL	EXPANDED INBAND	CCITT SYSTEM 5	TSPS
700 + 900	1			
700 + 1100	2	Coin Collect		
700 + 1300	4			
700 + 1500	7			
700 + 1700		Ringback	Code 11	ST3P
900 + 1100	3			
900 + 1300	5			
900 + 1500	8	Operator Released		
900 + 1700			Code 12	STP
1100 + 1300	6			
1100 + 1500	9			
1100 + 1700	KP	Coin Return	KP1	
1300 + 1500	0	Operator Attached		
1300 + 1700			KP2	ST2P
1500 + 1700	ST	Coin Collect Operator Released		

Fig. 35—Multifrequency Codes

7.46 A typical plan of MF pulsing from a switchboard position to a crossbar office is shown in Fig. 36. 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 signal is then sent automatically and the positional S (sender) lamp lights.

7.47 With some switchboards, the KP signal is not sent automatically and the KP key, 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.

7.48 MF pulses are also transmitted by senders. The senders receive numbers from customers or from operators or other senders by MF pulsing, TOUCH-TONE pulsing, or dial pulsing and transmit these numbers as MF pulses. MF senders in electromechanical switching systems, in general, are required 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 10 PPS for intercontinental dialing using CCITT Signaling System No. 5. The No. 1/1A ESS MF senders are arranged to outpulse with pulses and interdigital periods of 60 ±0.5 milliseconds each (a rate of approximately 8.3 digits per second). The present Bell System requirements for MF pulsing are 58 to 75 milliseconds for pulses and interdigital intervals. Other MF sender pulse and interdigital intervals are as follows:

- No. 2/2B ESS, Pulses and interdigital intervals are 75 milliseconds (50-millisecond pulses and interdigital intervals are an option).
- No. 3 ESS, Pulses and interdigital intervals are 70 milliseconds (50-millisecond pulses and interdigital intervals are an option).
- No. 4 ESS.

7.49 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 37 shows the major components of an early receiver design 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.

7.50 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 the operator keys MF pulses 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 step-by-step as well as crossbar equipment.

7.51 The normal power output of MF transmitters presently used in toll switchboards, testboards, test frames, and senders is -6 or -7 dBm per frequency at the zero transmission level point. The frequencies of the supply oscillators should be within ±1.5 percent of nominal. The older equipment transmits -6 dBm0 per frequency and the newer equipment transmits -7 dBm0 per frequency. The -7 dBm0 per frequency is the new Bell System standard. However, there are no plans to change the equipment using -6 dBm0 per frequency to the new standard level.

7.52 The MF tone leakage limit when no MF signals are being sent is -58 dBm0. When MF signals are sent, the total extraneous frequency components should be at least 30 dB below the level of either of the two signal frequencies when measured over a 3-kHz band.

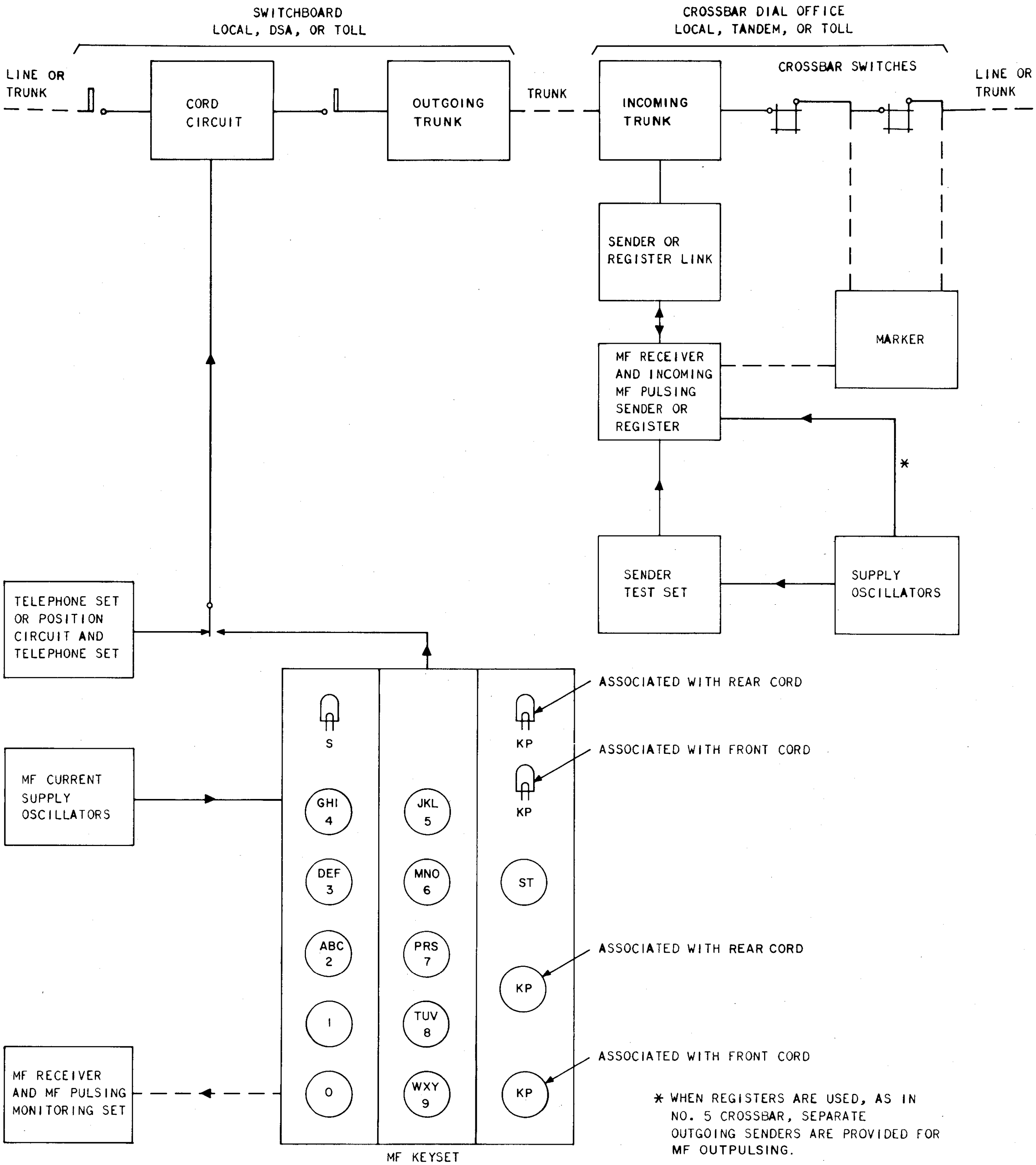


Fig. 36—MF Pulsing From a Switchboard to a Crossbar Central Office

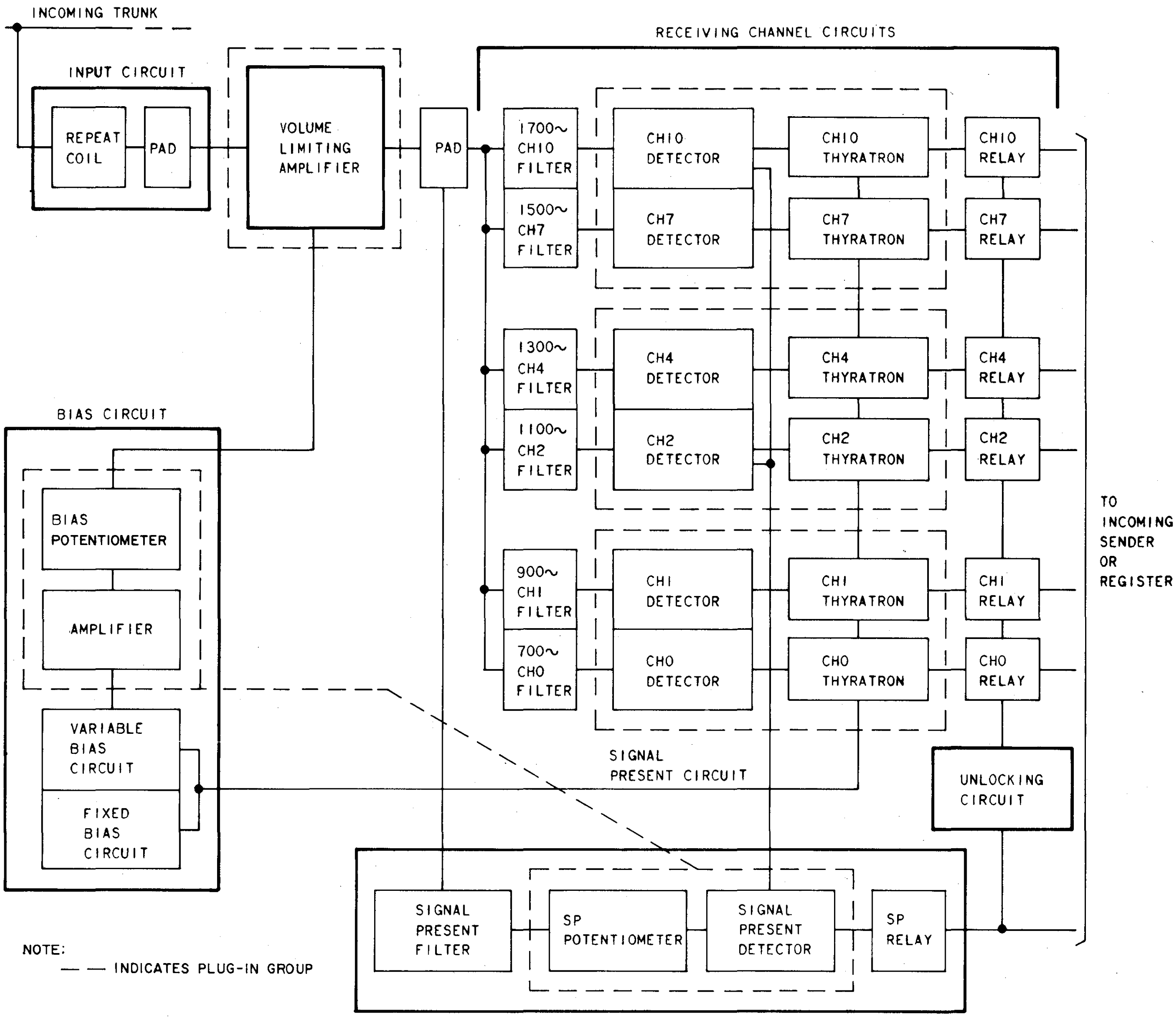


Fig. 37—MF Receiver Plan

7.53 The engineering limit for operating sensitivity of the MF receiver is -25 dBm per frequency for new receivers and -22 dBm per frequency for old receivers. 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.

7.54 The receiver should be able to operate and release in the presence of message circuit noise of 63 dBrnC0 with compandored carrier systems and 50 dBrnC0 with noncompandored facilities. In addition, impulse noise at the receiver can be as high as 98 dBrnC0 with compandored carrier systems and 81 dBrnC0 with noncompandored facilities. The limits for impulse noise power represent levels which are not exceeded more than 15 times in 15 minutes.

7.55 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 and a minimum interdigital interval (no tone) of 25 milliseconds. (Both tones are transmitted simultaneously; however, either tone can be received alone for up to 4 milliseconds.) This does not imply, however, that the MF receiver would accept a series of pulses of 30 milliseconds tone and 25 milliseconds no tone.

7.56 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 dB of slope, false operation resulting from modulation products, timing (speed), and ability to detect operator double keying.

7.57 The KP signal duration is 90 to 120 milliseconds. The receivers are designed to accept a KP signal of 55 milliseconds minimum, but it is considered good practice for senders to outpulse KP signals near 120 milliseconds to provide margin against transmission impairments such as delay distortion and Time Assignment Speech Interpolation (TASI) clipping. The No. 1/1A ESS sends a 120 ±0.5-millisecond KP signal.

7.58 Under some conditions, the No. 4A crossbar switching machine sends a spurious initial KP signal before the normal KP signal when outpulsing on intertoll trunks. This spurious signal can be 0 to 70 milliseconds long but usually is less than 40 milliseconds long. The length of the normal KP signal is not affected by the spurious signal and remains 100 ±10 milliseconds long.

7.59 The generation of the spurious KP signal depends upon the interaction of the No. 4A crossbar office and the other office. Investigation indicates that ESSs that return a start-dial signal quickly will cause more spurious KP signals to be transmitted from the No. 4A crossbar machine than electromechanical systems that have a longer interval from seizure to the start-dial signal.

7.60 Other Bell System offices avoid call failures working with MF pulsing from a No. 4A crossbar office for one or more of the following reasons:

(a) The MF receiver used in the No. 1/1A, 2/2B, and 4 ESSs is fast enough to receive both KP signals but the software is designed to ignore multiple KP signals.

(b) In electromechanical offices with the older vacuum tube MF receiver, the receiver is too slow to receive a large majority of spurious KP signals. The MF receiver equipped with vacuum tubes was standard for all new installations in electromechanical offices until about 1973.

(c) With the new transistorized MF receiver, it is possible to receive both KP signals, but the delay inherent in electromechanical offices in returning a start-dial signal reduces the probability of producing a double KP signal to a very low value.

(d) The No. 3 ESS and AIS do not connect to intertoll trunks and, therefore, are not susceptible to the problem.

7.61 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 4 milliseconds of each other.

7.62 Delay-dial/start-dial or wink-start signals are always required in connection with MF 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.

8. SPECIAL TOLL SIGNALING (CAMA, TSPS, AND IDDD)

SIGNALING TO CAMA AND TSP(S) OFFICES

8.01 Toll switching CAMA, TSP, and TSPS No. 1 offices provide the ability to record call details for customer billing. Toll switching CAMA offices handle noncoin direct-dialed calls; the TSPS is arranged to handle toll calls from noncoin and coin stations requiring operator assistance and can also operate as a CAMA office.

8.02 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 providing that it is equipped with ANI. If ANI equipment is not available at the local office, or if the calling customer 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).

8.03 The primary information categories transmitted from a local office to a CAMA or TSPS are the called number and the calling number. The called number is sent on either an immediate-dial basis for dial pulse calls or on a wink-start basis for MF pulsing calls. On dial pulse calls, the CAMA or TSPS goes off-hook toward the local office after the end of dialing has been recognized by a suitable timing interval. On MF pulsing calls to electromechanical CAMA offices (No. 4 crossbar, crossbar tandem, or No. 5 crossbar), the CAMA office returns an off-hook signal to the local office when the signal present (SP) circuit in the MF receiver indicates that the start (ST) pulse is no longer being received. On MF pulsing calls to electronic CAMA (No. 1/1A or No. 4 ESS) or TSPS offices, the off-hook from the CAMA or TSPS office can be returned to the local office as soon as the ST pulse is recognized by the CAMA or TSPS. As a result, the off-hook can arrive at the class 5 office while the ST pulse is still being sent.* This off-hook indication signals the local office to start outpulsing the ANI information. There is no requirement for a delay between the receipt of the off-hook start-dial by the local central office and sending of the KP pulse of the ANI information. However, it is good practice to have a minimum delay of 50 milliseconds between these two signals to permit the transients associated with the off-hook start-dial signal to dissipate before the first MF pulse is sent. (See paragraph 3.28 for information on a similar situation with the on-hook start-dial signal used to send address information.) MF pulsing is always used to send the ANI information.

* In Bell System local offices, the senders do not recognize the return of an off-hook signal while the ST pulse is being sent because they are all blind to the supervisory state during and after the outpulsing of the ST pulse. For information concerning unexpected stops, see paragraphs 3.33 through 3.35.

8.04 The 1975 issue of ***Notes on Distance Dialing*** simply indicated that the CAMA or TSPS went off-hook toward the local office when the called number was received.

8.05 The pulsing requirements between the CAMA or TSPS office and the local and distant offices for the called and calling number are the same as the requirements for normal pulsing on the network. (See paragraphs 7.43 through 7.62 and Part 4.) However, for the ANI case, the signaling formats are somewhat different than in network pulsing. The signaling formats for the called and calling numbers are covered in paragraphs 8.15 and 8.17.

8.06 On ONI calls, the CAMA or TSPS incoming trunk goes off-hook toward the local office, in the same manner as described in paragraph 8.03, after the called number has been received. This off-hook signal 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 except for wink signals associated with coin control and rering.

8.07 The trunk may be forced 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, may not result in an off-hook toward the local office.

SIGNALING TO CAMA

8.08 The following Bell System switching machines may be arranged as CAMA serving offices:

- Step-by-step intertoll
- No. 5 crossbar
- No. 1/1A ESS
- Crossbar tandem
- No. 4A/4M crossbar
- No. 4 ESS
- TSPS.

8.09 CAMA offices have three different called number outpulsing formats. These differences are important because they impose different permanent signal and partial dial timing requirements on the connected switching systems. The CAMA systems do not always outpulse all the called number digits at one time. Outpulsing can start:

(a) As soon as sufficient digits are available to advance the call toward its destination,

(b) When the first digit of the calling number is received, or

(c) When all digits of the calling number are received.

However, the last digit of the called number is not outpulsed until the complete calling number is received. This action is known as digital dragging. Digital dragging causes a nonuniform cadence of pulses at the receiving office. As a result, the receiving office may interpret a pause in pulsing caused by digital dragging as a permanent signal or partial dial. The effects of digital dragging can be experienced in offices not directly connected to a CAMA office where step-by-step toll offices and overlap outpulsing in crossbar tandem or No. 4 crossbar are involved.

> ***Note:*** Overlap outpulsing is a method of outpulsing developed to minimize post dialing delay. With overlap outpulsing, the call is advanced toward its destination as soon as sufficient address information is available. Once a call is advanced, each succeeding digit is sent forward as soon as it is received. Thus, with overlap outpulsing, the timing of the pulses from the CAMA office can be maintained to the local central office serving the called line.

8.10 The CAMA outpulsing formats are as follows:

(a) Crossbar tandem immediate-start (dial pulse) begins outpulsing as soon as the call can be advanced toward its destination. All but the units digit of the called number can be outpulsed before the calling number is recorded.

(b) Crossbar tandem nonimmediate-start (MF or dial pulse) does not begin outpulsing until the first digit of the calling number is received. This same format is also used for calls from step-by-step (CAMA), No. 4A crossbar, No. 5 crossbar, No. 1/1A ESS, or TSPS (CAMA) using immediate-start or nonimmediate-start outpulsing.

(c) The No. 4 ESS does not outpulse the called number until the complete calling number is recorded for either immediate-start or nonimmediate-start outpulsing.

The CAMA ANI pulsing format is shown in Fig. 38.

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.

Fig. 38—CAMA ANI Pulsing Format (Non-TSPS CAMA Office)

8.11 The recommended local or toll permanent signal and partial dial timing on trunks for new Bell System switching system designs are as follows:

	TIMING IN SECONDS	
	IMMEDIATE-START	NONIMMEDIATE-START
Permanent signal or partial dial timing	16 to 24	5 to 10
Overall timing	20 to 30	20 to 30

When crossbar tandem is no longer used in the network, the immediate-start recommendation could be reconsidered and possibly dropped.

8.12 The following shows the time intervals from request for ANI until the call is offered to an operator:

SYSTEM	SECONDS
Step-by-Step	5.0 to 9.0
No. 5 crossbar	4.4 to 8.4
No. 1/1A ESS	1.0 to 8.0
No. 2/2B ESS	Not available
No. 3 ESS	Not available
Crossbar tandem	7.5 to 10.0
No. 4A/4M crossbar	6.8 to 9.5
TSPS	12.0 to 18.0
No. 4 ESS	5.0

Note: With the exception of crossbar tandem, these times do not affect the permanent signal and partial dial timing in succeeding offices.

8.13 The operators who perform the ONI function can be CAMA or TSPS operators. When TSPS operators perform the ONI function for a separate CAMA office, the arrangement is known as CAMA transfer. With this arrangement, two voice-frequency circuits are required between the CAMA office and the TSPS: (1) the "talking path" over which call-defining zip tones are received from the CAMA office and over which the operator can converse with the customer, and (2) the "keypulse path" over which MF calling number signals are returned to the CAMA office as keyed by the operator. Table M indicates the exchange sequence of supervisory signals passed over these circuits between the CAMA office and the TSPS for loop and E&M signaling. The following will explain the various conditions for each sequence:

(a) ***Out-of-Service:*** The TSPS is not prepared to accept traffic from the CAMA office and will ignore seizure from the CAMA office. The CAMA office should recognize this state and not request service.

(b) ***Position Occupied:*** The TSPS is prepared to receive traffic from the CAMA office.

(c) ***Position Seizure:*** The CAMA office requests service from the TSPS.

(d) ***Position Busy:*** After a 700- to 900-millisecond delay, the TSPS reacts to the seizure of the CAMA office. This signals the CAMA office to send the call identity signals.

(e) ***Call Identity Signals:*** A 1- or 2-pulse order tone signal is sent by the CAMA office indicating whether the calling number is required as the result of an ANI failure or for a call that is normally operator identified (ONI).

(f) ***Sender Attached:*** A sender-attached signal is sent by the CAMA office to indicate that it is prepared to receive MF calling number signals.

(g) ***Position Attached:*** A position-attached signal is sent by the TSPS to indicate when an operator is actually attached to the trunk and ready to serve the customer. Position attached may occur before sender attached when a TSPS is lightly loaded. The CAMA office should be insensitive to this sequence.

(h) ***MF Calling Number Signals:*** MF tones are sent to the CAMA office identifying the calling number.

(i) ***Reorder:*** If the CAMA office cannot recognize the calling number signals as meaningful, it will send a reorder signal. The operator will recognize this signal and key the reset signal (in TSPS, KP BACK is keyed) which should prepare the CAMA office to receive the calling number again. The operator will key the calling number again. Should the number remain unacceptable to the CAMA office, the reorder signal will again be sent to the TSPS. When the operator decides that continuing the process will not salvage the call, the operator will cause the position disconnect signal to be sent to the CAMA office.

(j) ***CAMA Release:*** If the calling number is acceptable to the CAMA office, it sends the release signal to the TSPS.

(k) ***TSPS Release:*** The TSPS will respond to the CAMA release by returning to the position occupied condition.

(l) ***Position Disconnect:*** At any point in the signaling sequence, the TSPS can terminate the call by sending the position disconnect signal. The CAMA office will respond with CAMA release.

TABLE M

SUPERVISORY SIGNAL EXCHANGE SEQUENCE

SEQUENCE STATE	SYSTEM	SIGNAL	LOOP SIGNALING				E&M SIGNALING			
			TSPS		CAMA		TSPS		CAMA	
			TALK	KP	TALK	KP	TALK	KP	TALK	KP
a	TSPS	Out Of Service	On-Hook	On-Hook			On-Hook	Off-Hook		
	CAMA	Not Requesting Service			On-Hook	On-Hook			On-Hook	On-Hook
b	TSPS	Position Occupied	On-Hook	Off-Hook	On-Hook	On-Hook	On-Hook	On-Hook	On-Hook	On-Hook
c	CAMA	Position Seizure	On-Hook	Off-Hook	On-Hook	Off-Hook	On-Hook	On-Hook	Off-Hook	On-Hook
d	TSPS	Position Busy	On-Hook	On-Hook	On-Hook	Off-Hook	On-Hook	Off-Hook	Off-Hook	On-Hook
e	CAMA	Call Identity Signals	–	–	(Zip Tones*)	–	–	–	(Zip Tones*)	–
f	CAMA	Sender Attached	On-Hook	On-Hook	Off-Hook	Off-Hook	On-Hook	Off-Hook	Off-Hook	Off-Hook
g	TSPS	Position Attached	Off-Hook	On-Hook	Off-Hook	Off-Hook	Off-Hook	Off-Hook	Off-Hook	Off-Hook
h	TSPS	MF Calling Number Signals	–	(MF Signals)	–	–	–	(MF Signals)	–	–
i	CAMA	Reorder	Off-Hook	On-Hook	On-Hook	Off-Hook	Off-Hook	Off-Hook	Off-Hook	On-Hook
	TSPS	Or Reset	–	(Reset Tone†)	–	–	–	(Reset Tone†)	–	–
j	CAMA	CAMA Release	Off-Hook	On-Hook	On-Hook	On-Hook	Off-Hook	Off-Hook	On-Hook	On-Hook
k	TSPS	TSPS Release	On-Hook	Off-Hook	On-Hook	On-Hook	On-Hook	On-Hook	On-Hook	On-Hook
l	TSPS	Position Disconnect	Off-Hook (100 ms.) On-Hook	–	–	–	Off-Hook (100 ms.) On-Hook	–	–	–

* Call Identity Signal (Zip Tones):

Timing –ANI Failure 0.420 To 1.380 Second Tone

–ONI (2 Tones) 0.050 To 0.175 Second Tone
0.050 To 0.175 Second Silence
0.050 To 0.175 Second Tone

Tone
Frequency – 480Hz
Level – TSPS Expects A Minimum Of
0.062 Volt RMS (–24dBm, 900Ω Bridging)

† Reset Tone: 700 And 1700 Hz.

Note: E&M Signaling
Off-Hook = Battery On M Lead
On-Hook = Ground On M Lead

TSPS TRUNKING PLANS AND OUTPULSING FORMATS

8.14 When interfacing with end offices, the TSPS can have a variety of trunking plans and outpulsing formats as discussed in the following paragraph. However, what the customer is required to dial for the types of calls is not influenced by the trunking plan or outpulsing format used by the local central office. When it is desired to reach an operator (0 call), 0 is dialed. When special toll handling is desired (eg, collect, person-to-person, credit card, etc [0+ call]), 0 followed by the called number is dialed. The 0 and 0+ calls use the same ST 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 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.

*A complete digit must be received within 4 seconds for the call to be considered 0+; thus the customer has less than 4 seconds to dial the next digit.

8.15 The TSPS can have a variety of trunking plans as follows:

(a) Combine all coin and noncoin traffic on one supercombined trunk group. The pulsing format for this arrangement with ANI is shown in Table N.

(b) Combine all coin traffic on one trunk group and all noncoin traffic on a second trunk group. The pulsing format for this arrangement with ANI is shown in Table O.

(c) Combine all 0–, 0+ coin traffic on one trunk group and all 0–, 0+ noncoin traffic on a second trunk group. The pulsing format for this arrangement with ANI is shown in Table P. The 1+ coin and 1+ noncoin traffic would be handled on two additional trunk groups as described below.

(d) Use six individual trunk groups for 0–, 0+, 1+ coin and 0–, 0+, 1+ noncoin traffic. The pulsing format for this arrangement with ANI is shown in Table Q.

8.16 In each of the previously discussed cases where more than one type of traffic is carried on a single trunk group, each type of call is identified by distinctive MF start (ST) digits or information (I) digits transmitted from the local central office with the called and/or calling number. For dial pulsing calls, the identifying ST pulse is associated with the ANI information. For MF pulsing calls, the identifying ST pulse is associated with the address information. For both MF and dial pulsing calls, the information digit is associated with the ANI information. To separate traffic, a different information digit is used with each call to indicate whether or not it has been subject to local service observing and also whether it was processed by automatic identification, operator identification, or identification failure procedures. Tables N, O, P, and Q show this information.

8.17 Because the identifying ST pulse is associated with the called number, each of the above MF pulsing formats can be used without ANI from the class 5 office. The only usable situation under which the dial pulsing format without ANI could be used is when an individual trunk group is used for each type of service. In addition, Hotel-Motel and other screened traffic ***cannot*** be handled at the TSPS office without ANI from the class 5 office with either MF or dial pulsing. The complete TSPS pulsing formats are as follows:

(a) ***Required TSPS Multifrequency Formats:***

(1) Seizure—No start-dial signal—No address digits—No ANI

(2) Seizure—No start-dial signal—No address digits—KP-I-7 digits-ST†

(3) Seizure—No start-dial signal—No address digits—KP-I-7 digits-ST

(4) KP-ST†—No ANI

(5) KP-ST—No ANI

(6) KP-STP—No ANI

(7) KP-ST3P—No ANI

(8) KP-7 or 10 digits-ST†—No ANI

TABLE N

PULSING FORMAT FOR TSPS FROM LOCAL OFFICE SUPER COMBINED COIN AND NONCOIN TRUNK GROUP

MULTIFREQUENCY PULSING			
TYPE OF CALL	CUSTOMER DIALS	MF-PULSED CALLED NUMBER	ANI CALLING NUMBER
Noncoin			
Direct Dialed	1* + 7 or 10 digits	KP — 7 or 10 digits — ST2P	KP — I — 7 digits — ST
Operator Assistance	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			
Direct Dialed	1* + 7 or 10 digits	KP — 7 or 10 digits — ST	KP — I — 7 digits — ST
Operator Assistance	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			
Direct Dialed	1* + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — ST2P
Operator Assistance	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			
Direct Dialed	1* + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — ST
Operator Assistance	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

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 — without room number identification	6	6
Special Screening (eg, Charge-a-Call)	7	7
High Capacity Mobile (AMPs)	8	8
Hotel-Motel — with room number identification	91	91

* The prefix 1 may be used as an optional access digit.

TABLE O

PULSING FORMAT FOR TSPS FROM LOCAL OFFICE

COMBINED COIN OR COMBINED NONCOIN TRUNK GROUP

MULTIFREQUENCY PULSING			
TYPE OF CALL	CUSTOMER DIALS	MF-PULSED CALLED NUMBER	ANI CALLING NUMBER
Direct Dialed	1* + 7 or 10 digits	KP — 7 or 10 digits — ST	KP — I — 7 digits — ST
Operator Assistance	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
Direct Dialed	1* + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — ST
Operator Assistance	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

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 — without room number identification	6	6
Special Screening (eg, Charge-a-Call)	7	7
High Capacity Mobile (AMPs)	8	8
Hotel-Motel — with room number identification	91	91

* The prefix 1 may be used as an optional access digit.

TABLE P

PULSING FORMAT FOR TSPS FROM LOCAL OFFICE

COMBINED 0-, 0+ COIN OR COMBINED 0-, 0+ NONCOIN TRUNK GROUP

MULTIFREQUENCY PULSING			
TYPE OF CALL	CUSTOMER DIALS	MF-PULSED CALLED NUMBER	ANI CALLING NUMBER
Operator Assistance	0 (zero)	KP — ST†	KP — I — 7 digits — ST
Special Toll	0 + 7 or 10 digits	KP — 7 or 10 digits — ST†	KP — I — 7 digits — ST

DIAL PULSING			
TYPE OF CALL	CUSTOMER DIALS	DIAL-PULSED CALLED NUMBER	ANI CALLING NUMBER
Operator Assistance	0 (zero)	Seizure — No digits	KP — I — 7 digits — ST†
Special Toll	0 + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — ST†

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 — without room number identification	6	6
Special Screening (eg, Charge-a-Call)	7	7
High Capacity Mobile (AMPs)	8	8
Hotel-Motel — with room number identification	91	91

ST† indicates that any of the usable ST signals will be accepted.

TABLE Q

PULSING FORMAT FOR TSPS FROM LOCAL OFFICE

INDIVIDUAL 0–, 0+, 1+ COIN OR INDIVIDUAL 0–, 0+, 1+ NONCOIN TRUNK GROUPS

MULTIFREQUENCY PULSING			
TYPE OF CALL	CUSTOMER DIALS	MF-PULSED CALLED NUMBER	ANI CALLING NUMBER
Direct Dialed	1* + 7 or 10 digits	KP — 7 or 10 digits — ST†	KP — I — 7 digits — ST
Operator Assistance	0 (zero)	Seizure — No digits	KP — I — 7 digits — ST or ST†
Special Toll	0 + 7 or 10 digits	KP — 7 or 10 digits — ST†	KP — I — 7 digits — ST

DIAL PULSING			
TYPE OF CALL	CUSTOMER DIALS	DIAL-PULSED CALLED NUMBER	ANI CALLING NUMBER
Direct Dialed	1* + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — ST†
Operator Assistance	0 (zero)	Seizure — No digits	KP — I — 7 digits — ST†
Special Toll	0 + 7 or 10 digits	7 or 10 digits	KP — I — 7 digits — ST†

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 — without room number identification	6	6
Special Screening (eg, Charge-a-Call)	7	7
High Capacity Mobile (AMPs)	8	8
Hotel-Motel — with room number identification	91	91

* The prefix 1 may be used as an optional access digit.

ST† indicates that any of the usable ST signals will be accepted.

(9) KP-7 or 10 digits-ST—No ANI

(10) KP-7 or 10 digits-STP—No ANI

(11) KP-7 or 10 digits-ST2P—No ANI

(12) KP-7 or 10 digits-ST3P—No ANI

(13) KP-ST†-KP-I-7 digits-ST

(14) KP-STP-KP-I-7 digits-ST

(15) KP-ST3P-KP-I-7 digits-ST

(16) KP-7 or 10 digits-ST†-KP-I-7 digits-ST

(17) KP-7 or 10 digits-ST-KP-I-7 digits-ST

(18) KP-7 or 10 digits-STP-KP-I-7 digits-ST

(19) KP-7 or 10 digits-ST2P-KP-I-7 digits-ST

(20) KP-7 or 10 digits-ST3P-KP-I-7 digits-ST.

(b) ***Required Dial Pulsing Formats:***

(1) Seizure—No address digits—No ANI

(2) Seizure—No address digits—KP-I-7 digits-ST†

(3) Seizure—No address digits—KP-I-7 digits-STP

(4) Seizure—No address digits—KP-I-7 digits-ST3P

(5) 7 or 10 digits—No ANI

(6) 7 or 10 digits-KP-I-7 digits-ST†

(7) 7 or 10 digits-KP-I-7 digits-ST

(8) 7 or 10 digits-KP-I-7 digits-STP

(9) 7 or 10 digits-KP-I-7 digits-ST2P

(10) 7 or 10 digits-KP-I-7 digits-ST3P.

Note: ST† indicates any one of the usable ST signals (ST, STP, ST2P, ST3P).

DISCONNECT SEQUENCE ON CALLS FROM STEP-BY-STEP THROUGH CROSSBAR TANDEM CAMA OR TSPS OFFICES

A. Normal Disconnect

Calling Customer Goes On-Hook First

CAMA (1+ Noncoin)

8.18 When the calling customer disconnects, the local central office trunk circuit immediately sends on-hook to the CAMA office. After timing for a minimum of 280 milliseconds to allow the CAMA office to function, the local central office trunk circuit opens its sleeve lead for a minimum of 30 milliseconds to release the switches and the customer line. It then regrounds the sleeve to make itself busy to new calls.

8.19 When the CAMA office receives the on-hook signal from the local central office, it delays a minimum of 140 milliseconds and then sends off-hook supervision toward the called end. After an additional 90 to 290 milliseconds, the CAMA office releases the switches and, after completion of the disconnect entry, sends on-hook supervision toward the calling end. When the local central office trunk circuit receives the on-hook supervisory signal, it removes the sleeve ground, making itself available for a new call.

8.20 While the call is in progress, the CAMA trunk circuit may be conditioned, for maintenance reasons, to make the trunk busy when the call terminates. In this case, the CAMA office will not return on-hook supervision to the calling end after disconnect and the local central office will then maintain itself busy. When the CAMA office eventually reverts to on-hook, the local central office trunk circuit removes the ground from the sleeve and becomes available for a new call.

TSPS (0+ Coin, 0- Coin, and 1+ Coin)

8.21 When the calling customer disconnects, the local central office trunk circuit sends on-hook to the TSPS office immediately; but the local central office trunk circuit does not initiate its disconnect timing at this time. After a minimum of 1100 milliseconds delay to hold over possible customer flashing, the TSPS office sends an on-hook signal to the called end if not in overtime.

> ***Note:*** If in overtime, the on-hook supervision is maintained until an operator is attached to collect the overtime charges. When the overtime charges are collected, an on-hook signal is sent to the called end by the operator.

8.22 At the same time, the TSPS office sends the coin disposal signal to the local central office. If answer supervision was recorded, the coin collect signal is sent. If answer supervision was not recorded, the coin return signal is sent. The duration of the coin disposal signal varies with the type of facility. For loop signaling, the duration is 145 to 360 milliseconds; for E&M lead signaling, the duration is 1100 to 1800 milliseconds. On loop signaling trunks, the local central office trunk circuit times the duration of the coin disposal voltage to the coin telephone; on the E&M trunks, the duration of the MF tone signal from the TSPS times the duration of the coin disposal voltage to the coin telephone.

8.23 After the coin disposal signal is sent, the TSPS office sends an on-hook signal to the local central office; but the local central office trunk circuit will not release the switches until the coin disposal circuit has completed its timing.

8.24 After sending the on-hook signal to the local central office, the TSPS delays 50 to 100 milliseconds. If the calling end is still on-hook, the TSPS office returns the trunk to an idle trunk list, making it available for service.

8.25 While the call is in progress, the TSPS office may be conditioned, for maintenance reasons, to make the trunk busy when the call terminates. In this case, the TSPS office delays 800 milliseconds after sending the on-hook signal to the local central office and then, if the calling end is still on-hook, TSPS sends an off-hook signal which causes the local central office trunk circuit to ground the sleeve lead and thereby make itself busy. When the TSPS office eventually reverts to on-hook, the local central office trunk circuit removes the ground from the sleeve and becomes available for a new call.

Called Customer Goes On-Hook First

CAMA (1+ Noncoin)

8.26 When the called customer disconnects, the CAMA office trunk circuit will, after a delay of 13 seconds (minimum), send on-hook toward the called end and release the CAMA office switches, releasing the called customer.

> ***Note:*** TSPS delays 11.1 seconds (minimum) on called customer disconnects before sending an on-hook toward the called end.

8.27 After making the disconnect entry, the CAMA trunk circuit sends on-hook to the local central office trunk circuit. Upon receipt of this on-hook signal, the local central office trunk circuit, after a delay of 140 milliseconds (minimum), opens the sleeve lead for 30 milliseconds (minimum) to release the switches. It then regrounds the sleeve for 280 milliseconds (minimum) to cover the work time necessary to idle the trunk at the CAMA office. It then removes the ground to make itself available for a new call.

8.28 The release of the switches opens the customer T and R leads to the local central office trunk circuit disconnecting the customer line and releasing the A relay in the local central office trunk circuit, thereby sending an on-hook signal to the CAMA office.

8.29 Upon detection of this on-hook signal, the CAMA trunk circuit, after a delay of 140 milliseconds (minimum), returns to its idle condition and is available for a new call.

8.30 While the call is in progress, the CAMA trunk circuit may be conditioned, for maintenance reasons, to make the trunk busy. In this case, upon detection of the on-hook signal, the CAMA trunk circuit, after a delay of 140 milliseconds (minimum), returns off-hook supervision to the calling end to make the local central office trunk circuit busy.

TSPS (0+ Coin, 0– Coin, and 1+ Coin)

8.31 When the called customer disconnects, the TSPS office will, after a delay of 2 seconds (minimum), make the disconnect entry and send on-hook toward the called end, releasing the called customer.

> ***Note:*** The 2-second timing applies on coin overtime as well as time and charge calls. On coin initial period, timed released timing is 11.1 seconds.

8.32 After performing any operator functions, such as collecting additional charges, the TSPS office sends on-hook to the local central office trunk circuit. Upon receipt of this on-hook signal, the local central office trunk circuit, after a delay of 140 milliseconds* (minimum), opens the sleeve lead for 30 milliseconds (minimum) to release the switches. The trunk circuit then regrounds the sleeve to make itself busy for the 200 milliseconds (minimum) to cover the work time required to idle the trunk at the TSPS office. It then removes the ground to make itself available for a new call.

*There is an incompatibility between the minimum release time of 140 milliseconds and the maximum received coin control wink of 150 milliseconds. While there is an incompatibility in Bell System requirements, there is no incompatibility in Bell System practice which uses a relay with 190 milliseconds minimum release time and 425 milliseconds maximum release time to recognize the on-hook from the TSPS in the local office trunk circuit.

8.33 The release of the switches opens the customer T and R leads to the local central office trunk circuit disconnecting the customer line and releasing the A relay in the local central office trunk circuit, thereby sending an on-hook signal to the TSPS office.

8.34 After a delay of 240 to 345 milliseconds in the TSPS trunk circuit, the TSPS office will detect the on-hook signal and return the trunk to the idle list.

8.35 While the call is in progress, the TSPS office may be conditioned to make the trunk busy for maintenance reasons. In this case, the TSPS office, instead of returning the trunk to the idle list, will delay an additional 800 milliseconds; if the calling end is still on-hook, the TSPS office will return off-hook supervision to the calling end to make the local office trunk circuit busy.

B. Disconnect on Partial Dial Calls

Centralized Automatic Message Accounting (CAMA)

8.36 On partial dial calls, the CAMA office waits 17 to 25 seconds for the first dial pulse digit and 17 to 25 seconds between digits, recycling the timer as each digit is received. If the calling customer does not complete dialing and remains off-hook, the CAMA office functions as described in the following paragraphs.

CAMA Office With 3-Digit Register Plus Sender

8.37 The CAMA office trunk circuit sends reorder tone and waits indefinitely for the calling customer to disconnect. If the local central office trunk circuit is equipped with a disconnect timer (dial 1 for slumber), the customer will be disconnected after the time-out period and the trunk will be released forward.

CAMA Office With 10-Digit Register Plus Sender

8.38 The CAMA office register calls in a sender which directs the trunk circuit to send off-hook toward the local central office and the sender then proceeds to disconnect. When the local central office trunk circuit receives this off-hook signal, it completes line identification and outpulses the calling number. Upon disconnect of the sender, the trunk circuit again returns an on-hook signal to the local central office. The off-hook signal sent to the local central office has a duration of approximately 1 second.

8.39 Upon receipt of the on-hook signal, the local central office trunk circuit delays a minimum of 140 milliseconds and then opens the sleeve lead to disconnect the switches and the calling customer, making itself available for a new call.

Traffic Service Position System (TSPS)

8.40 On partial dial calls, the TSPS office waits 12 to 18 seconds for the first dial pulse digit and 12 to 18 seconds between digits, recycling the timer as each digit is received. If the calling customer remains off-hook, the TSPS office goes off-hook and sends reorder tone for 9.5 to 11.5 seconds. If the calling customer remains off-hook, the TSPS office sends an on-hook signal and monitors the trunk for on-hook from the calling end as described in paragraphs 8.26 through 8.30.

TSPS COIN CONTROL SIGNALS

(This information will be furnished later as a Technical Advisory.)

INTERNATIONAL DIALING—OUTPULSING FROM TSPS AND NO. 1 ESS

8.41 International dialing, which is described in Section 10, requires more digits than can be passed through the network in a single outpulsing when per-trunk signaling is used. As a result, a 2-stage outpulsing has been devised. The first stage MF outpulsing routes the call to an international gateway office. It is handled as any other network call that terminates in the North American Network. The MF signaling is on a link-by-link basis. The MF digits are received at each node (switching system used to provide the path from TSPS to an international gateway). Digits may be added or deleted for routing purposes at each node. The MF digits are again transmitted on the next transmission link in the connection. This process is repeated until the international gateway office is reached. The second stage, MF outpulsing, is done on an end-to-end basis. The MF pulses pass through the various switching offices in the connection as any other voiceband signal. The MF digits are only detected at the international gateway office.

8.42 After the international gateway receives the ST pulse from the first stage outpulsing, the international gateway delays at least 700 milliseconds to permit time for the transient conditions in the preceding switching machines to disappear. After the delay, if a register is available and attached to the circuit, a signal known as second-start-dial is sent, which is an off-hook signal of 400 milliseconds minimum duration. (A 220-millisecond off-hook must be seen at the TSPS.) At the completion of the second-start-dial signal, the TSPS or No. 1 ESS begins the MF outpulsing procedure per paragraph 3.28. The actual MF outpulsing meets the same requirements as the first stage outpulsing. (See paragraphs 7.43 through 7.62.) A 480-Hz tone is sent from the international gateway office from the time the second-start-dial signal is completed until the ST signal is received or until the MF receiver times out (10 to 20 seconds). The 480-Hz tone is to let operators know that they can start the second stage pulsing.

9. SIGNALING TO AIS

9.01 The AIS serves class 5 offices and works with either ANI or ONI identification of the called number. The signaling formats used for both ANI and ONI are shown in Table R. 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 the AIS. The features required in the trunks and interoffice signals are shown in Fig. 39. The AIS does not generate a unique disconnect signal. The disconnect is under control of the calling party. The local central office trunk must be held busy a minimum of 450 milliseconds before reseizure to allow time for the AIS trunk to restore to the idle state.

10. CARRIER GROUP ALARM

10.01 Carrier Group Alarm (CGA) is used to minimize the effects of carrier failures on switching systems and on service. Ideally, a CGA system should: (1) busy out the failed circuits, (2) release customers from the failed circuits, (3) stop charging, (4) prevent false charging, and (5) prevent the failed circuits from seizing the central office equipment. These five objectives are effected by the CGA equipment operating on the trunk equipment. This process is referred to as ***CGA trunk conditioning***. 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.

10.02 The operation of a CGA system can be divided into three parts: (1) detection of the carrier failure, (2) conditioning the failed trunk, and (3) reaction of the switching equipment to the processing of the failure.

TABLE R

SIGNALS TRANSMITTED TO AUTOMATIC INTERCEPT CENTER

<table>
<tr><th rowspan="4">CLASS</th><th colspan="4">LOCAL OFFICE</th><th>TRUNK CONCENTRATOR</th></tr>
<tr><th>ANI</th><th colspan="3">ONI</th><th>ONI</th></tr>
<tr><th rowspan="2">MF</th><th colspan="2">LOOP SIGNALING</th><th rowspan="2">E&M SIGNALING</th><th rowspan="2">MF</th></tr>
<tr><th>TIP</th><th>RING</th></tr>
<tr><td>Regular</td><td>KP + 3 + 7d + ST</td><td>Battery</td><td>Ground</td><td>One pulse</td><td>KP + 6 + ST</td></tr>
<tr><td>Trouble</td><td>KP + 1 + 7d + ST
or
KP + 1 + ST</td><td>Ground</td><td>Battery</td><td>Two pulses</td><td>KP + 8 + ST</td></tr>
<tr><td>Blank or unassigned number</td><td>KP + 0 + 7d + ST [1]
or
KP + 0 + ST</td><td colspan="2">Momentary +130V on tip and ring followed by battery on tip, ground on ring</td><td>Three pulses</td><td>KP + 7 + ST</td></tr>
<tr><td>Failure to identify line number</td><td>KP + 2 + ST</td><td colspan="2"></td><td></td><td></td></tr>
</table>

Notes:

1. If an announcement is given to the customer before the call is completed to the AIC, the KP + 5 + ST is transmitted to the AIC.
2. Information digits and KP signals are optional.

Automatic Number Identification (ANI):

(1) Battery and ground signaling.

(2) Reverse battery answer supervision.

(3) Reverse make-busy feature to make the local central office outgoing trunk busy from the 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 HILO, bridge, or dc signaling.

(c) No reverse make-busy feature.

(d) Idle condition same as ANI trunk.

(2) Three classes (three classes of intercept traffic on one trunk):

(a) DC signaling or dial pulse signaling. (See Table R.)

(b) No reverse make-busy feature.

(c) Idle condition same as ANI trunk.

Operator Assistance:

(1) Same as one class ONI.

Note: Local central office E&M outgoing trunks are converted to *loop* at the AIC.

Fig. 39—Interoffice Signaling for Automatic Intercept System (Incoming 2-Way Loop Trunk)

10.03 The carrier failure detection circuit is generally in the carrier terminal. With the No. 4 ESS, the software has the capability to detect carrier failure. For electromechanical systems, the trunk conditioning process is associated with the carrier or signaling equipment. Electronic systems perform at least part of the trunk conditioning process 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.

10.04 The CGA equipment can be collocated with or, where calling party control is used, remote from the switching system. Where there is more than one link of signaling equipment in a facility, CGA equipment can be collocated with the switching system and at one or more locations remote from the switching system. 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.

CALL PROCESSING

10.05 The next few paragraphs will discuss CGA actions, features, and limitations in the order they would occur when a carrier system fails and then restores.

A. Between Carrier Failure and Trunk Conditioning

10.06 After a carrier failure occurs (eg, loss of synchronization in a T-Carrier system) but before CGA trunk conditioning begins, it is desirable to maintain the same supervisory states on each trunk that existed before the failure. If the carrier cannot be restored in a reasonable time, eg, 2.5 seconds, trunk processing should be initiated to remove the trunks from service. However, since there is no fixed maximum in this case, the time could be longer or shorter than the 2.5 seconds given above. The time should be long enough to maximize the possibility of restoring the carrier before trunk processing begins, but short enough so that the customers using the facility are not more annoyed by the effects caused by the delay in processing the failure than they are by the effects of the carrier failure.

10.07 This method of maintaining the previous supervisory state after failure is designed into D3 and D4 channel banks. Its advantage lies in its capability to maintain connections even though signaling may be lost due to bursts of errors with digital carrier or due to the time required to augment certain protection switches in analog or digital carrier. This method not only saves calls on short failures, it also prevents massive seizures of circuits that were idle at the time of failure. It also prevents false charging before trunk processing begins.

10.08 Another method of saving calls that could be lost to short failures is to cause all trunks to go off-hook when the carrier fails. This method has been supplanted by the method described above. However, many T-Carrier systems now in service are still using this method. Its principal disadvantage is that it causes a mass seizure between carrier failure and trunk processing and can cause false charging if the interval between carrier failure and trunk processing is more than 2 seconds.

10.09 SF signaling units have a natural tendency to remain in the same supervisory state after the failure that they were in before the failure. However, all SF units and D1 and D2 channel banks can fail off-hook, on-hook, or alternating between off-hook and on-hook.

10.10 Typical intervals between carrier failure and the beginning of trunk processing vary from 300 milliseconds to 2.5 seconds. The shorter intervals can disconnect calls that could be saved with the application of supervisory control (off-hook on all trunks or off-hook on busy trunks). The longer intervals can cause false charges unless the same supervisory state is maintained before and after failure.

B. Trunk Conditioning

10.11 There are two methods of accomplishing trunk conditioning. The first controls supervisory signals associated with the signaling systems and the second uses auxiliary signals forwarded directly to the trunk circuit or to the central control of an ESS.

(1) Where trunk conditioning is accomplished through the control of supervisory signals, the associated signaling systems are forced on-hook. If the affected 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, thereby disconnecting 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 or operator control is used, the on-hook permits the calling party to release. As will be seen in paragraphs 10.13 through 10.18, 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) About 10 seconds after the failure is detected by the CGA equipment, an auxiliary signal from the carrier terminal is applied to the trunk circuits of all outgoing and 2-way trunks with calling party control. This auxiliary signal forces them off-hook, thereby making them appear busy to the switching system. The 1-way incoming and joint hold circuits remain on-hook.

10.12 The disadvantage of the supervisory busy-out for 2-way trunk circuits is that, in the failed condition, a permanent signal is presented to the switching system. 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 throughout the period of the carrier failure.

10.13 Supervisory conditioning can be applied at the switching system 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 remain on-hook during the carrier failure.

10.14 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 the No. 1/1A ESS and No. 4 ESS are for a carrier group rather than a single circuit. Except for the step-by-step system 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.

10.15 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 customer 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 customer 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 failure.

10.16 The winkoff signal can occur any time after the carrier failure is recognized. Most existing CGA circuits wink off the customer after about 10 seconds of forced on-hook. As long as the customer is not locked to the failed trunk for an excessive time, the winkoff timing is not critical.

10.17 Joint hold or operator control 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 customer to the trunk circuit. When the carrier failure ends, all signaling circuits are returned to on-hook and all supervisory signals restored to normal.

10.18 The following paragraphs discuss the ways that CGA, with supervisory conditioning techniques, can be applied to various types of signaling:

(a) CGA on trunks equipped with E&M lead signaling with supervisory conditioning as the 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 system 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 under way 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 or operator control trunks.

(b) CGA 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 or operator control 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.

(c) CGA on loop reverse battery signaling trunks with supervisory conditioning as the busy-out mode is a method of trunk conditioning. Since only 1-way trunks are available, the false seizure of switching equipment, which can occur 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 operator control 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.

(d) CGA on trunks 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 systems. It does not require collocation of the signaling and switching equipment. However, it is the only effective method for step-by-step, joint hold, and operator control 2-wire trunk circuits.

10.19 CGA on trunks to a No. 4 ESS or No. 1/1A ESS uses central control for at least part of the processing. The carrier system furnishes a loop closure on two auxiliary signaling leads to the ESS for the duration of the carrier failure. The loop closure causes the start of trunk processing within the switching system on a carrier group of 12 or 24 trunks. The No. 4 ESS does all trunk processing. The No. 1/1A ESS requires on-hook supervision from the failed incoming or 2-way trunks to process the failure properly. In addition to the CGA trunk processing, the No. 4 ESS also has a software CGA trunk processing capability that does not require either trunk conditioning from the carrier equipment or auxiliary signaling leads.

10.20 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 now available. Except for joint hold trunk circuits, this method of CGA trunk conditioning is the most universally used trunk conditioning arrangement.

10.21 Formerly, CGA was limited to short-haul carrier systems. The broadband (L) systems did not have CGA capability. A carrier failure signal is 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 a 2600-Hz SF signaling tone for an on-hook and no tone for an off-hook. However, these methods are not widely in use.

C. Carrier Restoral

10.22 As soon as the carrier failure is over, processing to restore the affected trunks begins. The exact procedure is individual to each carrier system. However, the net result, where the carrier system has direct or indirect control over the trunk processing, is to return the trunks to the idle state in a matter of seconds. Where the carrier system does not control the CGA process (eg, No. 4 ESS), manual intervention may be required to restore the trunks to service.

10.23 Carrier failure involving a TSPS can occur on either the local or the toll side of the TSPS. The failed trunks are processed by the carrier and signaling systems when the failure is between the local central office and the TSPS. When the carrier failure is between the TSPS and the toll office, the TSPS takes indirect maintenance action to place the trunks out of service after two call attempt failures.

CARRIER FAILURE BETWEEN LOCAL CENTRAL OFFICE AND TSPS

10.24 Upon carrier failure between the local central office and the TSPS, the carrier system goes through a series of actions to process the failure at both the local central office and at the TSPS.

10.25 The local central office uses a trunk circuit with operator control of disconnect (perhaps better called TSPS control of disconnect) as described in paragraph 2.17. This means that the customer is free to release until the TSPS sends an off-hook back to the local central office at the time the TSPS requests the calling number (ANI request). Once the off-hook has been sent to the local central office, the customer is locked to the trunk until the local central office sees an on-hook. Operator control of disconnect dictates that the CGA force on-hook toward the local central office for the duration of a carrier failure to prevent locking the customer to the TSPS trunk for the duration of the failure. Essentially, all CGA arrangements can provide an on-hook toward the local central office during carrier failure. To make the trunk busy during the carrier failure, the make-busy leads from the trunk circuit (or local central office in the case of ESS) must be connected to the CGA equipment which requires the collocation of switching and carrier equipment. During carrier failure, the CGA equipment should force an on-hook toward the TSPS. Essentially, all CGA arrangements can provide an on-hook toward the TSPS during carrier failure.

10.26 As a result of the CGA processing caused by a carrier failure, the following actions take place:

(1) Calls in progress are disconnected.

(2) Charges for all calls in progress are ended.

(3) The failed trunks are made busy at the local central office if the carrier is collocated and compatible with make-busy lead operation.

(4) Customers are released (winked off) or can release themselves (by hanging up) from the failed connections.

10.27 The only customers directly affected by the failure are those using the facilities at the time of failure. Of course, any customers attempting to use the group during the failure may be indirectly affected by the reduction of trunk group size or by being connected to failed trunks.

CARRIER FAILURE BETWEEN TSPS AND TOLL OFFICE

10.28 A carrier failure between the TSPS and the toll office is handled differently. There is no direct connection between the CGA circuits in the carrier system and the TSPS. Indirect maintenance action by the TSPS minimizes the service reaction during a carrier failure by removing trunks from service after two call processing failures. In order to remove trunks from service, the carrier system must provide an off-hook condition toward the TSPS toll side.

10.29 When a carrier failure occurs, a series of events takes place. The net result of these events is as follows:

(1) Calls in progress are disconnected.

(2) Charges for all calls in progress are ended.

(3) Customers are released (winked off) or can release themselves (by hanging up) from the failed connections.

(4) All trunks appear idle and available for service by the TSPS (when the customers who occupied the trunks during the failure hang up or are winked off).

10.30 The off-hook toward the toll side of the TSPS is not detected until the trunk is seized (off-hook) toward the toll office. As a result, the first time an idle trunk (involved in the failure) is used, the call attempt will fail because the CGA will be off-hook toward the TSPS.* The TSPS records the call failure but leaves the trunk in service. On the second call failure on a given trunk, the trunk is removed from service and placed on a high and wet list at the TSPS. Each trunk must fail twice with no successful sender attached signal before being removed from service. The trunk is removed from service by an on-hook signal followed by an off-hook signal to the local central office from the TSPS. The on-hook signal winks off the calling customer who returns to dial tone. The TSPS detects the on-hook from the local central office, waits 800 milliseconds and, if the calling end is still on-hook, sends an off-hook signal to the local central office. The off-hook signal makes the local central office trunk circuit busy (reverse make-busy). The reverse make-busy can be used in this case because, in contrast to carrier failures between the local central office and the TSPS, the TSPS can control the supervisory state of the trunk, thereby preventing the trapping of a customer on a failed trunk. In addition, a seizure (off-hook) is maintained toward the toll office to monitor toll office supervision and thereby detect when the carrier is restored to normal.

* Either the MF outpulser will time out or, on operator-assisted calls, the operator will release forward. The TSPS MF outpulser times out if a start-dial (on-hook) signal is not received in 16 to 24 seconds when all TSPS MF outpulsers are not busy or 4 to 8 seconds when all TSPS MF outpulsers are busy. Abandoned calls that seize an MF outpulser for more than 8 seconds are also counted as call failures.

10.31 There are no limits to the number of trunks in the same group that can simultaneously be placed on the high and wet list at the TSPS. The failed trunks are scanned every 200 milliseconds for MF trunks and 100 milliseconds for dial pulse trunks while out of service. They remain out of service until on-hook supervision is detected on the toll side. Once on-hook supervision is detected, the trunks are put in the idle state and returned to service without manual intervention.

10.32 Since an operator-assisted call would be retried by the operator, a minimum of one call and a maximum of two calls per trunk are affected by the failure. Service may be affected during the time that the failed trunks are still in service. The failure does not, however, lock out of service any customer nor does it tie up the processing capacity of the TSPS for a long time.

10.33 It is important that the carrier between the TSPS and the toll office fail in the off-hook condition toward the TSPS. Failure in the on-hook condition causes the TSPS to take a different action that results in keeping failed trunks in service and/or removing trunks from service in such a way that manual restoral is necessary.

NO. 4 ESS FAILURE

10.34 Failure of the associated No. 4 ESS toll office causes the TSPS to take indirect maintenance action to minimize the reaction to the failure. There is no possibility of completing the calls to a TSPS by redirecting the traffic during a failure of the associated toll office. Therefore, the maintenance action is limited to ensuring that traffic will resume normally when the No. 4 ESS recovers. The trunks to a failed No. 4 ESS office are removed from service after two call failures per trunk. The trunks remain out of service for 2 to 4 minutes and then return to service. In a long toll office failure, a single trunk would be placed out of service many times during the outage but return to service automatically.

10.35 The details of the maintenance reaction to a No. 4 ESS failure are nearly identical to those of a carrier failure between the TSPS and the toll office. The trunks are removed from service in an identical manner to the carrier failure case (paragraphs 10.28 through 10.33). The trunk is placed out of service at the local central office and on the high and wet list at the TSPS. The difference is that the No. 4 ESS trunk is on-hook (rather than off-hook) toward the TSPS. This changes the method of returning the trunks to service.

10.36 The TSPS trunk is off-hook toward the No. 4 ESS to monitor the toll office supervision. When the No. 4 ESS recovers, the off-hook from the TSPS will be recognized as a seizure. The No. 4 ESS will respond by sending a 140-millisecond off-hook wink to the TSPS as a start-dial signal. If the TSPS recognizes the off-hook, the TSPS will restore the trunk to service. However, the No. 4 ESS applies the off-hook signal to all trunks in a very short time. The TSPS cannot recognize the off-hook signals at the rate they are sent by the No. 4 ESS. As a result, only a few trunks are returned to service by this method because the TSPS buffer is filled to overflowing. Another TSPS action returns the other trunks to service.

10.37 In the high and wet stuck on-hook condition, the trunks remain on the high and wet list for 2 to 4 minutes. At the end of the 2- to 4-minute period, the trunks are returned to service if more than three other trunks are on the high and wet list in the stuck on-hook condition. Since this will be the case during a No. 4 ESS failure, trunks will return to service and again be removed from service many times during a long failure. This action does, however, permit the return to service of all trunks without human intervention after a No. 4 ESS failure.

11. CALL PROGRESS TONES (AUDIBLE TONE SIGNALS)

11.01 Signals in this category give information regarding the progress or disposition of telephone calls to operators and customers. The audible signals must, of course, be easy to interpret and must conform to the transmission system design requirements for signal levels and have freedom from interference effects with respect to: (1) voice currents, (2) circuit noise, or (3) other signaling systems.

11.02 The Bell System is using a great variety of different tone sources of Bell System and non-Bell System manufacture. They all meet the general requirements of being easy to interpret and not causing interference. However, the frequency content and exact level are not documented for all tones. There is no specific requirement for any tone. It is not expected that additional requirements will be established for existing tones; further, it is expected that existing tone sources will remain in service until the associated switching system is retired or until failure of the tone-generating equipment dictates replacement of the source. The level of Bell System call progress tones usually but not always lies 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 with a termination of 900 ohms.

PRECISE TONE PLAN

11.03 The "precise tone plan" has always been used in the No. 1/1A, 2/2B, 3, and 4 ESSs. The plan is based on four pure tones which, in central office applications, will be held to ±1.5 dB amplitude variation and ±0.5 percent frequency variation. These tones are 350, 440, 480, and 620 Hz. The total power of harmonics and other extraneous frequencies is at least 40 dB below the signal level measured where it is applied to the voice transmission path. The tones are assigned individually or in pairs (not modulated) to represent standard audible tone signals. The levels of the precise tones are included in paragraphs 11.07 through 11.15.

PRECISE TONE SOURCES IN ELECTROMECHANICAL OFFICES

11.04 Other types of Bell System switching systems can and have had the old tone sources replaced with precise tone sources. However, these tones may be distributed by resistive and/or capacitive networks that were not designed to produce the levels specified in the precise tone plan.

11.05 When TOUCH-TONE service is added to an office that does not have a precise tone supply, at least that portion of the office equipped for TOUCH-TONE service should be served from a precise dial tone supply. It is known, however, that some offices equipped for TOUCH-TONE service do not have a precise dial tone supply. In addition, the tone distribution system may not deliver the dial tone within the level variation specified in the precise tone plan.

NONPRECISE CALL PROGRESS TONES

11.06 The nominal frequency content of the nonprecise tones is listed in paragraphs 11.07 through 11.15. More complete information on nonprecise tones is covered in paragraph 11.16 and Table S.

DIAL TONE

11.07 Precise dial tone consists of 350 plus 440 Hz at a level of -13 dBm0 per frequency. The difference in frequency of 90 Hz gives this tone its buzzing sound. Nonprecise (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

11.08 Precise high tone consists of 480 Hz at -17 dBm0. Nonprecise (old) high tone is nominally 500 Hz when supplied from a tone alternator or 400 Hz from an interrupter.

11.09 Low tone gets its name from the prominent 140-Hz beat. Precise low tone consists of 480 plus 620 Hz at a level of -24 dBm0 per frequency. Interrupted low tone is heard by the customer when line busy, reorder, and no-circuit conditions exist.

11.10 Class-of-service tones are used at switchboards to indicate the class of service of the calling customer 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 TONE

11.11 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 TONE

11.12 This is low tone interrupted at 120 IPM which indicates that the local switching paths to the called 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.

TABLE S

TONE INFORMATION

RINGING SYSTEM	TONE OUTPUT	TONE FREQUENCY	FREQUENCY TOLERANCE	HARMONIC DISTORTION	VOLTAGE RATIO, MODULATED TO UNMODULATED	VOLTAGE RATIO TOLERANCE	NOTE
803C	Low Tone (LT)	600/120 Hz	Both +1.7% -8.3%	Unknown	1 to 4	Unknown	
	High Tone (HT)	500 Hz	+1.7% -8.3%	Unknown	—	—	
	Audible Ring (AR)	420/40 Hz	Both +1.7% -8.3%	Unknown	1 to 4	Unknown	1
804C	Low Tone (LT)	600/120 Hz	Both +1.3% -8.3%	Unknown	1 to 4	Unknown	
	High Tone (HT)	500 Hz	+1.3% -8.3%	Unknown	—	—	
	Audible Ring (AR)	500/40 Hz	Both +1.3% -8.3%	Unknown	Unknown	Unknown	1

(See Notes at end of table.)

TABLE S (Contd)

TONE INFORMATION

RINGING SYSTEM	TONE OUTPUT	TONE FREQUENCY	FREQUENCY TOLERANCE	HARMONIC DISTORTION	VOLTAGE RATIO, MODULATED TO UNMODULATED	VOLTAGE RATIO TOLERANCE	NOTE
805B	Low Tone (LT)	Approximately 600 Hz damped 160 times per second	±4.2% for the 160-IPS damping rate; unknown for the 600 Hz	Unknown	Unknown	Unknown	2
	High Tone (HT)	480 Hz	±4.2%	Unknown	—	—	3
	Audible Ring (AR)	Unspecified; generally has components in the 400- to 600-Hz range.	Unknown	Unknown	Unknown	Unknown	1
805C	Low Tone (LT)	600/120 Hz	Both ±X%	Unknown	Unknown	Unknown	
	High Tone (HT)	540 Hz	±X%	Unknown	—	—	4
	Audible Ring (AR)	420/40 Hz	Both +10% -8.3%	Unknown	Unknown	Unknown	1

(See Notes at end of table.)

TABLE S (Contd)

TONE INFORMATION

RINGING SYSTEM	TONE OUTPUT	TONE FREQUENCY	FREQUENCY TOLERANCE	HARMONIC DISTORTION	VOLTAGE RATIO, MODULATED TO UNMODULATED	VOLTAGE RATIO TOLERANCE	NOTE
806D and J86212T (Tones generated by high-speed interrupters)	Low Tone (LT)	Approximately 600 Hz damped 160 times per second	+15% - 8.3% for the 160-IPS damping rate; unknown for the 600 Hz.	Unknown	Unknown	Unknown	2
	High Tone (HT)	480 Hz	+15% - 8.3%	Unknown	—	—	3
	Audible Ring (AR)	Unknown	Unknown	Unknown	Unknown	Unknown	1
806D (Tones obtained from static frequency generators)	Low Tone (LT)	600/120 Hz	Both ±X%	Unknown	Unknown	Unknown	
	High Tone (HT)	540 Hz	±X%	Unknown	—	—	4
	Audible Ring (AR)	Unknown	Unknown	Unknown	Unknown	Unknown	1

(See Notes at end of table.)

TABLE S (Contd)

TONE INFORMATION

RINGING SYSTEM	TONE OUTPUT	TONE FREQUENCY	FREQUENCY TOLERANCE	HARMONIC DISTORTION	VOLTAGE RATIO, MODULATED TO UNMODULATED	VOLTAGE RATIO TOLERANCE	NOTE
806E	Low Tone (LT)	600/120 Hz	Both +2.8% -5.6%	Unknown	Unknown	Unknown	
	High Tone (HT)	540 Hz	+2.8% -5.6%	Unknown	—	—	
	Audible Ring (AR)	Unknown	Unknown	Unknown	Unknown	Unknown	1
806F	Low Tone (LT)	600/120 Hz	Both +2.8% -5.6%	Unknown	Unknown	Unknown	
	High Tone (HT)	540 Hz	+2.8% -5.6%	Unknown	—	—	
	Audible Ring (AR)	Unknown	Unknown	Unknown	Unknown	Unknown	1

Notes:

1. AR voltage level is unknown.
2. Derived from a 160-IPS interrupter driving a reactive circuit.
3. Derived from a 480-IPS interrupter driving a reactive circuit.
4. A frequency stability of ±X% indicates limits that are directly proportional to the frequency variation of the input ac voltage only and independent of load. This will be approximately ±0.5% for commercial ac service, but may be wider than this when ac supply is from emergency ac backup equipment, eg, ±2%;

11.13 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 step-by-step, 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 tone-off durations may range from 0.2 to 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-IPM rate, but no significance is attached to the relative tone-on and tone-off durations.

11.14 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

11.15 Precise audible ringing consists of 440 plus 480 Hz at a level of -19 dBm0 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. Nonprecise (old) audible ringing typically consists of 420 Hz modulated by 40 Hz. Other combinations were also used.

NONPRECISE CALL PROGRESS SYSTEMS

11.16 Nonprecise call progress tones have never been well characterized and documented. Available information is contained in Table S which, when combined with that information in paragraphs 11.07 through 11.09 and 11.15, constitutes the extent of current knowledge of nonprecise call progress tone characteristics. The nominal RMS voltage given is at the output terminals of the ringing system and the tolerance is unknown. Table S contains information on the tones produced by the 803C, 804C, 805B, 805C, 806D, 806E, 806F, and J86212T nonprecise systems. The 806D system was produced in two versions, the first in which the tones were generated from high-speed interrupters and the second in which the tones were obtained from static frequency generators.

11.17 From 1946 through 1973, a combined total of 8646 of the above nonprecise systems were manufactured by Western Electric with a breakdown as follows:

SYSTEM	NUMBER MANUFACTURED
803C	938
804C	2294
805B	249
805C	181
806D	1154
806E and 806F	3330
J86212T (like 806D)	500 or less (estimated)

11.18 It is estimated that most of the nonprecise ringing systems manufactured prior to 1946 were replaced by systems manufactured during the period 1946 through 1973. As of January 1, 1979, there were 8378 electromechanical offices in existence. The vast majority of these offices undoubtedly contain ringing systems included in the above list. The combined number of ringing systems in Bell System central offices furnished by outside suppliers is considered to be relatively small.

11.19 The tone voltages of the above systems manufactured during the 1946 through 1973 interval have unknown harmonic content and are generated, in general, by high impedance sources. These sources drive reactive connecting circuits which are terminated in distributed customer lines of varying lengths. Tone modulation of low tone and audible ring tone is invariably amplitude modulation of a widely variable nature.

COIN TONES

11.20 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 that enable the operator to check the amount deposited. On prepay service, in addition to the tones, a dc signal can be used by the operator or TSPS to detect whether coins have been deposited.

RECORDER WARNING TONE

11.21 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.

NETWORK TONES

11.22 Table T documents all tones currently used in the network. Tones are included if they are now in use in the network, even though they are obsolete (ie, would not be provided in newly installed equipment). Tones are ***not*** included if they need not ever be interpreted by a person, even though they might be heard by customers or operators from time to time, ie, MF signals. Each tone appears twice, first in a table of specifications (Table T) and again in a glossary of tone meanings (Table U). The tones are numbered consecutively in Table T and appear under the same number and title in Table U.

RECEIVER OFF-HOOK (ROH) TONE

11.23 ROH tone is not a signal used in the toll network and is never placed on trunks. It is placed on lines to inform the customer that the receiver has been left off-hook. In some cases, the tone is applied to FX lines using carrier facilities.

11.24 Every effort is made to prevent applying ROH tone, either automatically or manually, to lines that could be connected to an attendant headset. Several switching systems have facilities to prevent automatic application of ROH tone. Local test desk testers are instructed not to apply ROH tone to PBXs.

11.25 Developments to prevent automatic application of ROH tone to carrier facilities in electronic systems are now being considered. The No. 5 crossbar can now prevent application of ROH tone to carrier facilities in most cases. Local test desk testers are instructed not to apply ROH tone to any line equipment connected to carrier facilities.

11.26 Test of ROH tone on actual telephone connections showed the sound pressure levels varied from 109 to 110 dBa and 108 to 109 dB SPL*.

*0 dB SPL is 0.0002 dynes per square centimeter.

11.27 The ROH tone is applied to a line two times for approximately 50 seconds each time in most Bell System switching systems. However, the No. 2/2B ESS applies ROH tone once for a period of 40 seconds. Therefore, the ROH tone is well within Occupational Safety and Health Act (OSHA) limits which permit 110 dBa for 30 minutes and 115 dBa for 15 minutes.

TABLE T

BELL SYSTEM TONES (NOTE 1)

NAME	FREQUENCIES (Hz) (NOTE 2)	TEMPORAL PATTERN (NOTE 3)	LEVELS (NOTE 4)
1. Low Tone	480 + 620 600 × 120 600 × 133 600 × 140 600 × 160	Various	—24 dBm/frequency 61—71 dBrnC 61—71 dBrnC 61—71 dBrnC 61—71 dBrnC
2. High Tone	480 400 500	Various	—17 dBm 61—71 dBrnC 61—71 dBrnC
3. Dial Tone	350 + 440 See Low Tone (except 480 + 620)	Steady Steady	—13 dBm/frequency
4. Audible Ring Tone	440 + 480 420 × 40 500 × 40	2 seconds on, 4 seconds off. . .* 2 seconds on, 4 seconds off. . .* 2 seconds on, 4 seconds off. . .*	—19 dBm/frequency 61—71 dBm/frequency 61—71 dBm/frequency
5. Line Busy Tone	See Low Tone	0.5 second on, 0.5 second off. . .	
6. Reorder (local) (toll)	See Low Tone See Low Tone 480 + 620	0.3 second on, 0.2 second off. . . 0.2 second on, 0.3 second off. . . 0.25 second on, 0.25 second off. . .	
7. 6A Alerting Tone	440	2 seconds on, followed by 1/2 second on, every 10 seconds	
8. Recorder Warning Tone	1400	0.5-second burst every 15 seconds	
9. Recorder Connected Tone	440	0.5-second burst every 5 seconds	
10. Reverting Tone	See Low Tone	0.5 second on, 0.5 second off. . .	—24 dBm/frequency
11. Deposit Coin Tone	See Low Tone	Steady	
12. Receiver Off-Hook	1400 + 2060 + 2450 + 2600	0.1 second on, 0.1 second off. . .	0 dBm/frequency
13. Howler	480	Incremented in level every 1 second for 10 seconds	Up to +40 VU
14. Partial Dial Tone	See High Tone	Steady	

(See Notes at end of table.)

TABLE T (Contd)

BELL SYSTEM TONES (NOTE 1)

NAME	FREQUENCIES (Hz) (NOTE 2)	TEMPORAL PATTERN (NOTE 3)	LEVELS (NOTE 4)
15. No Such Number ("Cry Baby")	200 to 400	Frequency modulated at 1 Hz, interrupted every 6 seconds for 0.5 second	
16. Vacant Code	See Low Tone	0.5 second on, 0.5 second off, 0.5 second on, 1.5 seconds off. . .	
17. Busy Verification Tone (Centrex	440	Initial 1.5 seconds followed by 0.3 second every 7.5 to 10 seconds (6 seconds in No. 1/1A ESS)	—13 dBm
(TSPS)	440	Initial 2 seconds followed by 1/2 second every 10 seconds	—13 dBm
18. Call Waiting Tone	440	Two bursts of 0.5 second separated by 10 seconds	—13 dBm/frequency
19. Confirmation Tone	350 + 440	0.1 second on, 0.1 second off, 0.3 second on	—13 dBm/frequency
20. Indication of Camp-On	440	1 second every time attendant releases from loop	—13 dBm
21. Special Dial Tone	350 + 440	Three bursts (0.1 second on, 0.1 second off) then steady on	—13 dBm/frequency
22. Priority Audible Ring (AUTOVON)	440 + 480	1.65 seconds on, 0.35 second off. . .	—16 dBm/frequency
23. Preemption Tone (AUTOVON)	440 + 620	Steady 3 to 15 seconds	—18 dBm/frequency
24. Data Set Answer Back Tone	2025	Steady	—13 dBm
25. Automatic Credit Card Dialing — Prompt Tone	941 + 1477 followed immediately by 440 + 350	60 msec 940 msec (exponentially decayed from —10dBm per frequency at —3 TLP at time constant of 200 msec)	—10 dBm/frequency at —3 TLP

(See Notes at end of table.)

TABLE T (Contd)

BELL SYSTEM TONES (NOTE 1)

NAME	FREQUENCIES (Hz) (NOTE 2)	TEMPORAL PATTERN (NOTE 3)	LEVELS (NOTE 4)
26. Class of Service	See High Tone See Low Tone No Tone	0.5 to 1 second once 0.5 to 1 second once	
27. Dial-Normal Transmission Signal	See Low Tone	Steady	
28. Dial Jack Tone	See Low Tone	Steady	
29. Order Tones			
(single-order tone)	See High Tone	0.5 second, approximately	
(double-order tone)	See High Tone	Two short spurts in quick succession	
(triple-order tone)	See High Tone	Three short spurts in quick succession	
(quadruple-order tone)	See High Tone	Four short spurts in quick succession	
30. Intercepting Loopback Tone	See High Tone	Steady	
31. Number Checking Tone	See High Tone 135	Steady Steady	
32. Coin Denomination Tones			
3 slot stations 5¢	1050-1100 (bell)	one tap	
3 slot stations 10¢	1050-1100 (bell)	two taps	
3 slot stations 25¢	800 (gong)	one tap	
1 slot stations 5¢	2200 + 1700	one "beep"	
1 slot stations 10¢	2200 + 1700	two "beeps"	
1 slot stations 25¢	2200 + 1700	five "beeps"	
33. Coin Collect Tone	See Low Tone	Steady	
34. Coin Return Tone	See High Tone	0.5 to 1 second once	
35. Coin Return (Test) Tone	See High Tone	0.5 to 1 second once	
36. Group Busy Tone	See Low Tone	Steady	
37. Vacant Position Tone	See Low Tone	Steady	
38. Dial Off-Normal Tone	See Low Tone	Steady	

(See Notes at end of table.)

TABLE T (Contd)

BELL SYSTEM TONES (NOTE 1)

NAME	FREQUENCIES (Hz) (NOTE 2)	TEMPORAL PATTERN (NOTE 3)	LEVELS (NOTE 4)
39. Permanent Signal	See High Tone	Steady	
40. Warning Tone	See High Tone	Steady	
41. Trouble Tone	See Low Tone	Steady	
42. Service Observing Tone	135	Steady	
43. Proceed to Send Tone (IDDD)	480	Steady	—22 dBm
44. Centralized Intercept Bureau Order Tone	1850	500 msec	—17 dBm
45. ONI Order Tone	700 + 1100	95 to 250 msec once	—25 dBm†

Notes:

1. Tones 1 through 24 are customer tones; tones 25 through 44 are operator tones.
2. Where more than one frequency is used, the plus sign (+) means "added to" and the times sign (×) means "modulated by."
3. Three dots (. . .) in the pattern description means that the stated pattern is repeated indefinitely.
4. Except where noted, levels are given at the point of application to the circuit.

* Pattern is 1 second on, 3 seconds off . . . for PBX and centrex CU.

† At operating position.

TABLE U

GLOSSARY OF BELL SYSTEM TONES

NAME	DESCRIPTION
1. Low Tone	This is a generic tone used with various interruption patterns for the specific tones listed below and described elsewhere under their own titles. Line Busy Tone Reorder Reverting Tone No Circuit Tone No Such Number Vacant Code Group Busy Tone Deposit Coin Tone Vacant Position Tone Dial Off-Normal Tone Trouble Tone Dial Jack Tone Dial Test Signal Class of Service
2. High Tone	This is a generic tone used with various interruption patterns for the specific tones listed below and described elsewhere under their own titles. Partial Dial Tone Permanent Signal Coin Return (Test) Tone Coin Return Tone Number Checking Tone Intercepting Loopback Tone Warning Tone Order Tones Station Ringer Test Class of Service
3. Dial Tone	This tone is sent to a customer or operator to indicate that the receiving end is ready to receive dial pulses or TOUCH-TONE signals. It is used in all types of dial offices when dial pulses are produced by the customer's or operator's dials. Normally dial tone means that the entire wanted number may be dialed; however, there are some cases where the calling party must await a second dial tone or where an operator, after dialing an initial group of digits, must wait for a second dial tone before the rest of the number can be dialed. Some dialing switchboards are arranged to permit listening for dial tone between certain digits.
4. Audible Ring Tone	This is a ringing indication which is interpreted by the calling party to mean that the called line has been reached and that ringing has started. It is also used on calls to operators (special service, long distance, intercepting, etc) during the "awaiting-operator-answer" interval.

TABLE U (Contd)

GLOSSARY OF BELL SYSTEM TONES

NAME	DESCRIPTION
5. Line Busy Tone	Low tone interrupted at 60 IPM, 50 percent BK, indicates that the called customer's line has been reached but that it is busy or being rung or on permanent signal. When a line busy signal is applied by an operator, it is sometimes call a *busy-back tone*.
6. Reorder	Low tone interrupted at 120 IPM, in all types of offices, indicates that the local or toll switching or transmission paths to the office or equipment serving the called customer are busy. This signal may indicate a condition such as a timed-out sender or unassigned code dialed. It is interpreted by either a customer or an operator as a reorder signal. In No. 5 crossbar, No. 1/1A ESS, No. 2/2B ESS, and No. 1 step-by-step offices using the Precise Tone Plan, the temporal pattern is 0.25 second of low tone and 0.25 second off. In other offices, the intervals are 0.3 second of low tone and 0.2 second off (local), and 0.2 second low tone and 0.3 second off (toll).
7. Alerting Tone	Indicates that an operator has connected to the line (emergency interrupt on a busy line during a verification call).
8. Recorder Warning Tone	When recording equipment is used, this tone is connected to the line 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. This tone is required by law and is recorded along with the speech.
9. Recorder Connected Tone	This tone is used to inform the customer that his/her call is completed to a recording machine and that he/she should proceed to leave a message, dictate, etc. It is to be distinguished from the recorder warning tone, which warns the customer that his/her 2-way conversation is being recorded.
10. Reverting Tone	The same type of signal as line busy tone is used for reverting tone in all systems. In No. 5 crossbar systems, a second dial tone is sometimes also used when a calling party identification digit is required. The reverting signal informs the calling subscriber that the called party is on the same line and that he/she should hang up while the line is being rung.
11. Deposit Coin Tone	This tone, sent from a CDO to a post-pay coin telephone, informs the calling party that the called party has answered and that the coin should be deposited.
12. Receiver Off-Hook Tone	This tone is used to cause off-hook customers to replace receiver on-hook on a permanent signal call and to signal a non-PBX off-hook line when ringing key is operated by a switchboard operator.
13. Howler	This tone is used in older offices to inform a customer that his/her receiver is off-hook. It has been superseded by the receiver off-hook tone.

TABLE U (Contd)

GLOSSARY OF BELL SYSTEM TONES

NAME	DESCRIPTION
14. Partial Dial Tone	High tone is used to notify the calling party that he/she has not commenced dialing within a preallotted time, measured after receipt of dial tone (permanent signal condition), or that he/she has not dialed enough digits (partial dial condition). This is a signal to hang up and dial again.
15. No Such Number ("Cry Baby")	This signal tells the calling party to hang up, check the called number, and dial again. Calls to unassigned or discontinued numbers may also be routed to intercepting operators or preferably to a machine announcement system, such as the 6A or 7A, which verbally supplies the required message. In some offices, reorder tone is returned in this condition.
16. Vacant Code	This tone is used in crossbar systems to indicate that the dialed office code is unassigned. In step-by-step areas, this signal is called *vacant level tone.* Recorded verbal announcements may also be used for this service. For operator-originated calls, the verbal announcement is preceded by two flashes.
17. Busy Verification Tone (Centrex)	Busy verification is a centrex feature that allows the attendant to call and be connected to a busy centrex station within the attendant's customer group. The *busy verification tone* is applied to *both* parties of the connection to inform them of the intrusion by the attendant. No tone is applied if the station called for busy verification is idle.
18. Call Waiting Tone	Call Waiting is a special service that allows a busy line to answer an incoming call by flashing the switchhook. Audible ring (instead of line busy) is applied to the calling line, and the *call waiting tone* is applied to the called line. (So that only the call*ed* party hears the tone, the connection is momentarily broken, and the other party to that connection experiences a moment of silence.) Flashing the switchhook places the existing connection on hold and connects the customer to the waiting call.
19. Confirmation Tone	This tone is used to acknowledge receipt by automatic equipment of information necessary for special services. It is currently used for: (1) Speed Calling — dialed number has been recorded or (2) Call Forwarding — dialed number has been recorded and service is activated or Call Forwarding — service is deactivated.
20. Indication of Camp-On	Attendant camp-on service allows an ESS centrex attendant to hold incoming calls to busy lines. Each time the attendant releases his/her talking connection from the loop involved in the camped-on call, the *indication of camp-on tone* is heard by the called customer if the customer has subscribed to the indication of camp-on option. The customer may get this tone several times as the attendant reconnects and releases from the loop in response to timed reminders from the console.

TABLE U (Contd)

GLOSSARY OF BELL SYSTEM TONES

NAME	DESCRIPTION
21. Special Dial Tone	This tone is used with three way calling, centrex station dial transfer, and centrex conference (station or attendant) services. The user on an existing connection flashes the switchhook, receives *special dial tone,* and dials number of the third party to be added to the connection.
22. Priority Audible Ring (AUTOVON)	This tone replaces normal audible ring for priority calls within AUTOVON.
23. Preemption Tone (AUTOVON)	This tone is provided to both parties of a connection that is preempted by a priority call from AUTOVON.
24. Data Set Answer Back Tone	This tone is heard by customers when manually initiating a data call. It normally occurs shortly after the onset of audible ringing and means that the remote data set has answered. The data set at the calling end should then be put into the data mode.
25. Automatic Credit Card Dialing — Prompt Tone	This tone is used to inform the customer that his/her credit card information must be keyed in.
26. Class of Service	These signals are used at a toll board operating as an "A" board to identify the class of service of the calling customer. The indication may be high, low, or no tone.
27. Dial-Normal Transmission Signal	This is a second dial tone returned to an operator between digits indicating that he/she may dial the remainder of the number. For example, when an operator reaches a link-type CDO via a step-by-step office after dialing a routing code, he/she must pause until an idle link at the CDO returns dial tone. This method of operation is not recommended or considered standard.
28. Dial Jack Tone	Low tone is used as a start-dial signal to tell a DSA operator that the connection reached through a dial jack is ready to receive dialing.
29. Order Tones	High tones sent over interposition, local interoffice, or toll trunks indicate: (1) to the originating operator that the order should be passed and (2) to the receiving operator that an order is about to be passed. For Call Announcer (CA) and Automatic Display Call Indicator (ADCI), the tone serves function (2) only. (a) Single-order tone — This is a relatively long (approximately 0.5 second) signal which means that the originating operator should pass the office name and number. (b) Double-order tone — This signal is two short spurts in quick succession and means that the operator should pass only the desired number.

TABLE U (Contd)

GLOSSARY OF BELL SYSTEM TONES

NAME	DESCRIPTION
29. Order Tones (Contd)	(c) Triple-order tone — This signal is three short spurts in quick succession and means that the operator should pass the office name only and wait for another order tone. (d) Quadruple-order tone — This signal is four short spurts in quick succession and means that the operator should pass the city name only and wait for another challenge. It is used in manual toll tandem (also called zip tones or trunk assignments tones).
30. Intercepting Loopback Tone	High tone sent from an intercept operator to the "A" board operator in manual offices indicates that the intercept operator has completed the call and that the "A" operator should disconnect from the circuit. The completion of intercepted calls in this manner is no longer
31. Number Checking Tone	High tone is sometimes used at DSA switchboards in No. 1 crossbar and some step-by-step areas to verify the verbal identification of the calling line.
32. Coin Denomination Tones	These tones enable the operator to determine the amount deposited in coin telephones.
33. Coin Collect Tone	Low tone over a coin recording-completing trunk informs the originating toll operator that the local operator or coin control circuit has collected the charge.
34. Coin Return Tone	High tone over a coin recording-completing trunk informs the originating toll operator that the local operator or coin control circuit has returned the charge when the connection is not completed (also called coin refund tone).
35. Coin Return (Test) Tone	High tone is used to tell an operator in a dial central office that a testman has completed a call to his/her position over a coin trunk.
36. Group Busy Tone	This audible signal is indicated by low tone on the sleeve of trunk jacks at cord switchboards. Absence of the tone tells the operator that there is at least one idle trunk in a group.
37. Vacant Position Tone	Low tone is applied to all straightforward trunks terminating in a vacated position in manual offices.
38. Dial Off-Normal Tone	Low tone is returned to an operator after he/she has completed a call into a step-by-step office and after the calling party has answered to remind him/her to restore the dial key.

TABLE U (Contd)

GLOSSARY OF BELL SYSTEM TONES

NAME	DESCRIPTION
39. Permanent Signal	A customer's line, not in use, which exhibits a steady off-hook condition is routed to a permanent signal trunk. High tone, superimposed on battery, is supplied through a resistance lamp to the ring of the trunk. The tone is used to inform an operator or other employee making a verification test that the line is temporarily out of service. An intermittent ground may also be applied to the ring of the telephone systems left in the hold condition. Typical reasons for the line condition are: (a) No dialing within the allowed waiting interval. (b) A handset is off-hook. (c) Low insulation resistance or other line trouble. In some offices, if three or more digits are dialed but not a complete telephone number or code, the call is released and dial tone is returned.
40. Warning Tone	High tone warns an operator that the circuit he/she is connected to is not in condition for normal operation. Examples: (1) An operator at an ADCI position plugs into the wrong jack. (2) An operator at a sender monitor position plugs into a sender supervisory jack while the sender is under test.
41. Trouble Tone	Low tone applied by an operator or testman at a B position in a manual office to the jack sleeve of a line or trunk in the calling multiple tells other operators the line or trunk is in trouble (also called plugging-up cord tone).
42. Service Observing Tone	This tone indicates that the trunk to which it is applied is being service observed.
43. Proceed to Send Tone (IDDD)	This tone informs the operator that an overseas sender has been seized and the address information (KP-CC-CC-ST) should be transmitted.
44. Centralized Intercept Bureau Order Tone	This tone tells the centralized intercept bureau operator that a call has reached the position.
45. ONI Order Tone	This tone tells the ONI operator that a call has reached the position.

11.28 Because of the circuit used to provide ROH tone, it is not possible to give individual tone levels at a specific reference point. Therefore, Fig. 40 and the following paragraphs will describe the ROH tone generator, distribution arrangement, and measurement equipment in some detail.

11.29 There are four Hartley oscillators, one for each frequency shown in the left portion of Fig. 40 (1400, 2060, 2450, and 2600 Hz). The oscillators depend upon circuit nonlinearities to limit output amplitude. There is no per-oscillator adjustment. The maintenance practice indicates that the oscillators are operating satisfactorily if the output of each is greater than 1 volt when measured on a 400-type Hewlett-Packard ac voltmeter.

11.30 A keyer applies and removes power from the oscillators. The keyer applies power for 0.1 second and then removes power for 0.1 second on a repetitive basis to provide 5-PPS tone from each oscillator.

11.31 A 150-KOHM resistor isolates each oscillator from a common tone bus where all four tones are present at approximately equal amplitude. A 1000-ohm potentiometer is connected from the tone bus to ground to control the voltage supplied to the amplifier. This is the only adjustable element in the ROH tone generator and distribution circuit.

11.32 The mixed and keyed tones are fed from the potentiometer to the amplifier. The output of the amplifier is a balanced signal which is fed to the resistive distribution network. The output of the amplifier is the location specified as the measuring location for adjustment purposes. A volume indicator is attached at the output of the amplifier and the potentiometer is adjusted to give a +11 VU reading at this point. The volume indicator used is described in more detail in the following paragraphs.

11.33 The ROH tone then passes through two 442-ohm resistors and a 94E repeat coil after leaving the amplifier. The tone is estimated to be at a level of +6 VU at this point and at a level of +5 VU after passing through the switching machine to the customer's side of the main distributing frame. However, there are no requirements for tone level at these locations.

11.34 The following is a synopsis of the volume indicator description:

(a) The volume indicator consists of an indicating meter and a calibrated attenuator in series. It is intended primarily for the measurement of speech or music volume or the level of a nonsinusoidal signal at a given point in a circuit. Such measurements made in VU are valid only when read in a prescribed manner on a standard VU meter having closely controlled dynamic characteristics and calibrated so that the volume indicator reads 0 VU (algebraic sum of meter needle deflection and volume indicator attenuator setting) when it is bridged across a 600-ohm circuit terminated in 600 ohms in which 1 mW of 1000-Hz power is flowing.

(b) The actual dynamic characteristic of a standard volume indicator is such that when a steady sine wave is suddenly impressed, the meter will reach 99 percent of its steady-state reading in 0.3 second ±10 percent and overswing the steady-state value by at least 1 but not more than 1.5 percent. The time for the pointer to come to rest after removal of the voltage should not be far different from the response time. It should be noted that when used to measure the level of speech or music, the indication in VU is not a true measure of average power, the meter being too slow to indicate true peak power and too fast to give a true indication of average power.

(c) For steady-state sine-wave power, the readings of the instrument in VU are numerically equal to the level in dBm (for the case of a 1000-Hz test signal in a 600-ohm circuit). Therefore, the volume indicator may be used for many types of transmission measurements where the range of the meter and its accuracy are considered adequate.

(d) As used to measure the level of the ROH tone generator, the volume indicator has an impedance of 7500 ohms.

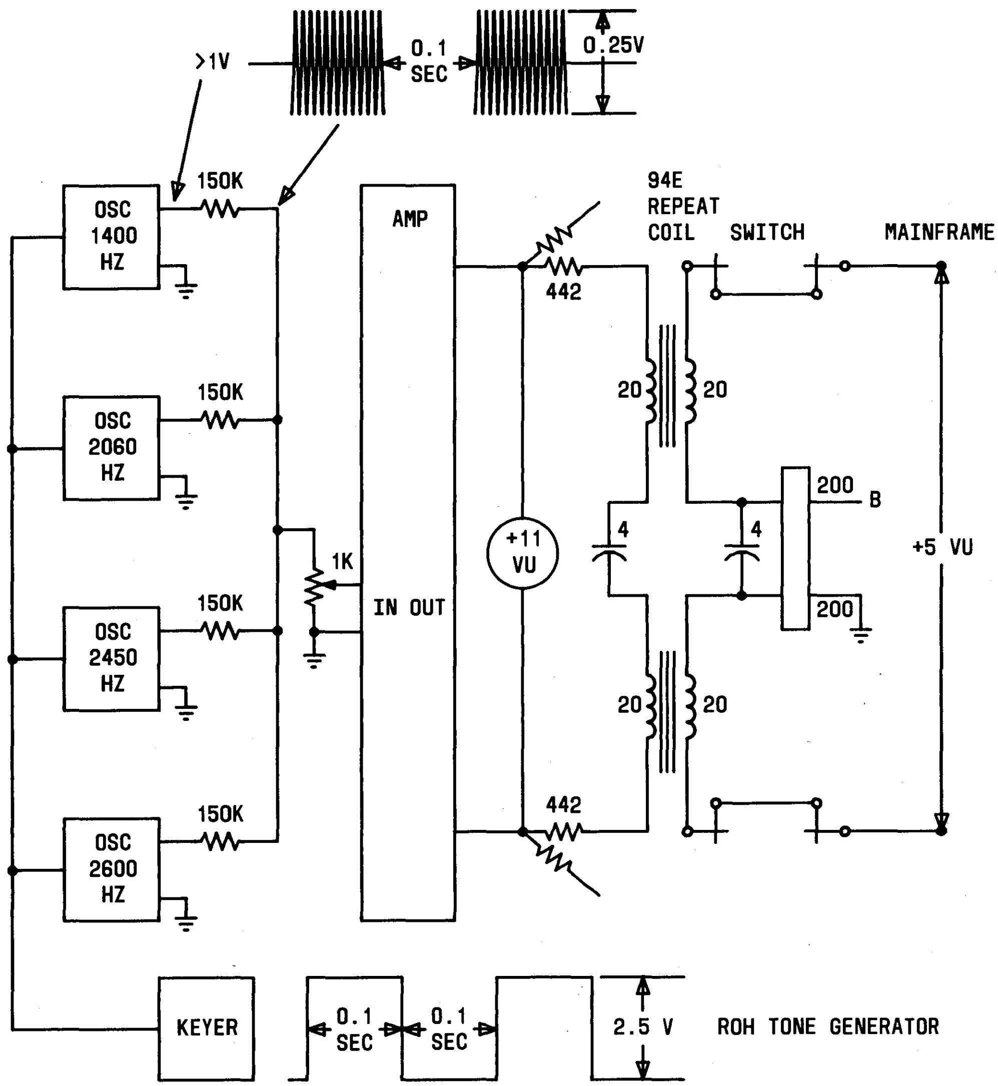


Fig. 40—ROH Tone Circuit

12. OTHER MISCELLANEOUS SIGNALS

RINGING

12.01 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 toll 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.

12.02 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. The TSPS does not provide a ringing start signal.

12.03 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 105 Vac 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.

A. Ring Forward (Rering)

12.04 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 toll dialing circuits, ring forward is a momentary on-hook of 100 ±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. On trunks arranged for loop signaling, an SX +130 volt ring forward signal (paragraph 12.05) is sent for 100 ±30 milliseconds.

B. Crossbar Tandem—Ring Forward Signal

12.05 The incoming intertoll trunk circuit in the crossbar tandem office will recognize a momentary on-hook signal on the E lead as a ring forward (rering) signal. To be recognized as a ring forward signal, the on-hook signal must be: (1) longer than the recognition time of the trunk circuit (about 50 milliseconds) and (2) shorter than the disconnect time of the trunk circuit (disconnect time covered in paragraph 2.13) (less than 140 milliseconds). After the recognition time has passed, the trunk circuit is primed to send this ring forward signal toward the terminating end of the circuit. When the E lead has returned to off-hook, the trunk circuit converts the incoming ring forward signal to an SX forward rering signal which is +130 volts through 2000 ohms applied for 100 milliseconds minimum to both the tip and ring leads in the terminating direction. This signal passes through the switch where one of two conditions can occur.

(1) If there is an outgoing trunk circuit in the crossbar tandem office, the ring forward signal can be converted to a form compatible to the next signaling link or blocked from progressing into the next signaling link.

(2) If there is no outgoing trunk circuit, as is the case with most loop outgoing trunks in the crossbar tandem office, the SX forward rering signal will pass through the trunk facility to the incoming trunk circuit in the terminating office. If the incoming trunk circuit does not have a supervisory relay with balanced windings, the +130 volt signal may act as a false disconnect signal. (See Fig. 41 and Section 4.)

C. Ringback

12.06 Ringback 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 or TSPS console. 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 customer or to alert the calling customer.

12.07 Operator-controlled ringing (ringback) is required on all coin lines to ring the telephone if the calling customer hangs up after the call is completed to alert the customer when an overtime deposit is necessary. It is also used to summon a customer who has requested a time and charge quote but has hung up. Ringback has also been used to identify the calling line on emergency calls, on other than 4- or 8-party lines, if the caller inadvertently hangs up before identifying the location of the emergency. This second use is not necessary and not provided for in the TSPS because the TSPS operator has the calling number, for other than 4- or 8-party lines, displayed on the position for ANI calls.

12.08 If a 4- or 8-party line customer has made an emergency call and then hung up, the calling number will not be available at the TSPS. In addition, the operator ringback request for a multiparty line is ignored in the No. 3 ESS. For emergency calls to the No. 2/2B ESS, a special emergency key is required at the TSPS in addition to the regular ringback key.

12.09 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, ringing is applied only if the station is off-hook.

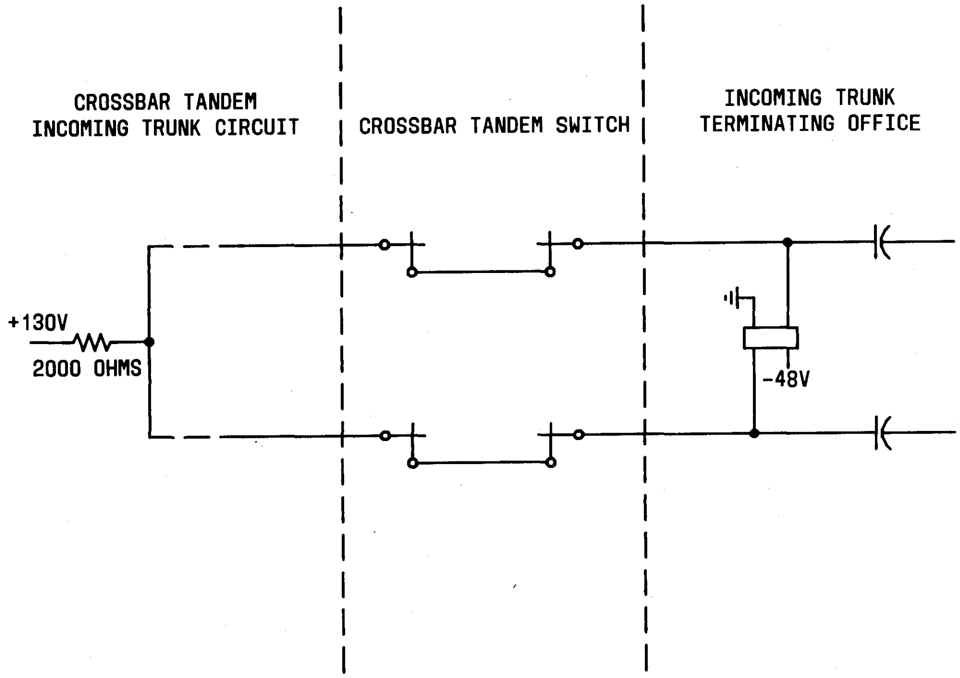


Fig. 41—Incoming Trunk Circuit Without Balanced Windings on Supervisory Relay

12.10 Unrestricted ringback is provided:

(a) For all coin lines regardless of serving office type

(b) For all single-party ESS lines

(c) For all (single-party) lines in electromechanical offices that have no party lines.

Restricted ringback is used to guard against annoying a customer if the operator should attempt to ring back against a party line and rings the wrong party.

12.11 With loop trunks to the local central office as the ringback signal, 20-Hz ringing or reverse battery can be used. Noncoin trunks can use a single wink, while coin trunks can use MF tones or multiwink, as described later, as a ringback signal.

12.12 An emergency ringback method is available for use with recording—completing trunks from some local central offices. In this case, an operator, having determined that some emergency exists on a line that has gone on-hook after being 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 the TSPS and is classified "manufacture discontinued" for other equipment arrangements. Therefore, there is no way in an emergency situation for TSPS to ring back a multiparty line.

D. TSPS Noncoin Wink Ringback Signal

12.13 The wink ringback signal sent from the TSPS on noncoin trunks is 75 milliseconds (+50, -5 milliseconds). The trunk circuit should be capable of recognizing an on-hook wink having a duration of 50 to 150 milliseconds.

TONES AND ANNOUNCEMENTS

12.14 Tones and announcements are used to inform customers and operators of various conditions encountered on dialed calls. They are also required for service analysis of conditions which result in failure to complete dialed calls. Analysis data are used to evaluate administrative, engineering, and maintenance efforts to improve service.

12.15 Tones are used primarily to identify busy conditions of lines and some trunks. Generally, 60-IPM tone is used to identify busy lines and 120-IPM tone is used to identify busy trunks. The appropriate customer action for either condition is to hang up and try the call again.

12.16 Announcements are used when the condition encountered requires explanation for both customers and operators. Announcements also suggest the appropriate action to be taken. The use of "no circuit" (N), "overload" (O), and "special" (X) announcements space attempts in order to relieve overloaded switching systems and trunk networks.

12.17 Local options on tones and announcements created no serious problem prior to the advent of toll dialing. However, with the system now an integrated multioffice network, a variety of tones or announcements for the same conditions are most confusing from the customer standpoint. Also, nonuniformity makes it impossible to analyze performance results with any degree of accuracy. Service evaluators (observers) identify each type of announcement by certain key words in the announcement. Therefore, uniformity of tones and announcements throughout the system is a requirement.

A. Location Codes

12.18 Identification codes are appended to recorded announcements to facilitate trouble tracing and to help locate the source of blockages encountered on the toll network. They provide a savings in both man-hours and circuit outage time since, except where CCIS is involved, call failures can be referred directly to the office where the blockage occurred.

12.19 Experience has shown that adverse customer reaction to identification codes is minimized when the code number is placed at the end of the announcement. Since announcement trunks are arranged so that a customer hears the announcement from its beginning, the code will be heard only when the customer remains on the line throughout the entire message.

12.20 Identification codes are assigned according to the following guidelines:

(a) Codes are assigned to toll switching offices.

(b) The first three digits of the code are the Numbering Plan Area (NPA) code indicating the location of the switching office.

(c) The fourth and fifth digits are assigned as follows:

- Digit 1—Assigned to switching system serving as a Regional Center
- Digit 2 or 3—Assigned to switching systems serving as Sectional Centers
- Digit 4 and higher—Assigned to Primary and Toll Center switching systems.

12.21 Switching systems with trunks utilizing CCIS should append the letter ***C*** to their identification code. For example, the code for the Atlanta 4E office, with CCIS, would be 4043C. This is done to alert network maintenance that an announcement received at a CCIS office could be the result of a blockage condition beyond the office transmitting the announcement.

12.22 Gateway office announcement codes will contain one additional suffix digit to further describe the announcement condition encountered. The authorized suffixes are as follows:

- Digit 1—International No Circuit (NC)
- Digit 2—International Reorder
- Digit 3—International Vacant Code
- Digit 4—International Unauthorized Code
- Digit 5—International Foreign Failure.

An example of an identification code of this type for Pittsburgh is 4121C1, indicating an NC condition to an international point from Pittsburgh.

12.23 Certain announcements terminated in the Mass Announcement System (MAS) will contain the identifying suffix ***M*** in addition to the area code and identification code, ie, 2141M for a Dallas MAS vacant code announcement.

12.24 Requests for new assignments or changes to United States system codes shown in Table V should be made to:

District Manager—Network Methods
Telephone: (201) 221-5788

12.25 The TransCanada Central Traffic Staff is responsible for the administration of the TransCanada code list shown in Table W.

B. Special Announcements

12.26 Recommended standard announcements in no way prohibit the use of special announcements when required for specific situations such as disasters and work stoppages.

C. Equipment Operation

12.27 Announcement trunks should be equipped for delayed cut-through so that an announcement will be heard from the start of the message. There should be an audible ring during the interval before the start of the announcement and the interval should be as short as possible. Announcements should be brief and carefully prepared. It is important also that announcement facilities be kept in working order and proper routines established to check and maintain the quality of announcements.

12.28 Announcement systems used for intercepted numbers should be arranged for operator cut-through.

D. Recommended Tones and Announcements

12.29 Figure 42 provides a list of recommended tones and announcements for the various conditions encountered. Also see Technical Advisory 28 for additional information.

12.30 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 intercept 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 intercept trunks may be brought into the center or to subcenters to which the announcements are transmitted.

12.31 A smaller machine is used in small dial offices where neither operator intercept nor the larger intercept 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 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.

12.32 Direct-dialed toll 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.

12.33 Crossbar tandem and No. 4 crossbar switching systems are equipped so that appropriate recorded announcements may be returned to calls which fail to complete because:

(a) All trunks are busy due to heavy traffic or disaster.

(b) A switching system is overloaded.

(c) Vacant codes or unauthorized numbers are dialed.

(d) Operating or equipment irregularities are encountered.

12.34 Cut-through to an operator is not contemplated under these circumstances. Figure 42 contains some of the tones and announcements recommended for network dialing.

TABLE V

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
2012	Newark 4T	20319	New Britain 1E
2014	Rochelle Park No. 1	20320	New London 1E
2015	Newark-Essex No. 1	20321	New Haven 1E
2016	Newark-Essex No. 2	20322	Stamford 1E
2017	Newark-Jersey No. 1	20323	Hartford 1E
2018	Newark-Jersey No. 2	20324	Norwalk 1E
2019	Paterson	20325	Bridgeport 1E
20110	Hackensack	20326	Bristol 1E
20111	New Brunswick XBT	20327	Middletown 1E
20112	Asbury Park		
20113	Freehold	204	See TransCanada (Table W)
20114	Morristown		
20115	Bergen	2052	Birmingham
20116	Flemington	2054	Montgomery
20117	Clinton	2055	Mobile
20118	Newton	2056	Decatur
20119	New Brunswick 4T	2057	Gadsden
20120	Newark No. 7 4T	2058	Huntsville
20121	Sussex	2059	Dothan 1
20122	Cedar Knolls	20510	Tuscaloosa
20123	Rochelle Park No. 2	20511	Jasper
20124	Belvidere Tandem	20512	Selma
		20513	Leesburg
2022	Washington 4T Sect.	20514	Sheffield
2024	Washington-4E Pri.	20515	Foley
2025	Washington-Uptown	20516	Monroeville
2027	Washington-DuPont	20517	Atmore
2028	Mount Pleasant	20518	Dothan 2
2029	Washington-Southwest XBT	20522	Anniston
2032	New Haven 4T	2062	Seattle 4T Sect.
2034	Hartford No. 1 and 2	2063	Seattle 4E
2035	Hartford No. 3 4T	2064	Seattle XBT
2036	New Haven XBT	2065	Seattle-Mutual
2037	Bridgeport	2067	Tacoma
2038	Stamford	2068	Seattle 4T Pri.
2039	Waterbury	2069	Everett
20310	Meriden XBT	20610	Poulsbo 4P
20311	Danielson		
20312	Danbury ESS	2074	Portland XBT
20313	New London XBT	2075	Bangor
20314	Norwalk	2076	Lewiston
20315	Bridgeport 4A	2077	Portland 4T
20316	Manchester ESS	20710	North Anson
20317	Torrington ESS		
20318	Meriden 1E	2084	Boise

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS
WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
2085	Twin Falls	21232	Kings No. 1 and 2
2086	Pocatello	21233	Forest Hills No. 1 and 2
2087	Idaho Falls	21235	Queens No. 1
2088	Salmon	21236	Jamaica
2089	McCall	21237	Richmond Hill No. 1
20810	Lewiston	21238	Richmond Hill No. 2
20811	Coeur D' Alene	21239	Staten Island
20812	Moscow	21242	Chelsea No. 1 and 2
		21243	Tenth Ave. No. 3
2092	Stockton No. 4T	21244	Lexington
2094	Fresno XBT	21245	Varick 4T
2095	Modesto	21246	Queens No. 2
2096	Fresno 4T	21247	West St. 6
2097	Reedly	21248	East 97th St.
2098	Stockton XBT	21249	New York No. 6
2099	Fresno ESS 1	21250	Williamsburg
		21251	New York 12
2122	New York No. 4	21252	Broadway No. 24
2123	New York No. 7	21253	Borough No. 4
2124	West St. No. 4		
2125	West St. No. 5-TSP	2132	Los Angeles No. 2
2126	Vesey No. 1	2134	Los Angeles No. 3
2127	Vesey No. 2	2135	Los Angeles 01 TSPS
2128	Vesey No. 3	2136	Gardena No. 2
2129	Borough No. 3	2137	Gardena TSPS
21210	New York No. 10 4T	21310	El Monte
21211	Tenth Ave. No. 1	21315	Sherman Oaks No. 2 4T
21212	New York No. 11 4T	21316	Sherman Oaks 02 TSPS
21213	Gotham No. 8	21331	Gardena No. 3
21214	Gotham No. 9	21340	Long Beach
21215	Interzone	21341	Santa Monica
21216	Brooklyn 4T	21373	Sherman Oaks No. 3 4T
21217	York No. 1	21374	Sherman Oaks 03 TSPS
21218	York No. 2		
21219	Amsterdam No. 1 and 2	2141	Dallas 4 ESS
21220	Broadway No. 2	2142	Dallas 4T Sect.
21221	Midtown No. 1 and 2	2144	Greenville
21222	Tenth Ave. No. 2	2145	Longview
21223	East 97th St. No. 5	2146	Athens
21224	Bronx No. 1 and TSP		
21226	Tremont No. 1 and 2	2151	Wayne
21228	Albermarle No. 1 and Brooklyn	2152	Philadelphia No. 2
21229	Albermarle No. 2-TSP	2153	Philadelphia 4 ESS
21231	Bushwick No. 1 and 2	2154	Philadelphia-East A

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
2155	Philadelphia-East B	2184	Virginia
2156	Philadelphia-North A	2185	Wadena
2157	Philadelphia-North B		
2159	Tullytown	2192	South Bend 4T
21510	Reading	2194	South Bend XBT
21511	Allentown	2195	Fort Wayne
21512	Fort Washington		
21513	Easton	3012	Baltimore No. 2 4T
21514	Philadelphia No. 3 4T	3014	Baltimore TDM 3
21515	West Chester	3015	Silver Spring-Toll
21516	Lansdale	3016	Baltimore TDM 6
21517	Pottstown	3017	Baltimore TDM 7
		3018	Hyattsville
2162	Cleveland 4T Sect.	3019	Baltimore No. 9 4T
2163	Cleveland 4E Sect.	30110	Silver Spring-Local
2164	Cleveland-Clearwater No. 1	30112	Bel Air
2165	Cleveland-Garfield	30113	Salisbury
2166	Cleveland-Henderson No. 1		
2167	Cleveland-Henderson No. 2	3025	Dover
2168	Akron XBT	3027	Wilmington No. 4
2169	Canton XBT		
21610	Youngstown XBT	3031	Denver 4T Reg.
21611	Cleveland-Clearwater No. 2	3032	Denver 4T Sect.
21612	Ashtabula	3033	Denver 5 4 ESS
21613	Geneva	3034	Grand Junction
21614	Elyria	3035	Pueblo
21615	Cleveland 4T Pri.	3036	Denver No. 4 ZUNI
21616	Akron 4T	3037	Colorado Springs
21617	Warren	3038	Boulder
21618	Jefferson	3039	Ft. Collins
21619	Wooster	30310	Greeley
21620	Oberlin	30311	Sterling
21621	Youngstown 4A		
21622	Lorain	3042	Charleston
21623	Medina	3044	Clarksburg
21624	Minerva	3045	Wheeling
21625	New Philadelphia	3046	Bluefield
		3047	Elkins
2172	Springfield	3048	Fairmont
2174	Champaign 4T	3049	Lewisburg
2175	Decatur	30410	Logan
2176	Champaign XBT	30411	Weirton
		30412	Huntington
2183	Duluth	30414	Morgantown

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
30415	Parkersburg	3136	Detroit No. 2 4T
		3139	Flint
3052	Orlando	31310	Pontiac XBT
3054	Winter Park	31311	Plymouth 4T
3055	Miami 4T	31312	Pontiac 4T
3057	Fort Lauderdale	31313	Port Huron ESS
3058	West Palm Beach XBT	31314	Mt. Clemens ESS
3059	Ojus No. 1		
30510	West Palm Beach 4T	3141	St. Louis 4T Reg.
30511	Ojus No. 3	3142	St. Louis 4T Sect.
30512	Lake Buena Vista	3144	St. Louis TDM 1
30513	Winter Garden	3145	St. Louis TDM 2
		3146	St. Louis TSP
306	See TransCanada (Table W)	3147	Sikeston
		3148	St. Louis Kirkwood
3072	Cheyenne	3149	Jefferson City
3075	Casper	31410	Rolla
3076	Rock Springs	31411	Sullivan
3077	Sheridan	31412	Wentzville
3078	Worland	31413	Columbia
		31414	Mexico
3084	Grand Island	31415	Hannibal
3085	Sidney	31416	Poplar Bluff
		31417	Flat River
3094	Peoria 4T	31418	Cape Girardeau
3095	Peoria XBT	31419	Eldon
3096	Rock Island		
		3154	Syracuse
3122	Chicago No. 7 4 ESS	3155	Utica
3124	Chicago-Stewart No. 1 and 2	3156	Oswego
3126	Chicago-Wabash No. 1 and 2	3157	Seely T. C.
3127	Chicago-Franklin No. 1 and 2	3158	Newark
3129	Chicago-Bl. Plaine No. 1 and 2	3159	Geneva
31211	Chicago-Kedzie No. 1 and 2	31510	Watertown
31212	Oakbrook	31511	Potsdam
31213	Morton Grove	31512	Ogdensburg
31214	Northbrook No. 2 (4A)	31513	Fulton
31215	Chicago Canal/ESS Tandem		
31217	Northbrook ESS Tandem	3164	Wichita
31218	Chicago 8	3165	Hutchinson
		3166	Parsons
3132	Detroit No. 1 4T		
3134	Detroit-Cadillac-Woodward	3272	Indianapolis
3135	Detroit-University	3174	Kokomo

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS
WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
3184	Lafayette	40411	Augusta
3185	Shreveport	40412	Cartersville
3186	Alexandria	40413	Rome
3187	Lake Charles	40414	Athens
3188	Monroe	40415	Cornelia
3194	Davenport	4052	Oklahoma City 4A
3195	Waterloo	4053	Oklahoma City 4E
3196	Cedar Rapids	4054	Clinton
3197	Clinton	4055	Enid
		4056	Durant
4014	Providence TDM 1	4057	Lawton
4015	Providence TDM 2	4058	Kingfisher
4016	Providence 4T		
		4062	Billings
4022	Omaha	4064	Helena
4024	Lincoln	4065	Great Falls
4025	Hastings	4066	Livingston
4026	Nebraska City	4067	Kalispell
4027	Beatrice	4068	Missoula
4028	David City	4069	Shelby
4029	Auburn	40610	Havre
40210	Fairbury	40611	Butte
40211	Geneva	40612	Glasgow
40212	Hebron	40613	Miles City
40213	Seward	40614	Glendive
40214	Superior	40615	Kallispell
40215	Tecumseh		
40216	Wahoo	4082	San Jose 4T
40217	Tora	4084	San Jose XBT
40218	Aurora	4085	Salinas
40219	Falls City	4086	Santa Clara Metro
		4087	San Jose TSPS
403	See TransCanada (Table W)		
		4121	Pittsburgh Reg. 3 4E
4041	Rockdale	4122	Pittsburgh 4T Sect. 1
4042	Atlanta 4T Sect.	4124	Pittsburgh-TDM A
4043	Atlanta 4E	4125	Pittsburgh-TDM B
4044	Atlanta XBT	4126	Greensburg
4045	Columbus	4127	Charleroi
4046	Atlanta 4T Pri.	4128	McDonald
4047	Dalton	4129	Uniontown
4048	Tocca	41210	Washington
4049	Winder	41211	Newcastle

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS
WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
4132	Springfield	4196	Paulding
		4197	Lima
4143	Waukesha Sect.	4198	Defiance
4144	Milwaukee No. 2	4199	Napoleon
4146	Racine	41910	Van Wert
4147	Appletown	41911	Wauseon
4148	Oshkosh	41912	Stony Ridge
4149	Watertown	41913	Mansfield
41411	Milwaukee 4T Pri.	41914	Shelby
41421	Plymouth	41915	Bucyrus
41422	Green Bay	41916	Mount Gilead
41423	Berlin	41917	Findlay
41424	Fond du Lac	41918	Sandusky
41425	Sheboygan	41919	Tiffin
		5014	Little Rock
4152	Oakland 4T	5015	Fort Smith
4153	San Francisco 43T 4 ESS	5016	Fayetteville
4154	Oakland-Franklin	5017	Jonesboro
4155	Oakland-Franklin 1	5018	Pine Bluff
4156	Oakland No. 1		
4158	San Francisco-Bush 0 and 1	5022	Louisville
4159	Oakland Eastbay 4T	5024	Paducah
41510	San Francisco-Onon	5025	Madisonville
41511	San Francisco-Onon 1	5026	Elizabethtown
41512	San Rafael	5027	Campbellsville
41513	Concord	5028	Glasgow
41514	Palo Alto	5029	Frankfort
41515	San Francisco 41T		
41516	Redwood City	5032	Portland No. 1
41517	Hayward	5033	Portland No. 2 4 ESS
41518	San Francisco 42T	5034	Eugene
41519	Oakland TSPS	5035	Pendleton
41520	San Francisco TSPS	5036	Astoria
41521	Redwood City TSPS	5037	Bend
		5038	Roseburg
		5039	Klamath Falls
416	See TransCanada (Table W)	50310	Corvallis
		50311	Salem XB
4174	Springfield	50312	Newport
4175	Joplin	50313	Albany
		50314	Baker
418	See TransCanada (Table W)	50315	Medford
		50316	Merrill
4194	Toledo	50317	White City
4195	Kenton	50318	Redmond

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS
WITHIN THE UNITED STATES

IDENT. NO.	OFFICE
50319	Burns
50320	Hood River
50321	Sheridan
50322	Myrtle Creek
50323	Beaverton
50324	Hood River
50325	Sheridan
50326	Merrill
50327	Burn
50328	White City
50329	Redmond
50330	Lebanon
5042	New Orleans 4T
5043	New Orleans 4 ESS
5045	New Orleans XBT
5046	Baton Rouge
5047	Hammond
5048	Covington
5049	Houma
50410	Donaldsonville
5052	Albuquerque
5054	Roswell
5055	Alamagordo
5056	Clovis
5057	Demine
5058	Farmington
5059	Gallup
50510	Hobbs
50511	Las Cruces
50512	Las Vegas
50513	Raton
50514	Santa Fe
50515	Truth or Consequences
506	See TransCanada (Table W)
5074	Owatonna
5075	Windom
5094	Spokane
5095	Yakima
5096	Ellensburg
5097	Sunnyside
5122	San Antonio
5125	Harlingen
5126	Austin 4T
5127	Harlingen 4T
5128	Corpus Christi
5129	San Marcos
5132	Cincinnati 4T
5134	Dayton
5135	Cincinnati-St. Bernard
5136	Cincinnati-West 7th
5137	Batavia
5138	Sydney
5139	Greenville
51310	Belle Fontaine
51311	Lebanon
51312	Eaton
51318	Cincinnati TSPS
514	See TransCanada (Table W)
5152	Des Moines
5154	Mason City
5162	Suffolk
5163	Garden City 4E
5165	Hempstead No. 2
5166	Hempstead No. 3
5167	Hempstead No. 4
5168	Deer Park No. 1
5169	Deer Park No. 2
51610	Garden City 4T
5174	Lansing XBT
5175	Saginaw XBT
5176	Jackson
5177	Lansing 4T
5178	Saginaw 4T
5179	Alma 4T
51710	Adrian
5182	Albany 4T
5184	Albany XBT
5185	Plattsburg

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS
WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
5186	Champlain	6075	Binghamton 4T
5187	Glens Falls	6076	Hornell
		6077	Ithaca
519	See TransCanada (Table B)	6078	Oneonta
		6079	Sidney
6012	Jackson	60710	Dundee
6014	Tupelo	60711	Delhi
6015	Hattiesburg		
6016	Greenwood	6082	Madison No. 2
6017	McComb	6084	Janesville
6018	Meridian	6086	La Crosse
6019	Gulfport	6087	Dodgeville
60110	Columbus	6088	Mauston
60111	Grenada	6089	Madison No. 1
60112	Laurel		
60113	Biloxi	6092	Camden 4T
60114	Natchez	6094	Camden XBT
60115	Greenville	6095	Trenton
		6096	Atlantic City
6022	Phoenix 4T	6097	Hamilton Square
6024	Mesa 4A		
6025	Tucson	6122	Minneapolis
6026	Window Rock	6123	Minneapolis 4 ESS
		6125	St. Paul 4T
6034	Manchester No. 1	6126	St. Cloud
6035	Manchester No. 2	6127	Willmar
6036	Concord		
		613	See TransCanada (Table W)
		6144	Columbus 4T
604	See TransCanada (Table W)	6145	Columbus XBT
		6146	Mt. Vernon
6054	Sioux Falls	6147	Pataskala
6055	Rapid City	6148	Sunbury
		6149	Columbus 4E
6064	Danville		
6065	Winchester	6152	Nashville
6066	Paintsville	6154	Knoxville
6067	Lexington	6155	Chattanooga
6068	Ashland	6156	Cookeville
6069	Hazard	6157	Johnson City ETS
60610	Morehead	6158	Chattanooga ESS
60611	Somerset		
		6162	Grand Rapids 4T
6070	Norwich	6164	Kalamazoo XBT
6074	Binghamton XBT	6165	Kalamazoo 4T

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS
WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
6166	Grand Rapids XBT	7025	Las Vegas
6167	Traverse City	7026	Reno TSPS
6168	Muskegon 4A		
		7034	Leesburg
6172	Cambridge 18 (4 ESS)	7035	Roanoke
6173	Boston 4A (B9)	7036	Arlington-Toll TDM
6174	Newton	7037	Arlington-Local
6175	Boston-Franklin CAMA	7038	Roanoke 4A
61710	Dorchester	7039	Woodbridge
61713	Malden	70310	Arlington 4T
61715	Harrison	70311	Fredricksburg
61716	Kendall Square	70312	Winchester
61717	Boston Tandem 17	70313	Norton
61721	Brockton XBT	70314	Culpeper
61722	Brockton 4A	70315	Harrisonburg
61723	Fairhaven 4A	70316	Waynesboro
61724	Fall River	70317	Edinburg
61725	Framingham XBT No. 1	70318	Covington
61726	Framingham XBT No. 2		
61727	Framingham 4A	7042	Charlotte
61728	Lawrence XBT	7043	Charlotte 4 ESS
61729	Lawrence 4A	7044	Asheville
61730	Worcester XBT	7045	Gastonia
61731	Worcester 4A	7046	Hickory
61743	MET TDM No. 3	7047	Concord
		7048	Marshville
6182	Collinsville	7049	Sylva
6184	Olney	70410	Morganton
6185	Marion	70411	Salisbury
6186	Alton	705	See TransCanada (Table W)
6187	Centralia		
		7072	Santa Rosa No. 4
7012	Fargo 4A	7074	Santa Rosa XBT
7014	Bismarck	7075	Eureka
7015	Grand Forks		
7016	Grafton	709	See TransCanada (Table W)
7017	Fargo 1E		
7018	Jamestown	7124	Sioux City
7019	Dickinson		
70110	Williston	7132	Houston No. 1
		7133	Houston 4E
7022	Reno 4T Sect.	7134	Galveston
7024	Reno XBT Pri.	7135	Beaumont

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
7136	Houston No. 2	7178	Hazelton
7137	Houston No. 3	7179	York
7138	Beaumont 1E	71710	Scranton ESS
7139	Nacogdoches	71711	Harrisburg ESS
71310	Huntsville	71712	Wilkes-Barre ESS
71311	Richmond	71713	Scranton 1A ESS
		71720	Stroudsburg
7141	San Bernardino		
7142	Anaheim 28T	8012	Salt Lake City
7143	San Diego 4E	8014	Provo
7144	Anaheim XBT		
7146	Oceanside	8024	White River Junction 1A ESS
7147	Anaheim 77T	8025	Burlington
7148	Ontario 91T	8026	Rutland
7149	Anaheim 01 TSPS		
71410	Anaheim 02 TSPS	8032	Columbia
71411	San Diego 02 TSPS	8034	Greenville
		8035	Charleston
7152	Eau Claire	8036	Florence
7154	Stevens Point	8037	Rock Hill
7155	Marshfield	8038	Orangeburg
7156	Rice Lake	8039	Myrtle Beach
7157	Wausau	80310	Spartanburg
7158	Hudson	80311	Greenwood
7159	Ashland	80312	Sumter
71510	Superior	80313	Lancaster
71511	Rhinelander		
		8042	Richmond 4A
		8043	Richmond 4E
7164	Buffalo 4T	8044	Norfolk XBT
7165	Buffalo-Erie	8045	Danville
7166	Buffalo-Frontier	8046	Emporia
7167	Batavia	8047	Onancock
7168	Olean	8048	Norfolk 4T
7169	Dunkirk	8049	Lynchburg
71610	Rochester	80410	Chase City
71611	Geneseo	80411	Warsaw
71612	Jamestown	80412	Charlottesville
71613	Holcomb		
		8054	Bakersfield
7172	Harrisburg 4A	8055	San Luis Obispo
7174	Scranton 4A	8056	Newhall
7175	Williamsport		
7176	Wilkes-Barre XBT	8062	Amarillo XBT
7177	Lancaster	8064	Amarillo 1 ESS

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
8066	Lubbock 1 ESS	8172	Fort Worth 4A
		8173	Fort Worth 4E
807	See TransCanada (Table W)	8174	Waco
		8175	Wichita Falls
8084	Honolulu	8176	Killeen
		8177	Stephenville
8122	Bloomington	8178	Temple
8124	Evansville	8179	Cisco
		81710	Decatur
8134	Tampa No. 2		
8135	Fort Myers	819	See TransCanada (Table W)
8136	Sarasota		
8137	Winter Haven 4E	9012	Memphis
8139	St. Petersburg		
8130	Clearwater	902	See TransCanada (Table W)
81310	Avon Park		
81311	Tampa No. 3	9042	Jacksonville
81312	Naples	9043	Jacksonville 4 ESS
		9044	Leesburg
8144	Altoona	9045	Tallahassee
8145	Erie	9046	Pensacola
8146	Warren	9047	Gainesville
8147	State College	9048	Chipley
8148	Dubois	9049	Fort Walton Beach
		90410	Crestview
8151	Norway	90411	Panama City
8154	Rockford	90412	Ocala
		90413	Live Oak
8162	Kansas City 4E	90414	Daytona Beach
8166	St. Joseph	90415	Quincy
8167	Warrensburg	90416	Marianna
8168	Oak Grove	90417	Port St. Joe
8169	Harrisonville		
81610	Clinton	9064	Sault St. Marie
81611	Maryville		
81612	Lexington	9074	Anchorage
81613	Higginsville	9075	Fairbanks
81614	Milan	9076	Juneau
81615	Cameron	9077	Ketchikan
81616	Chillicothe	9078	Dead Horse
81617	Moberly	9079	Anchorage No. 2
81618	Kirksville		
81619	Sedalia	9122	Macon

TABLE V (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS WITHIN THE UNITED STATES

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
9124	Moultrie	91414	Walden
9125	Milledgeville	91415	Middletown
9127	Fitzgerald		
9128	Dawson	9152	Sweetwater
9129	Thomasville	9154	El Paso
91210	Waycross	9155	Abilene
91211	Savannah ESS	9156	Midland
91212	Hawkinsville		
91213	Millen	9161	Sacramento 4T
91214	Bainbridge	9164	Sacramento XBT
91215	Brunswick	9165	Reading
91216	Dublin	9166	Chico
91217	Valdosta	9167	Sacramento TSPS
91218	Albany	9168	Sacramento 4E
9134	Salina	9184	Tulsa
9135	Mission		
9136	Hays	9192	Greensboro
9137	Topeka	9194	Winston-Salem
		9195	Raleigh
9141	White Plains 4T Reg.	9196	Laurinburg
9144	White Plains XBT	9197	Fayetteville
9145	Mount Vernon No. 1	9198	Durham
9146	Nyack	9199	Rocky Mount
9147	Mount Kisco	91910	Wilmington
9148	Poughkeepsie	91911	Elkin
9149	Monticello-TSP	91912	Mount Airy
91410	Mount Vernon No. 2	91913	Asheboro
91411	White Plains 4T Pri.	91914	Durham EAX
91412	Reinbeck	91915	High Point
91413	Monroe	91916	Goldsboro

TABLE W

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS WITHIN THE TRANSCANADA TELEPHONE SYSTEM

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
2042	Winnipeg 4ACT	41812	Montmagny
2044	Brandon SP1-4W	41813	Rimouski No. 2 SP1-4W
		41814	St. Felicien
3061	Regina No. 2 SP1-4W	41815	St. Marie de Beauce
3062	Regina No. 1 XBT	41816	Riviere du Loup
3064	Saskatoon SP1-4W	41817	Thetford Mines
3065	Moose Jaw	41818	Alma
3066	Prince Albert	41819	New Carlisle
3067	Yorkton	41820	Cap Aux Meules
4032	Calgary No. 2 SP1-4W	5062	Saint John
4034	Drumheller	50610	Moncton
4035	Edmonton No. 1	50611	Newcastle
4036	Edmonton No. 2 TOPS		
4038	Medicine Hat	5141	Montreal No. 1 4AETS
4039	Grande Prairie	5144	Montreal No. 2 XBT
40310	Calgary No. 1 XBT	5145	Montreal No. 3 SP1-4W
40311	Lethbridge SP1-4W	5146	Montreal No. 4 SP1-4W
40313	Peace River	51410	Joliette
40314	Red Deer	51411	St. Jerome
40315	Edson	51412	Valleyfield
40317	Vegreville	51413	Granby
40318	Camrose	51414	St. Jean
40320	Hay River	51415	Sorel
40321	Inuvik	51416	St. Hyacinthe SP1-4W
40322	Whitehorse		
		5194	London No. 1
4162	Toronto No. 1 4ACT	5195	Kitchener
4164	Toronto No. 2 XBT	5196	Windsor
4165	Hamilton	5197	London No. 2 SP1-4W
4166	Toronto No. 3 4AETS	51910	Brantford
4167	Toronto No. 4 SP1-4W	51911	Chatham
4168	Hamilton No. 2 SP1-4W	51912	Guelph
41610	Brampton	51913	Orangeville
41611	Fort Erie	51914	Owen Sound
41612	Markham	51915	Sarina
41614	St. Catharines SP1-4W	51916	Simcoe
41615	Newmarket	51917	Stratford
41616	Niagara Falls	51918	St. Thomas
41617	Welland	51919	Walkerton
41618	Port Hope	51920	Woodstock
41619	Oshawa SP1-4W	51921	Tillsonburg
		51922	Clinton
4182	Quebec No. 2 SP1-4W		
4184	Quebec No. 1 XBT	6042	Vancouver No. 2 4AETS
41810	Chicoutimi	6044	Abbotsford
41811	Donnacona	6046	Gibsons

TABLE W (Contd)

IDENTIFICATION CODES FOR RECORDED ANNOUNCEMENTS WITHIN THE TRANSCANADA TELEPHONE SYSTEM

IDENT. NO.	OFFICE	IDENT. NO.	OFFICE
6048	New Westminster	7055	Sudbury
6049	Squamish	7056	North Bay
60410	Kamloops	7057	St. Ste. Marie
60413	Cranbrook	70511	Peterborough
60414	Grand Forks	70513	Chapleau
60417	Nakusp	70514	Parry Sound
60418	Nelson	70515	Orillia
60420	Trail	70516	Bracebridge
60421	Williams Lake	70517	Midland
60422	Victoria	70518	Lindsay
60423	Alert Bay	70519	New Liskeard
60424	Campbell River	70520	Timmins
60426	Duncan		
60427	Nanaimo	7092	Corner Brook SP1-4W
60428	Port Alberni	7094	St. John SP1-4W
60429	Powell River	7095	Grand Falls
60430	Prince George	7096	Bay Roberts
60432	Dawson Creek	7097	Marystown
60433	Prince Rupert	7098	Stephenville Crossing
60434	Fort Nelson		
60436	Terrace	8074	Thunder Bay SP1-4W
60437	Vancouver No. 1 FW1	80710	Geraldton
60441	Vernon	80711	Marathon
60442	Kelowna	80712	Dryden
60443	Penticton	80713	Fort Frances
6134	Ottawa No. 1 XBT	8194	Sherbrooke
6135	Ottawa No. 2 4AETS	81910	Drummondville
61310	Brockville	81911	Lac Megantic
61311	Cornwall	81912	Mount Laurier
61312	Kingston	81913	St. Agathe
61313	Smiths Falls	81914	Trois Rivieres
61314	Belleville	81915	Victoriaville
61315	Pembroke		
61316	Renfrew	9024	Halifax No. 1 4ACT
		9025	Charlottetown SP1-4W
7054	Barrie	9026	Kentville SP1-4W

CONDITION ENCOUNTERED	RECOMMENDED TREATMENT	RECOMMENDED ANNOUNCEMENT
NORMAL		
Signal to Start Dialing	Dial Tone	—
Connected to Called Line or to Operator Trunk	Audible Ringing Tone	—
Line Busy	60-IPM Tone	—
ALL TRUNKS BUSY		
Local	120 IPM Tone	—
Toll Connecting	Announcement N	We're sorry, all circuits are busy now. Will you please try your call again later. This is a recording. (Pause) (Location Code)
Intertoll		
Normal	Announcement N	We're sorry, all circuits are busy now. Will you please try your call again later. This is a recording. (Pause) (Location Code)
Disaster — RSS (Remote Switching System). Standalone Operation	Announcement X	(With flexibility due to situation) We're sorry (storm, flood, tornadoes, etc), damage in (or near) (city) has blocked your call. Emergency calls may be placed through your operator. This is a recording. (Pause) (Location Code)
SWITCHING BLOCKAGE OR COMMON CONTROL EQUIPMENT IRREGULARITY		
Local		
Switching Blockage or Equipment Irregularity	120-IPM Tone	—
No Dial Tone Situations	Announcement O	We're sorry, due to heavy calling, we cannot complete your call at this time. Will you please hang up and try your call later. If your call is urgent, please try again now. This is a recording.
Sender or Transmitter Overload	Announcement N	We're sorry, all circuits are busy now. Will you please try your call again later. This is a recording. (Pause) (Location Code)
Toll		
ESS and Common Control Systems		
Switching Path Busy	Announcement P	We're sorry, your call did not go through. Will you please hang up and try your call again. This is a recording. (Pause) (Location Code)
Sender or Transmitter Overload	Announcement N	We're sorry, all circuits are busy now. Will you please try your call again later. This is a recording (Pause) (Location Code)
Step-by-Step Systems Switching Path Busy	120-IPM Tone	—

Fig. 42—Recommended Tones and Announcements

CONDITION ENCOUNTERED	RECOMMENDED TREATMENT	RECOMMENDED ANNOUNCEMENT
NETWORK MANAGEMENT CONTROL	Announcement N	We're sorry, all circuits are busy now. Will you please try your call again later. This is a recording. (Pause) (Location Code)
	or	
WORK STOPPAGE	Announcement X	We're sorry (storm, flood, tornadoes, etc), damage in (or near) (city) has blocked your call. Emergency calls may be placed through your operator. This is a recording. (Pause) (Location Code)
MISDIALING	Work Stoppage Announcement	We're sorry, because of a work stoppage, the operator will be delayed in helping you. If your call is urgent, stay on the line and the operator will answer as soon as possible. This is a recording.
Access Code Dialed in Error	Access Code Dialed in Error Announcement	We're sorry, it is not necessary to dial a "1" (or "0") when calling this number. Will you please hang up and try your call again. This is a recording.
Access Code Not Dialed	Access Code Not Dialed Announcement	We're sorry, you must first dial a "1" (or "0") when calling this number. Will you please hang up and try your call again. This is a recording.
Vacant Code	Announcement L	We're sorry, your call cannot be completed as dialed. Please check the number and dial again or call your operator to help you. This is a recording. (Pause) (Location Code)
Unauthorized CAMA (UCA) ("1" or "0" Plus Unauthorized Code)	Announcement L	We're sorry, your call cannot be completed as dialed. Please check the number and dial again or call your operator to help you. This is a recording. (Pause) (Location Code)
Misrouted Non-CAMA (MCA) ("1" or "0" Plus Local Code)	Access Code Dialed in Error Announcement	We're sorry, it is not necessary to dial a "1" (or "0") when calling this number. Will you please hang up and try your call again. This is a recording.
Partial (Insufficient) Digits	Announcement P	We're sorry, your call did not go through. Will you please hang up and try your call again. This is a recording. (Pause) (Location Code)
NUMBERS INTERCEPTED		
Vacant or Disconnected Numbers (Includes Vacant Thousands and Hundreds)	Vacant — Disconnect Number Announcement	*Direct Operator Intercept Trunks Not Provided:* We're sorry, you have reached a number that has been disconnected or is no longer in service. If you feel you have reached this recording in error, please check the number or try your call again. *Direct Operator Intercept Trunk Provided:* We're sorry, you have reached a number that has been disconnected or is no longer in service. Please check the number and dial again, or stay on the line and an operator will answer you.

Fig. 42—Recommended Tones and Announcements (Contd)

CONDITION ENCOUNTERED	RECOMMENDED TREATMENT	RECOMMENDED ANNOUNCEMENT
Centrex Nonworking Stations	Centrex Nonworking Station Announcement	We're sorry, the number you have reached is not in service. If you are calling the (ABC Company), please dial (XXX-XXXX). If you need help, dial your operator. This is a recording.
Intra-Centrex Calls for Unassigned Numbers or Restricted Codes	Common Centrex Announcement	We're sorry, your call cannot be completed as dialed. Please check the number and dial again, or call your attendant to help you. This is a recording.
PBX Service Converted Centrex	Centrex Number Change Announcement	Telephone numbers at the (ABC Company) have been changed. For their new numbers, please dial (XXX-XXXX). This is a recording.
RECEIVER OFF-HOOK	ROH Announcement	If you'd like to make a call, please hang up and try again. If you need help, hang up and then dial your operator. This is a recording.
INITIAL COIN DEPOSIT MADE	Dial Tone First Announcement	The call you have made requires a 10-cent (initial rate) deposit. Please hang up momentarily, listen for dial tone, deposit 10 cents (initial rate), and dial your call again. This is a recording.
CUSTOM CALLING FEATURE	Custom Calling Announcement	We're sorry, your call cannot be completed as dialed. Please check your instruction manual or call the (Business Office or Repair Service) for assistance. This is a recording.
TSPS		
Queue Entrance Allowed	Float Announcement X	Due to (the emergency condition), all operators are busy now. If you will stay on the line, an operator will answer as soon as possible.
Queue Entrance Not Desired	Block Announcement X	Due to (the emergency condition), we are able to complete only emergency calls. If your call is an emergency, please dial your operator. Otherwise, please try your call later.
Queue Entrance Not Allowed by Design	Announcement P	We're sorry, your call did not go through. Please hang up and try your call again.

Fig. 42—Recommended Tones and Announcements (Contd)

TOUCH-TONE SERVICE

12.35 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.

12.36 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	A
	770	4	5	6	B
	852	7	8	9	C
	941	*	0	#	D

Note: The * and # symbols are for new services. At present, the # is an optional end-of-dialing signal on IDDD calls to avoid timing when address lengths are variable. The new standard for custom calling services uses the format *XX(X) as customer input to the central office.

A. Requirements for a TOUCH-TONE Central Office Receiver

12.37 The requirements for the TOUCH-TONE central office receiver are as follows:

- Registration of TOUCH-TONE signals:

(a) TOUCH-TONE receiver checks that two of the tones are present and that one is from each group of four.

(b) The receiver should register the digit if the frequencies are within ±1.5 percent of their nominal values, but not register the digit if the deviation of either frequency is greater than ±3.5 percent.

(c) The receiver should register TOUCH-TONE digits as short as 40 milliseconds and should recognize interdigital intervals as short as 40 milliseconds. The shortest cycle time (tone-on plus tone-off interval) which must be accepted is 93 milliseconds. Digits less than 23 milliseconds in duration should be rejected.

(d) The receiver should register TOUCH-TONE digits with a power per frequency of -25 to 0 dBm and with the high-frequency tone power of +4 to -8 dB relative to that of the low-frequency tone as measured with a 900-ohm termination bridged across the receiver.

Note: The overload level value of 0 dBm assumes a termination of 900 ohms. In electronic and step-by-step switching offices, the termination is 900 ohms. However, in the crossbar offices, the TOUCH-TONE receiver is bridged across a dial pulse receiver which is not a 900-ohm termination but a much higher impedance. This raises the effective voltage level of the signal at the TOUCH-TONE receiver. As a result, a receiver in a crossbar office must operate with up to 2 volts per frequency.

(e) TOUCH-TONE digits should be registered in the presence of central office precise dial tone (paragraph 11.03). The level of the dial tone is nominally -10 dBm (-13 dBm per frequency) at the point of application when a 900-ohm test termination is substituted for the customer line. However, under extreme service conditions involving critical loop lengths, the dial tone level can be as high as an equivalent of a 0-dBm total for the two frequencies as measured with a 900-ohm termination bridged across the receiver.

(f) Low-level TOUCH-TONE digits should be registered with a low error rate in the presence of Gaussian noise. Details of this test are as follows:

(1) Error rate should be less than one error in 10,000 pulses with a TOUCH-TONE pulsing rate of 10 PPS with a 50-millisecond tone-on and a 50-millisecond interdigital interval. All TOUCH-TONE digits should be incorporated in the sequence of pulses.

(2) Each TOUCH-TONE frequency should be at nominal value and at a level of -20 dBm

into a 600-ohm test termination. The method of measuring the tone levels is shown in Fig. 43.

(3) The noise source for the tests is shown in Fig. 44. The noise generator produces 0- to 3-kHz band limited Gaussian noise at a level of -35 dBm (55 dBrn or 53 dBrnC) as measured in a 600-ohm test termination.

(4) The test TOUCH-TONE receiver is connected to the digit and noise sources as shown in Fig. 45. This arrangement effectively places the TOUCH-TONE receiver across a 600-ohm test termination during the test.

(g) Low-level TOUCH-TONE digits should be registered with a low error rate in the presence of impulse noise. Details of the test are as follows:

(1) The TOUCH-TONE pulsing rate should be 10 PPS with a 50-millisecond tone-on time and a 50-millisecond interdigital interval. All TOUCH-TONE digits should be incorporated in the sequences of pulses.

(2) Each TOUCH-TONE frequency should be at nominal value and at a level of -20 dBm into a 600-ohm test termination. The method of measuring the tone levels is shown in Fig. 43.

(3) The impulse noise source for the tests should be the 201 noise tape (Note 1) shown in Fig. 46. With the noise level adjusted to 90 dBrnC (Note 2), there should be no more than 14 errors in 10,000 pulses (16.7 minutes).

Note 1: 201 noise tape available from AT&T, Director—Purchased Products, 295 North Maple Avenue, Basking Ridge, New Jersey 07920.

Note 2: Defined as 15 peaks exceeding 90 dBrnC in 15 minutes.

(4) The test TOUCH-TONE receiver is connected to the digit and noise sources as shown in Fig. 47. This arrangement effectively places the TOUCH-TONE receiver across a 600-ohm termination during the test.

(h) Double-digit registration of a single TOUCH-TONE digit should not occur often in the presence of impulse noise. Details of this test are as follows:

(1) The TOUCH-TONE pulsing rate should be 4 PPS with a 180-millisecond tone-on time and 70-millisecond interdigital interval. All TOUCH-TONE digits should be incorporated in the sequence of pulses.

(2) Each TOUCH-TONE frequency should be at nominal value and at a level of -20 dBm into a 600-ohm test termination. The method of measuring the tone levels is shown in Fig. 43.

(3) The impulse noise source for the tests is shown in Fig. 46. With the noise level adjusted to 90 dBrnC, there should be no more than 14 errors in 10,000 pulses (16.7 minutes).

(4) The test TOUCH-TONE receiver is connected to the digit and noise sources as shown in Fig. 47. This arrangement effectively places the TOUCH-TONE receiver across a 600-ohm termination during the test.

(i) TOUCH-TONE digits should be accurately registered in the presence of signal echoes which are delayed up to 20 milliseconds and reduced in level by at least 10 dB with respect to the incident signal.

(j) The average rate of digit simulation by speech, room noise, etc, prior to TOUCH-TONE signaling and during interdigital intervals, should be less than one occurrence in 3000 calls for digits 0 through 9, one occurrence in 2000 calls for digits 0 through 9 plus * and #, and one occurrence in 1500 calls for all 16 combinations.

(k) The minimum input impedance for the TOUCH-TONE receiver over the TOUCH-TONE signaling frequency range is 40,000 ohms.

(1) The minimum longitudinal balance for a TOUCH-TONE receiver is 50 dB.

• TOUCH-TONE receiver test circuit:

(a) The low-level test for electromechanical offices is -19 dBm ±1 dB per tone delivered to a 900-ohm test termination that replaces the subscriber register and TOUCH-TONE receiver.

(b) The low-level test for electronic offices is -22 dBm ±1 dB level per tone. The TOUCH-TONE is bridged across a 900-ohm resistive termination.

B. Requirements for a TOUCH-TONE Station Test Receiver

(a) The station test receiver should have an input impedance identical to, and be bridged across the loop termination at the same point as, the service receiver of the particular central office involved.

(b) The edge-band frequencies of the test receiver should be centered at ±1.5 percent of the nominal TOUCH-TONE frequency and held to a tolerance of ±0.2 percent.

(c) The effective sensitivity should be 1 ±1 dB more restrictive than the service receiver and should tolerate the same range of twist as the service receiver; ie, the test receiver should tolerate a difference in the high-frequency level with respect to the low-frequency level of +4 to -8 dB.

(d) The limiting pulsing speed and pulse duration of pulses that will be accepted by a test receiver when working in conjunction with a speed test circuit for TOUCH-TONE automatic dialers are as follows:

(1) Signals of greater than or equal to 48 milliseconds should be accepted and signals of less than 43 milliseconds in duration should be rejected.

(2) Interpulse intervals of greater than or equal to 45 milliseconds should be accepted and intervals of less than 40 milliseconds in duration should be rejected.

(3) Cycle time of greater than or equal to 97 milliseconds should be accepted and cycle times of less than 93 milliseconds should be rejected.

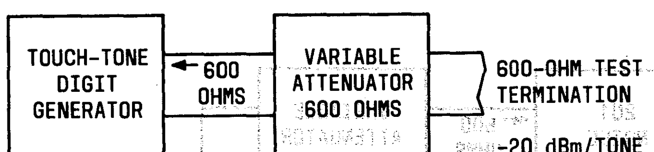


Fig. 43—TOUCH-TONE Digit Source

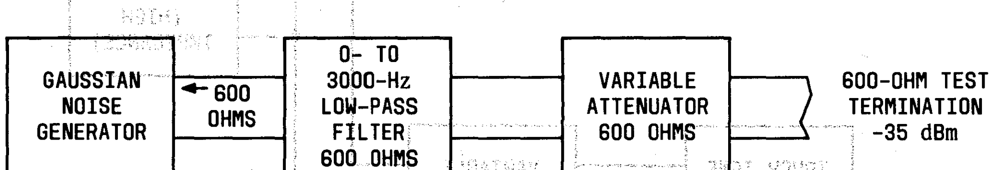


Fig. 44—Gaussian Noise Source

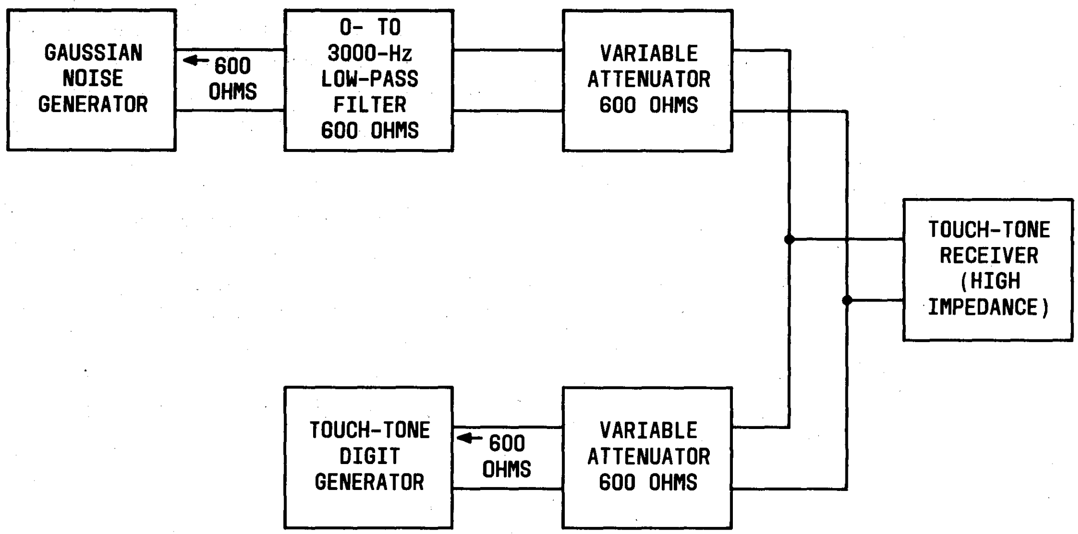


Fig. 45—Gaussian Noise Test of TOUCH-TONE Receiver

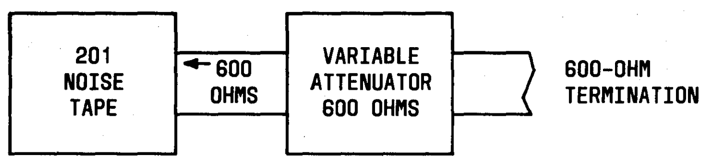


Fig. 46—Impulse Noise Source

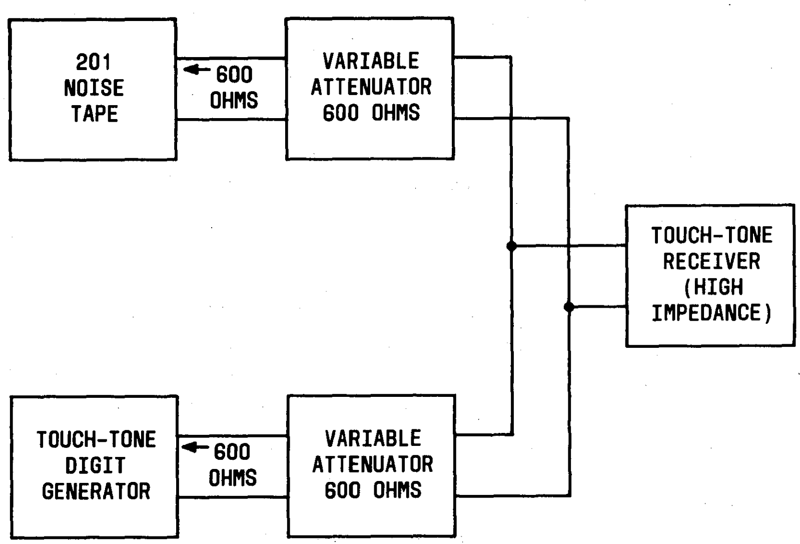


Fig. 47—Impulse Noise Test TOUCH-TONE Receiver

C. TOUCH-TONE—No. 1/1A ESS (Receiver and Transmitter)

12.38 Some TOUCH-TONE receivers, like those used in the No. 1/1A ESS, will interpret the TOUCH-TONE digit # (pound sign) as an end of dialing signal. The No. 1/1A ESS pound sign can be used to eliminate a time-out when a variable number of digits can be expected. However, other TOUCH-TONE receivers, like those used in No. 5 crossbar, will route a call to reorder if a pound sign is received while the TOUCH-TONE receiver is attached.

12.39 The No. 1/1A ESS can provide a TOUCH-TONE transmitter for outpulsing to a PBX, centrex, or other location. The transmitter always connects to a No. 1/1A ESS trunk circuit which has either line or trunk functions. A trunk circuit with line functions is used when a line is the connecting circuit at the distant end and a trunk circuit with trunk functions is used when a trunk is the connecting circuit at the distant end. The requirements for the transmitter are as follows:

(a) The tone level is -7 dBm0 ±0.5 dB per frequency.

(b) The frequency tolerance of individual frequencies is ±1.5 percent.

(c) When a TOUCH-TONE digit is being sent, the total extraneous frequency components should be at least 30 dB below the level of either of the two signal frequencies when measured over a 3KC band.

(d) The tone leakage limit when no TOUCH-TONE digit is being sent is -58 dBm0.

(e) The TOUCH-TONE transmitter is arranged to apply both tones comprising the TOUCH-TONE digit to the trunk or line simultaneously and neither tone is transmitted if either tone source should fail.

(f) The digital and interdigital interval is 50 ±0.5 milliseconds.

(g) The transmitter operates wink-start or delay-dial expected to trunks.

(h) The transmitter operates ground-start to lines.

(i) There is no option to operate dial tone start to either lines or trunks.

(j) In TOUCH-TONE signaling, there are no equivalents of the KP and ST signals used in MF pulsing.

12.40 In addition to the TOUCH-TONE transmitter, a new TOUCH-TONE receiver has been added to the No. 1/1A ESS. Like the TOUCH-TONE transmitter, the new TOUCH-TONE receiver connects only to No. 1/1A ESS trunk circuits. Unlike the TOUCH-TONE transmitter, the TOUCH-TONE receiver connects only to trunk circuits that have trunk functions. The characteristics of the new TOUCH-TONE receiver are as follows:

(a) The receiver meets the requirements given in paragraph 12.37.

(b) Both common control or manual TOUCH-TONE outpulsing is received.

(c) The receiver will provide either dial tone or a wink-start signal to the connected trunk when ready to receive information. However, a given trunk cannot send both dial tone and a wink-start signal.

12.41 The older No. 1/1A ESS TOUCH-TONE receiver connects only to lines. It only provides dial tone start (no arrangement for wink-start or delay-dial operation).

D. End-to-End TOUCH-TONE Signaling

12.42 There are several barriers to end-to-end TOUCH-TONE signaling. First, some switching systems reverse the polarity on the line during the call. This can disable the TOUCH-TONE pad. Second, to permit proper coin totalizer operation and to prevent fraud in many single slot coin telephone situations, the normal negative battery supply from the local central office is replaced with a positive battery supply. This disables the TOUCH-TONE pad. Third, echo suppressors can attenuate the TOUCH-TONE signals enough to cause signaling failures if dial tone start is used.

12.43 To enable TOUCH-TONE signaling in a telephone attached to a switching system that changes line polarity during a call, a polarity guard can be applied to the telephone. This provides proper polarity to the telephone regardless of the line polarity.

12.44 Enabling TOUCH-TONE signaling in single slot coin telephones has many ramifications which are discussed in more detail in a Technical Advisory to be issued. Briefly, complete TOUCH-TONE signaling enablement in Bell System switching systems, while preserving proper coin totalizer operation and fraud prevention, requires either (1) a polarity guard in the coin station and Automatic Coin Telephone System features in the TSPS or (2) dial-tone-first features in the class 5 switching systems and auto bill calling features in the TSPS. Dial-tone-first is covered in Section 4. Auto bill calling is covered in Technical Advisory No. 62.

12.45 When TOUCH-TONE signaling is transmitted over facilities using echo suppressors and dial tone is sent from the incoming switching system, there is some risk that the first TOUCH-TONE signal will be attenuated over the entire TOUCH-TONE digit or over the first portion of the digit as follows:

The attenuation varies from zero loss to complete blockage of tone depending on the relative TOUCH-TONE and dial tone levels at the echo suppressor location. Under adverse conditions, typical loss for a split 4A echo suppressor is 6 dB. The echo suppressor terminal used in the No. 4 ESS introduced 11 dB of loss in a field situation (using split operation).

In many of these unfavorable circumstances, the attenuation will occur over only the first portion of the pulse. The attenuated portion of the pulse can be as long as 64 milliseconds.

12.46 There is no guarantee that end-to-end TOUCH-TONE signaling with dial tone present will always work over facilities using echo suppressors. The present echo suppressors will remain in service for many years.

12.47 One solution is to use TOUCH-TONE to dial pulse converters when pulsing over facilities using echo suppressors and dial tone must be used as a start signal. In situations where the dial tone can be reduced in level or eliminated (by using a zip tone or an announcement), link-by-link or end-to-end TOUCH-TONE signaling can be successfully sent over facilities containing echo suppressors.

13. SENDER AND REGISTER TIMING AND EFFECT ON SIGNALING

13.01 The senders and registers used in toll 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 reorder and release.

13.02 The requirements for digit pulsing which result from digit registration timing are given for the various switching systems in Fig. 48. 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 Fig. 48, some of the intervals are automatically reduced during periods of heavy traffic in order to conserve common control equipment.

13.03 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 Fig. 3. 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.

	4A AND 4M			4A AND 4M CAMA		CROSSBAR TANDEM (INCL CAMA)		NO. 5 CROSSBAR (INCL CAMA)		STEP-BY-STEP CAMA		NO. 1 ESS		OBJECTIVE FOR NEW SYSTEMS	
	DP SENDER	DP REG	MF	DP	MF	DP ‡	MF	DP	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¶		16-24	5-10
Each digit must be received within _____ seconds after previous digit.														16-24	5-10
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¶		20- 30††
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.

‡ Includes both 3- and 10-digit register operation.

§ Assumes discontinuation of timing for stations digit.

¶ Under overload conditions.

**Centrex (1XX and 0XX) only.

††Optional.

Fig. 48—Digit Timing Requirements (Minimums)

NOTES ON THE NETWORK

SECTION 6

COMMON CHANNEL INTEROFFICE SIGNALING

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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, are exchanged by these systems over the signaling links instead of being sent over the voice path as done using inband signaling techniques.

1.02 Block diagrams for systems using inband signaling and CCIS are shown, respectively, in Fig. 1(A) and 1(B). 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 are supplanted by a signaling link between the two processors and a number of continuity-checking transceivers.

1.03 As shown in Fig. 1, the signaling link consists 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 signaling terminal and VFL. The VFL is a conventional 4-wire message-grade transmission facility with characteristics similar to a 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. 1(B), 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 is sent over the same signaling links. Therefore, all portions of the signaling network are sufficiently redundant and diversified so as to ensure signaling availability. The functions performed by each of these components are 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. The major advantages are described in paragraphs 2.02 through 2.08.

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 are 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

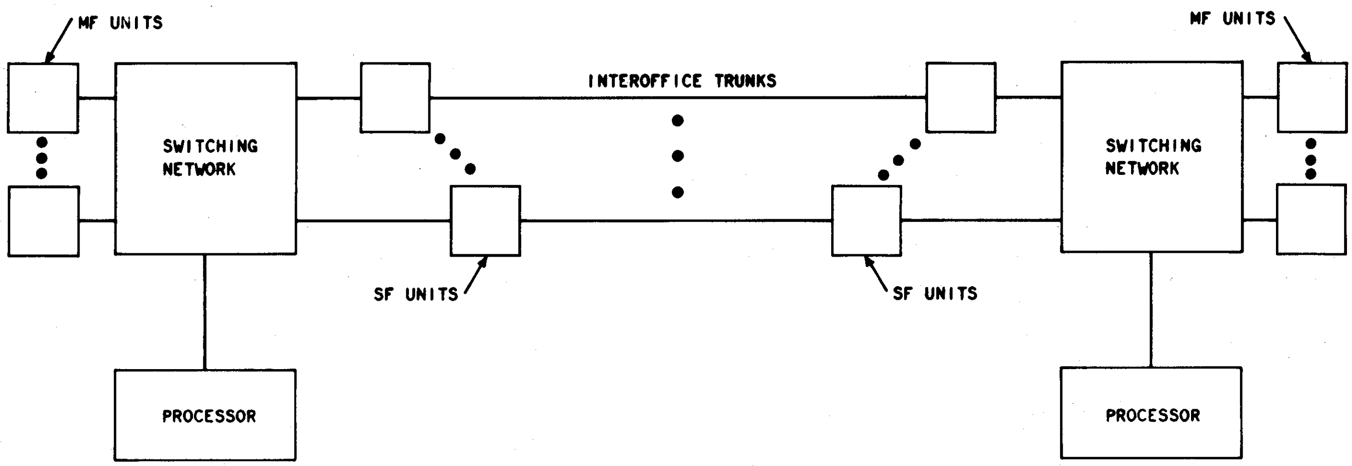


FIG. 1(A)—SF/MF SIGNALING

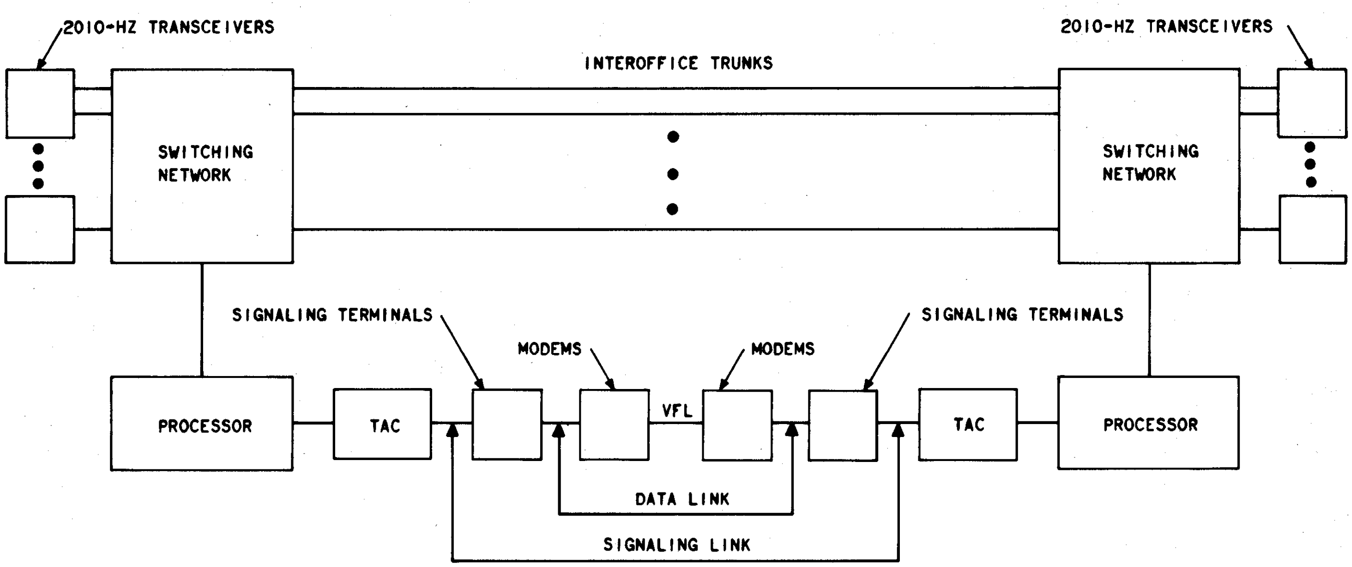


FIG. 1(B)—FUNCTIONAL BLOCK DIAGRAM - CCIS SYSTEM

Fig. 1—Signaling System Block Diagrams

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 ensure 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 International Telegraph and Telephone Consultative Committee (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 other conventional methods.

FLEXIBILITY

2.08 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 is extended to more local Electronic Switching System (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 the CCIS 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:

(a) ***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.

(b) ***Out-of-Chain Routing Indicator:*** Used to indicate whether or not a given call has been routed in chain or out of chain.

(c) ***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 [(b) and (c)] can be used to show whether or not 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:*** This feature is 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 in paragraph 3.06) to permit the sending of subscriber busy at the local office, when applicable, to the originating international exchange. This allows the originating international exchange to release the connection forward and apply audible busy tone toward the calling subscriber.

3.05 ***Calling Party Category:*** This feature is 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.

Note: This latter information is not currently being used.

3.06 ***Routing Category:*** This feature is used to indicate the type of call such as ordinary interoffice, international outbound, overflow, or international inbound.

3.07 ***Ineffective Attempt Signals:*** Ineffective attempt signals, such as trunk congestion, switching congestion, address incomplete, vacant national number, and call failure, are transmitted in the backward direction. These signals are used in place of audible tones or announcements. Use of these signals enables a switching system close to the call source to release the forward connection and terminate to an appropriate audible signal or recorded announcement closer 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 (paragraph 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 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. A different procedure is used to remove the entire carrier group when the group is arranged for software carrier group alarm.

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 provides 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" (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 is divided into ten signaling regions which have been chosen to correspond to the existing regions of the Direct Distance Dialing (DDD) hierarchy. All CCIS-equipped switching systems within a switching region concentrate the signaling traffic for all their CCIS trunks on a few well-loaded "Access" (A) links to a pair of signal message concentrators in the region called STPs. ("A" links are always provided in fully redundant pairs, one link pair [one active and one standby] to each of the two STPs in the region.) Between regions, pairs of "Bridge" (B) links connect each STP to its counterparts in the other region.

4.03 Because the signaling for 2250 trunks is sent over the A link pairs to the two STPs, 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 are 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 1 (TG1) would be sent over link A1 to STP1 where it would be forwarded (after translation) over link A2 to SO2. Interregional signaling, on the other hand, will normally involve two STPs; thus signaling from SO2 to SO4 for TG3 would be sent over link A2 to STP1, then forwarded over link B1 to STP2, and finally sent over link A4 to SO4.

4.05 In some cases, a CCIS SO 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" (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 fails, interregional signaling will be disrupted. For this reason, all signaling paths and STPs are duplicated and fully redundant. The existing network structure is shown in Fig. 3. Here each STP is connected to the "mate" STP in its own region by "Cross" (C) links and to the mate STPs in all other regions by B links. Together, the four links between two regions are referred to as a "quad." Additional redundancy is achieved by providing A links from each SO to both STPs in the home switching region. "A11" and "A12" illustrate this redundancy. To achieve even greater reliability, two VFLs are assigned to each A link. These VFLs 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 in paragraphs 4.21 through 4.24 and paragraphs 4.25 through 4.27, respectively.

OPERATION OF SIGNALING LINKS

4.08 Refer to the block diagram of the CCIS system shown in Fig. 1(B). 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 SUs are described in paragraphs 4.15 through 4.20. These SUs are passed to a 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

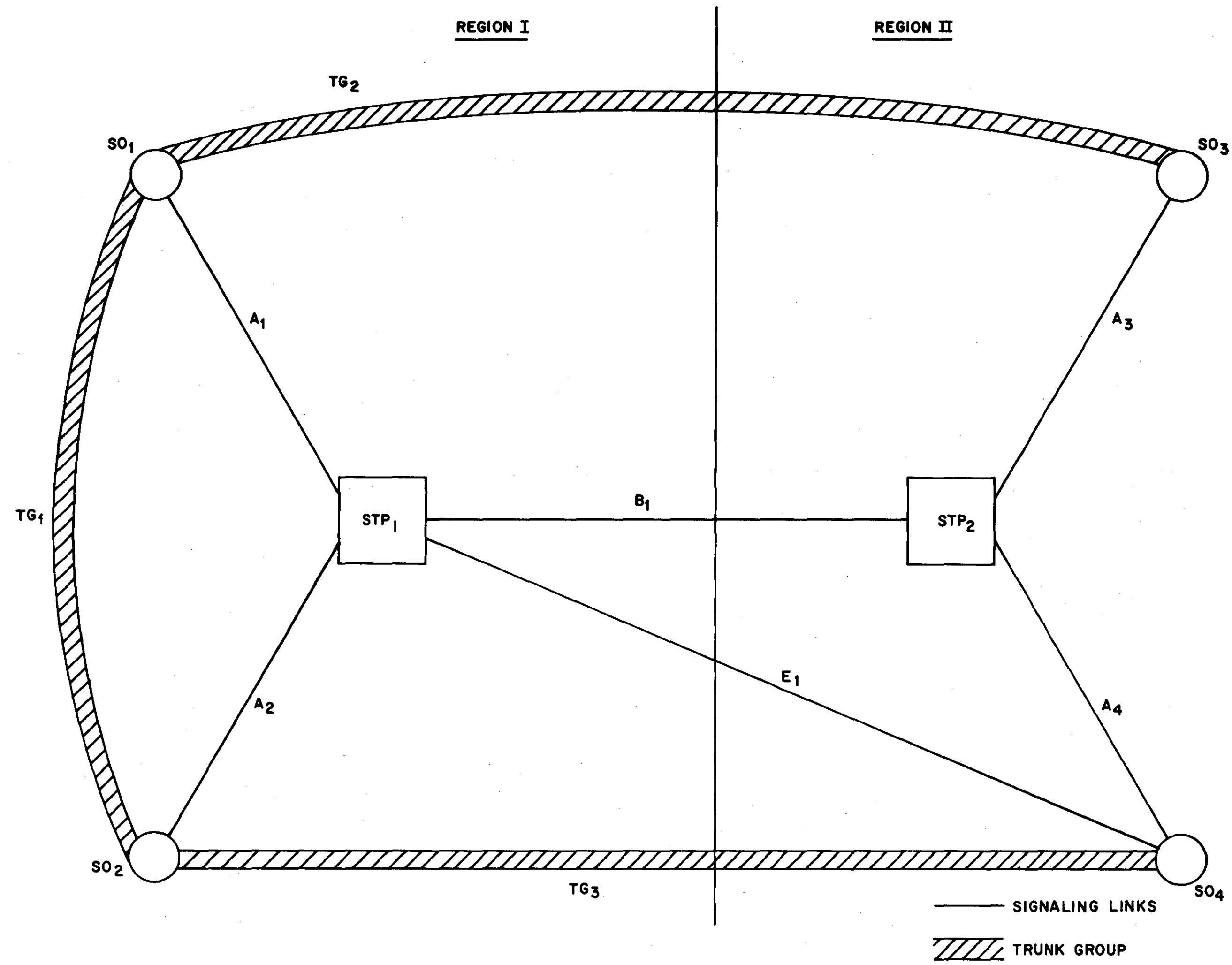


Fig. 2—Basic (Nonredundant) Signaling Network Structure

processor. Thus, in order to use one type of signaling terminal for all systems, the TAC is different for different processors.

> *Note:* The relative priorities in descending order are: acknowledgment signals, faulty link information, retransmission of answer signals due to errors, 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 is 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; ie, both directions of transmission are used for signaling at the same time. A 4-phase modem, operating at 2400 bps, is used.

4.11 At the far SO or STP, a modem converts SUs back into digital format and relays them to the receive portion of the signaling terminal.

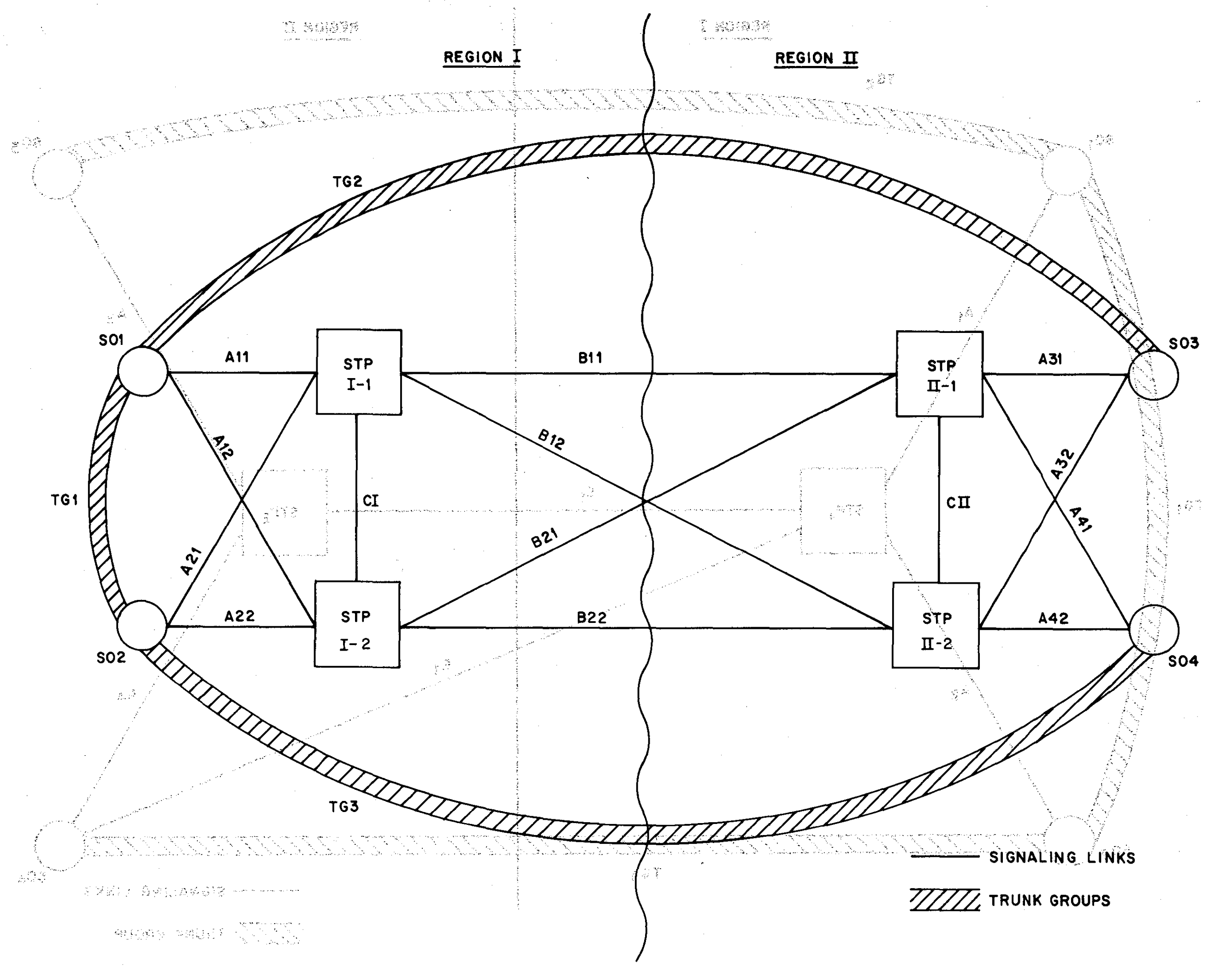


Fig. 3—Planned Signaling Network Structure

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 to blocks of 12. The first 11 SUs contain signaling information and the twelfth SU is an Acknowledgment Signal Unit (ACU). The ACU is coded to indicate (1) the number of the block in which it is included, (2) the number of the block sent in the reverse direction which is being acknowledged, and (3) acknowledgment bits indicating whether or not each of the 11 SUs of the block being acknowledged was received without error.

4.13 As described in paragraphs 4.11 and 4.12, 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 ensure continuity of service, provision is made for automatic transfer from a faulty link to an alternate link in the event of a failure condition. The signaling terminal monitors the data carrier and the SU error rate continuously.

Either a total failure (exceeding 350 ms) or excessive SU 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.

4.15 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. Also, stringent rules requiring physical diversity of CCIS links to prevent correlated failures are intended to further increase CCIS reliability.

DATA MESSAGE FORMAT

4.16 In the CCIS system, the basic data word is the SU. An SU is 28 bits long with the last eight bits used for error checking. Therefore, each SU contains a 20-bit field used for signaling information. When no data-filled SUs are being transmitted, a Synchronization Signal Unit (SYU) is transmitted to maintain synchronization.

4.17 CCIS messages can be one or more SUs 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 (MUMs) are generally used for passing address information (ie, digits).

4.18 Figure 4 shows the format fields for an LSU and a miscellaneous MUM. 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 in the group. The Initial Signal Unit (ISU) of the miscellaneous MUM has a unique heading code which identifies it as an ISU and an ISU-type code which identifies the message as a miscellaneous MUM. The length indicator gives a count of how many Subsequent Signal Units (SSUs) may be expected. A unique heading code is used to identify an SSU. The first SSU of a miscellaneous MUM has a message category to identify the type of miscellaneous MUM. The miscellaneous MUM may be used for telephone signals, network management messages, and to furnish a special (header) message for routing signals via C links between intraregional STPs.

4.19 An example of the structure of an MUM is an IAM for a 7-digit call as illustrated in Fig. 5(A). The ISU contains the trunk identity in the trunk label field. The first SSU contains a 16-bit field of 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 as shown in Fig. 5(B). In this case, the IAM contains abbreviated routing information which is equivalent to a specific full routing information combination. This feature reduces by one the number of SUs necessary to encode an IAM.

4.20 Figure 6 illustrates the IAM and LSUs 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.

4.21 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

4.22 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 SOs 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.

4.23 Signal routing at the STPs is performed as follows. All incoming and outgoing signaling links at the STPs will be assigned a "link number."

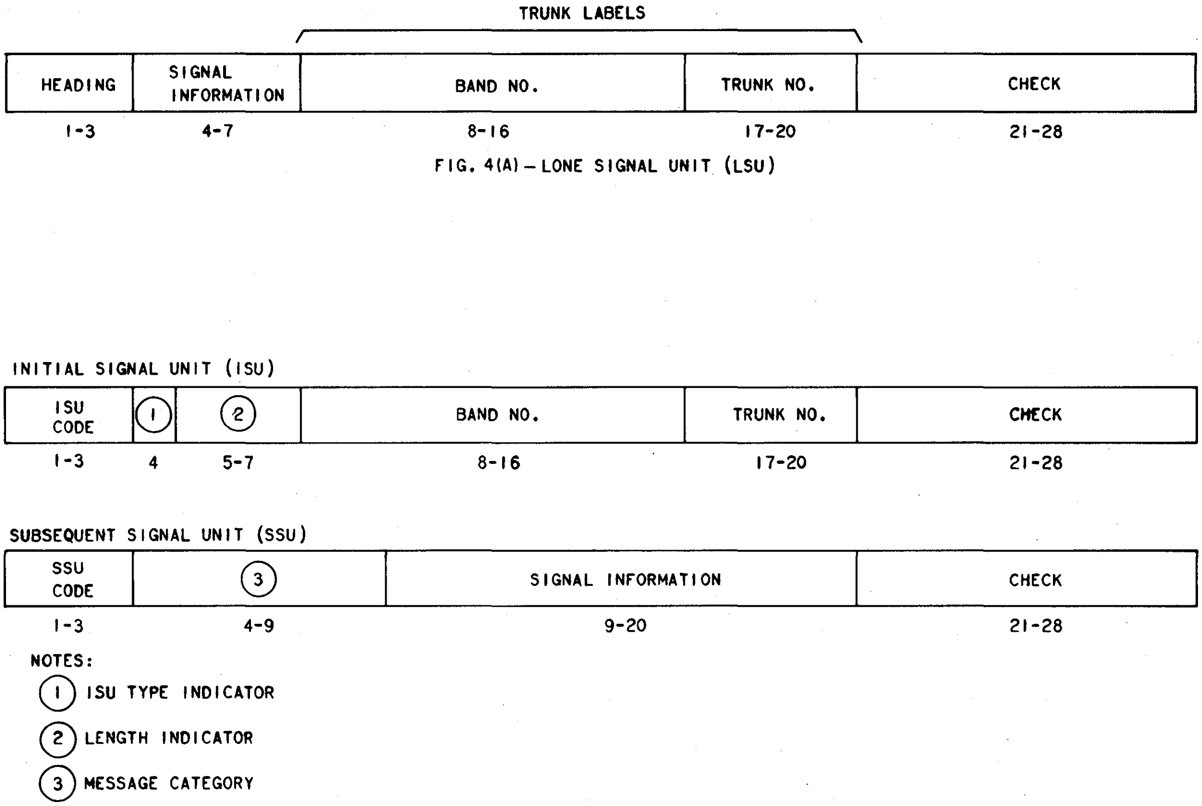


FIG. 4(A) — LONE SIGNAL UNIT (LSU)

FIG. 4(B) — MISCELLANEOUS MULTIUNIT MESSAGE (MUM)

Fig. 4—Signal Unit Formats

Furthermore, each STP will have stored in memory a "band translation" table for each A and B 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 number and transmits this modified message on the indicated outgoing link.

4.24 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.

4.25 Figure 3 shows 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 B links of a quad should be balanced as much as possible. This will be accomplished as follows. 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 each STP will be divided between the two B links according to the value of a low order bit in the band number part of the label.

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 "O"S

FIG. 5(A) - INITIAL ADDRESS MESSAGE (WITH EXPANDED 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)

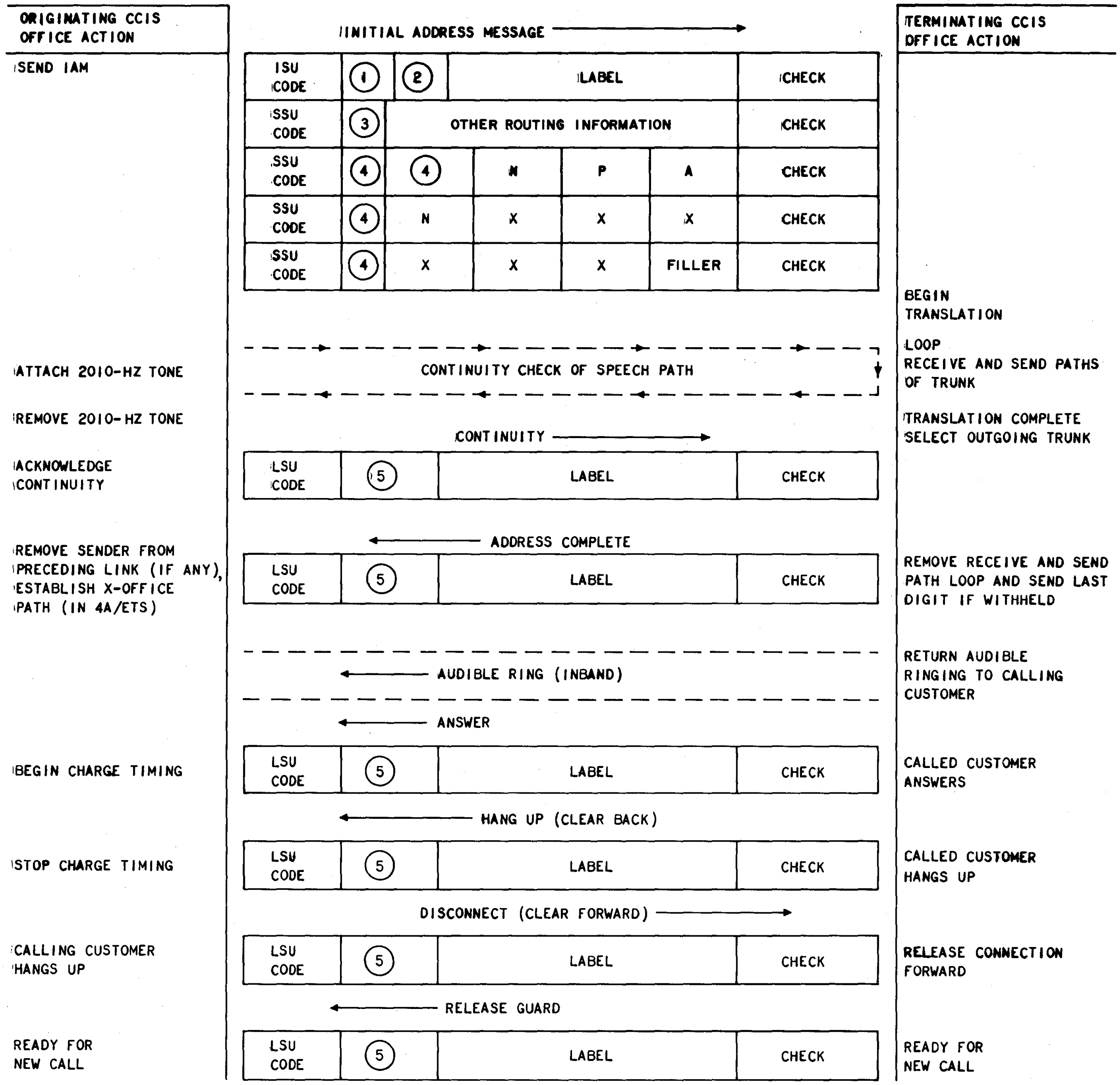
2 LENGTH INDICATOR (IE; 2 SSU'S)

3 ABBREVIATED ROUTING INFORMATION INDICATOR

4 NO INFORMATION - "O"S

FIG. 5(B) - INITIAL ADDRESS MESSAGE (WITH ABBREVIATED 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. EXPANDED INFORMATION INDICATOR
4. NO INFORMATION - ALL "0"S
5. SIGNAL INFORMATION (IE, ANSWER, DISCONNECT, ETC)

Fig. 6—Generalized Signal Sequence—10-Digit CCIS Call

ROUTING DURING LINK FAILURES—SIGNALING NETWORK CONTROLS

4.26 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 link will be routed on the mate B link. Traffic at an STP for a failed A link or outgoing interregional signaling at an STP with both B links failed will be routed to the mate STP over the C link.

4.27 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 SOs 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 SOs and other STPs. Examples of such signals are Transfer Prohibited (TFP) and Transfer Restricted (TFR) messages.

4.28 TFP messages are sent by an STP to appropriate STPs and SOs whenever an STP determines that it has no outgoing path available for signaling of trunks with a given band number.

4.29 Similarly, receiving a TFR message from an STP indicates that all signaling which that STP receives with the indicated band number will be routed over C links.

4.30 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

4.31 In addition to the signaling network controls, there are 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

4.32 When a CCIS SO experiences a serious processor failure, the CCIS terminals at that office signal the STPs in the signaling network to cut off all CCIS 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.

4.33 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 paragraph 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 forward 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 SUs. 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 to provide these controls in an economical and efficient manner led to the establishment of a CCIS Network Administration Center (CNAC) operated by AT&T Long Lines to perform these functions. Two functional activities must be performed by the CNAC. 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 engineers to provide the required relief.

6.04 The value of a CNAC 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 CNAC analyze all the forecasts and comparing them with the existing CCIS network, a more thorough analysis can be made. Also, the CNAC 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 ensure 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 AT&T 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 CNAC 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 AT&T Long Lines Circuit Layout personnel 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 CNAC.

7. MAINTENANCE

OVERALL CONTROL AND COORDINATION

7.01 The maintenance control and coordination of the CCIS 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 ensure 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 link is a communication path between two switching or signaling processors. This logically puts the responsibility for the overall link in the area of other switching maintenance functions, ie, 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. Note that the MOC is directed from the Switching Management Control Center.

7.05 To assist the MOC in its responsibilities in the No. 4 ESS environment, the Trunk Operations Center (TOC) has a subcontrol responsibility for the VFL portion of the signaling link. The TOC operates in parallel support of the MOC, ie, as overall plant control or noncontrol end of the VFL. In the non-No. 4 ESS offices, the MOC retains VFL responsibility.

7.06 Further allocation of maintenance responsibility within a typical CCIS-equipped office is described as follows:

(a) ***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.

(b) ***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 a part of the VFL.

(c) ***Transmission Systems Maintenance:*** Includes all equipment considered 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 verbal 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 or verbally 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 an 18-second proving period, will be set at 3 minutes. During this interval, the failed link is monitored for errors. If ten or fewer SUs 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. Voice communication should be established between the involved MOCs and the central office coordinating both ends. 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 TOC 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 TOC 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 TOC. 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 TOC 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 the STP and 4A/Electronic Translator System (ETS) differs from that of No. 4 ESS offices. The 4A/ETS and STP offices will essentially employ a dedicated wired path between modems and VFLs via a dedicated per-link test access circuit which, among other functions, permits testing access to be established to the VFL from the TOC over a dedicated test access path. In the No. 4 ESS, 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 loopback 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. The No. 1/1A ESS configuration is similar to the 4A/ETS.

7.17 As mentioned in paragraph 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 loopback type test. A passive loopback will be connected at the SO and a maintenance T/M connected at the STP. An automatic processor-controlled test will then be made.

7.18 If the test fails, a notification will be given 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 SO on a demand basis. The results of a demand test will be presented at the initiating office.

8. MESSAGE DESCRIPTIONS

8.01 Additional Routing Information and Data Message Format have been discussed in Parts 3 and 4, respectively. The message formats for other types of messages will also 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 signal groups are:

(1) Telephone signals

(2) Trunk-related signals

(3) Management signals

(4) Signaling System Control signals

(5) Special signals.

The codings are:

HEADING CODE	SIGNAL UNIT TYPE	GROUP
000	Lone Signal Unit	(1)
001	Lone Signal Unit	(1)
010	Lone Signal Unit	(1)
011	Acknowledgment Signal Unit	(4)
100	Lone Signal Unit	(1)
101	Initial Signal Unit	(1) through (5)
110	Subsequent Signal Unit	(1) through (4)
111	Lone Signal Unit	(1), (3), and (4)

8.03 What follows is a partial alphabetical listing of signals. It is divided into sections (telephone signals, management signals, etc) and provides the standard abbreviations and definitions. More detail is available from the United States Independent Telephone Association (USITA) Technical Advisory Number 14 on CCIS.

8.04 ***Lone Signal Unit—Telephone Signals:***

ADN ***Address-Complete Signal, No Charge:*** 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:*** A signal sent in the backward direction indicating that the number of address signals received is not sufficient for setting up the call.

ANC ***Answer Signal, Charge:*** 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:

(a) To start charging the calling customer

(b) To start the measurement of call duration for international accounting purposes if this is desired.

SSD ***Second-Start-Dial Signal:*** A signal sent in the backward direction on outbound international calls indicating that the second stage of outpulsing can begin.

BLO ***Blocking Signal:*** 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.

CFL ***Call-Failure Signal:*** 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 ***Clear-Back (Hang-Up) Signals:***
CB2 Signals sent in the backward direction,
CB3 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, these signals perform a supervisory function. In automatic operation, the signals initiate a timing interval which, if exceeded, stops the charging and causes release of the established connection.

CLF ***Clear-Forward (Disconnect) Signal:*** 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:*** A signal sent in the backward direction indicating that an office is unable to act upon an IAM received from a preceding office because the message is considered unreasonable.

COT ***Continuity Signal:*** 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):*** A signal sent in the backward direction indicating that the line(s) connecting the called party with the office is (are) busy.

MRF ***Message-Refusal Signal:*** A signal sent by an STP in response to the reception of an IAM or reset trunk signal which it is unable to deal with as a consequence of the transfer-prohibited situation.

NSC ***National-Switching-Congestion Signal:*** 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 Signal:*** 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 ***Reanswer Signals:*** Signals sent
RA2 in the backward direction to indicate
RA3 that the called party, after having hung up, again lifts the receiver or

in some other way reproduces the answer condition, eg, switchhook flashing.

RLG ***Release-Guard Signal:*** 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:*** 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:*** 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.

8.05 ***Two-Unit Telephone Signals:***

FDT ***Forward-Transfer (Ring-Forward) Signal:*** On operator-to-operator calls, this signal is sent in the forward direction when the outgoing office operator wants to recall the distant operator.

VNN ***Vacant-National-Number Signal:*** A signal sent in the backward direction used to indicate that the received national number is not in use (eg, spare level, spare code, vacant customer number).

8.06 ***Lone Signal Unit—Signaling-System-Control Signals:*** These are signals used for the proper functioning of the signaling system via the common signaling link.

ACU ***Acknowledgment Indicator:*** Information indicating whether or not an error has been detected in a received SU.

COV ***Changeover Signal:*** 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.

LTR ***Load-Transfer Signal:*** 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***

MCO ***Manual-Changeover Signal:*** 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***

MVT ***Manual-Voice-Frequency-Link-Transfer Signal:*** A signal sent in either direction between an SO and an STP indicating that the active VFL should be interchanged with the inactive VFL.

SRD ***Standby-Ready Signal:*** 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 prove-in period.

SRA ***Standby-Ready-Acknowledgment Signal***

SYU ***Synchronization Signal:*** A signal sent in order to establish and maintain synchronization between the two ends of a signaling channel.

TSV ***Test-Voice-Frequency-Link Signal:*** A signal sent in either direction between an SO and an STP indicating that the sending end is prepared to test the standby VFL and requesting the other end to prepare for the test.

VLF ***Voice-Frequency-Link-Test, Failed Signal:***

VLP ***Voice-Frequency-Link-Test, Passed Signal***

8.07 ***Lone Signal Unit—Signaling-Network-Management Signals:*** These signals provide 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:*** A signal sent by an STP after transmitting the last-band status signal to notify other STPs or SOs of the completion of the band status update.

LKF ***Link-Failed Signal:*** A signal sent by an STP to a mate STP identifying a failed signaling link.

LKN ***Link-Normal Signal:*** 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:*** A signal sent by an SO 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:*** A signal sent by an 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***

TAA ***Transfer-Allowed-Acknowledgment Signal***

TFA ***Transfer-Allowed Signal:*** A signal sent by an STP when it is again ready to transfer signals for a particular group of trunks.

TFP ***Transfer-Prohibited Signal:*** 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:*** A signal sent by an STP for each label band of a failed signaling link to request other STPs and SOs 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 Unit—Network-Management Signals:*** These signals provide 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) Signals:*** Signals sent from one SO 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:*** Signals sent in response to the corresponding DOC signals.

8.09 ***Multiunit — Network-Management Signals:***

OTO ***Out-of-Chain-Routing-Turnoff Signal:*** A signal sent to notify an office sending out-of-chain calls to another office that no more calls to a Numbering Plan Area (NPA) or office code should be routed to it for some time period.

Selectivity Signals: Signals used to indicate difficulty of routing traffic to various destinations.

(a) SHR Selectivity, hard-to-reach

(b) SLN Selectivity, normal.

8.10 ***Special Signals:***

Header Signal: A signal prefixed by an STP to each single or MUM 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: Information is sent in the forward direction to identify the source and destination of calls. The categories for calls are:

(a) Ordinary Interoffice—Originates and terminates in the North American NPA.

(b) International Inbound—Originates outside the North American NPA but terminates within it.

(c) International Outbound Overflow—Originates in an International Switching Center (ISC) but overflows to another ISC for call completion.

Nature-of-Trunk Indicator: Information sent in the forward direction about the nature of the trunk or any preceding trunk(s) already engaged in the connection:

(a) Satellite trunk, or

(b) 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.

Out-of-Chain-Routing Indicator: Information transmitted in the forward direction to indicate whether the call has been routed out of the hierarchical chain. The indications are:

(a) In chain,

(b) Out of chain on this link, or

(c) Out of chain on a previous link.

Calling-Party's-Category Indicator: Information sent in the forward direction about the category of the calling party.

Continuity Check Cancellation Indicator (Forward): Information 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.

9. DIRECT SIGNALING

9.01 The present CCIS network has the ability to route messages that are trunk related (ie, assigned to a signaling path or band). Direct signaling gives the network the capability of routing a message to a particular destination based on address information in the message and not based on the point of origination or on band-assigned paths through the network. This new signaling capability accommodates the addition of data bases to the network and the development of new features that allow connecting offices to gain access to the network for nontrunk related signaling.

GENERAL CONCEPT OF DIRECT SIGNALING

9.02 The method of routing telephone signaling messages over the CCIS network involves the use of band numbers. Band numbers are preassigned on specific pairs of signaling links thereby defining paths through the network corresponding to voice telephone trunks.

9.03 Direct signaling is intended to provide a more flexible method of routing data messages over the CCIS network. The data could, for example, be related to the telephone network services and features which require data communication between two entities which are not the termination points of any direct trunk groups. A direct signaling message could be injected anywhere in the CCIS network and be routed properly to its intended destination. The signaling paths for direct signaling messages are not restricted to specifically preassigned signaling link pairs, or link complements, as is the case with messages which contain band numbers. Direct signaling provides the CCIS message routing flexibility necessary to access CCIS data bases which is required for some of the new telephone network services and features planned for introduction.

9.04 Direct signaling messages are all MUMs. The message address, being larger than the label field used to route messages for Plain Old Telephone Service (POTS), is contained in the first two SUs. Every node in the CCIS network is assigned at least one node, or function, number. Most CCIS network nodes also have other numbers associated with them. An SO could be identified by the NPA-NXX codes of the POTS customers it serves. An enhanced 800 Service data base could be identified by the 800-NXX codes of the 800 Service customers it serves. The address field of a direct signaling message would contain any one of the number codes associated with the desired destination. Since the address is not related to any specific signaling link, the direct signaling message could be transmitted over any available signaling link in the pool of signaling links leading to the desired destination in the most direct route possible. That pool of links is determined by the routing data associated with the destination address. The specific link within the pool of links is chosen by a load balancing algorithm in such a way that all the links in the pool will carry equal amounts of total traffic including both the direct signaling and banded messages.

NOTES ON THE NETWORK

SECTION 7

TRANSMISSION CONSIDERATIONS

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1. GENERAL

1.01 This section of ***Notes on the Network*** presents transmission considerations bearing on dial-direct and operator-assisted traffic. The first part of this section contains general information and outlines general transmission considerations for the network.

1.02 Transmission criteria that fall into three major categories are discussed in this section. These categories are:

- Objectives
- Requirements
- Thresholds.

1.03 Objectives are goals which can be classified in several ways. One classification is the time frame in which the objective is expected to be met, ie, current, near term, or long range. Most of the objectives in this section are current objectives which should be met now. Purpose is another classification for which the objective is intended, ie, design, initial performance, or in-service performance. Objectives may apply to overall connections, trunks, loops, transmission facilities, switching systems, etc. There may be separate objectives for existing versus new. Objectives for design purposes may be expressed as a single value, but objectives for initial and in-service performance are typically expressed as a distribution with limits set to control performance within certain bounds.

1.04 Requirements* are established to provide a practical means of meeting objectives. Objectives are typically established for a large population. Requirements are set for use on individual circuits or a small population of circuits. This section deals with requirements applicable to initial and in-service performance of trunks and design requirements for loops.

*When used for equipment evaluation, requirement has a different meaning.

1.05 Thresholds relate mainly to in-service performance and are set in order to:

(a) Indicate when corrective measures are worthwhile

(b) Indicate when corrective action should be taken to enable the current in-service performance objective to be met

(c) Serve as a reference point for measurement plans dealing with the effectiveness of maintenance

(d) Serve as a reference point for measurement plans dealing with actual in-service performance.

Even though these thresholds may be the same or similar for a given impairment, the four purposes above are distinct. Only those thresholds for (b) are included in this section.

1.06 All these objectives, requirements, and thresholds reflect an overall philosophy of a proper balance between the customer's service needs, the customer's perception of transmission performance, and the economic aspects of achieving this performance through new designs or improved maintenance. When transmission performance degrades, customer opinion degrades correspondingly. Eventually, customers may initiate overt action such as requesting operator assistance, reporting troubles, or requesting credit for poor transmission. Such customer actions are costly to the telephone companies and are indicative of unsatisfactory service. The incidence of such difficulties is controlled by design objectives, maintenance thresholds, and performance limits.

1.07 In general, improvements to the network are achieved through an evolutionary process guided by long-term goals. As telecommunications technology evolves, the objectives and requirements must be reviewed and updated. Transmission performance is evaluated through the use of computer models which relate transmission impairments to customer opinion of transmission quality. These models are based on surveys of plant performance to characterize the incidence of transmission impairments in the network and subjective tests to determine the relationship between transmission impairments and customer opinion. In addition, transmission performance for data communications is evaluated through laboratory analysis of error characteristics with various families of data sets. The transmission performance experienced by the customer depends in part on the interaction of the station equipment with the subscriber's loop. Acoustic-to-electric transducer efficiency depends on loop current and other factors. Frequency response, sidetone performance, and impedance of the station equipment also affect transmission quality. The network performance models assume a standard station set based on the characteristics of the 500 set in conjunction with loop current distributions obtained from surveys and analyses.

1.08 Customer opinion is rendered on a scale of "excellent, good, fair, poor, and unsatisfactory." Estimates of the distribution of opinion for various network conditions are termed "grade of service." Grade-of-service calculations are used to estimate the impact of new or revised objectives on the distribution of customer opinion. Subjective judgments of transmission quality depend, in part, on the general setting in which the telephone is used, the range of transmission conditions encountered, and other factors. Therefore, changes in grade of service under alternative transmission plans are more meaningful than absolute values of grade of service.

1.09 Performance objectives are goals for network performance. The incidence of each transmission impairment is characterized by a distribution; a long-range performance objective is best stated as the distribution which the plant should achieve based on trends in technology, economics, and customer opinion. New designs should be based on the long-term objectives. Circuit order requirements and maintenance requirements are based on the performance obtainable with existing equipment and operating procedures. In some cases, older systems will not be able to meet the long-term objectives; these systems should be upgraded or removed on a planned basis. Circuit order requirements reflect the capabilities of the system when it is properly installed and adjusted. They include tests of transmission parameters which generally remain stable over the lifetime of the equipment if the requirement is initially met. Routine maintenance requirements are thresholds beyond which corrective measures should be taken. Performance limits (sometimes called immediate action or turndown limits) are thresholds beyond which performance is deemed unsatisfactory. By referring to an objective distribution, the percentage of trunks which should be in compliance with the maintenance requirements and limits can be determined. Typically, in a well-designed and well-maintained plant, 95 percent of the trunk population should be in compliance with routine maintenance requirements and 99 percent should be in compliance with performance limits. Circuit order requirements should be met, essentially without exception, at the time a circuit is turned up for service.

1.10 The balance of this section presents the specific information about the transmission parameters. Some of the parameter requirements are set by the needs of voice communication; these are discussed in terms of grade of service. Other impairments primarily affect data transmission, leading to parameter requirements set by the needs of that service. The effects on voice or data transmission are described for each parameter, followed by the methods for controlling the parameter. This includes applicable objectives, tests, requirements and limits for connections, individual trunks, and their subcomponents.

1.11 The Switched Digital Network (SDN) exerts a profound influence on transmission objectives. It introduces new potential impairments for which objectives must be established, changes the range of parameters to be expected for existing impairments, and changes the constraints that bear on techniques for controlling transmission impairments. References to the SDN will be found throughout this section. Considerations bearing uniquely on the SDN will be found at the end of the section.

2. ECHO, SINGING, AND NEAR-SINGING

2.01 Echo is the power which has been reflected in some manner from the primary speech path. This reflection can occur in the transmission path either at a 4- to 2-wire junction or at an impedance irregularity on a 2-wire circuit. The reflected signal causes three types of phenomena: talker echo, listener echo (or "near-singing"), and singing.

2.02 Figure 1 shows an example of how an echo occurs on an end-to-end connection. The 2-wire path at each end includes the customer loop and may also include 2-wire switches and trunks. The 4-wire path may include 4-wire intertoll trunks and switches or could consist of a single 4-wire digital end office. The 4-wire path is connected to the 2-wire path at each end by a hybrid. If the impedance of the balancing network at the hybrid does not match the impedance of the 2-wire path, some of the power arriving on the 4-wire path will be reflected. Multiple echo paths can occur on connections which have multiple reflection points, but even such connections are usually considered to have a single predominant echo.

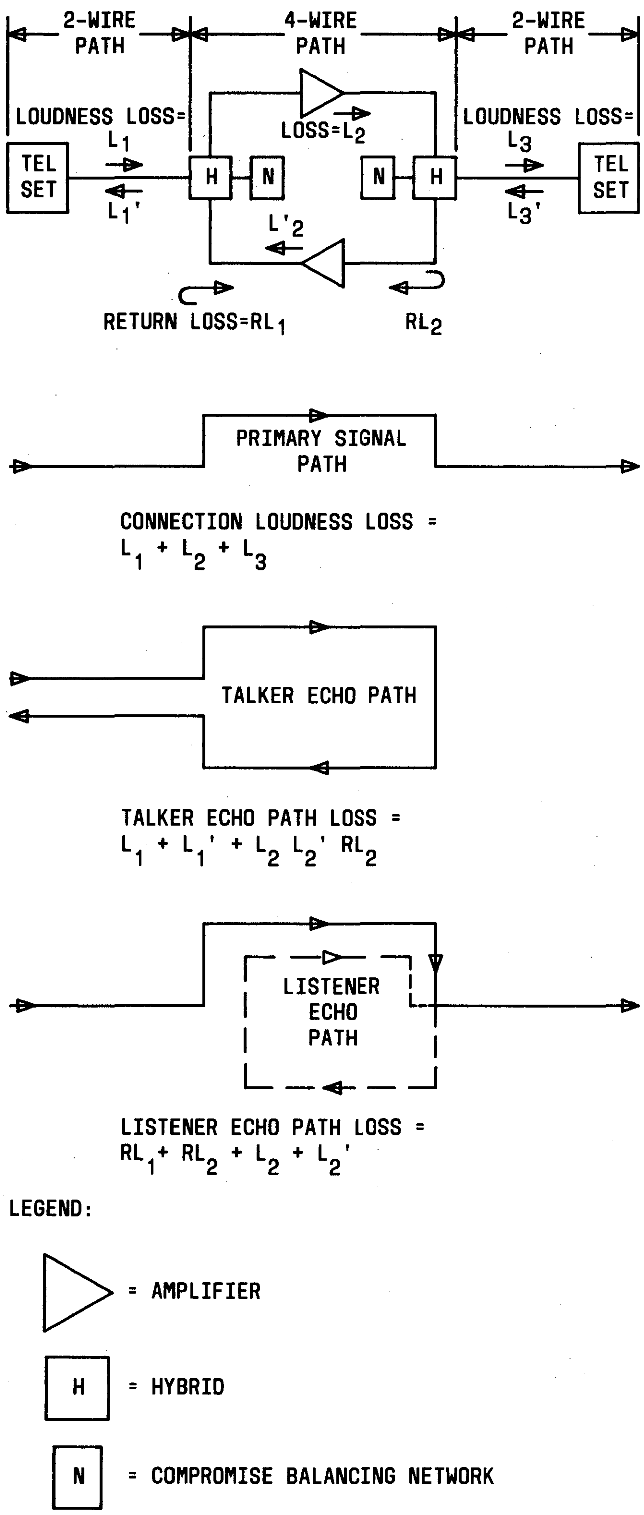


Fig. 1—Echo Path in a Telephone Connection

2.03 The fraction of power reflected depends on the impedance mismatch. It is expressed in terms of return loss in dB as follows:

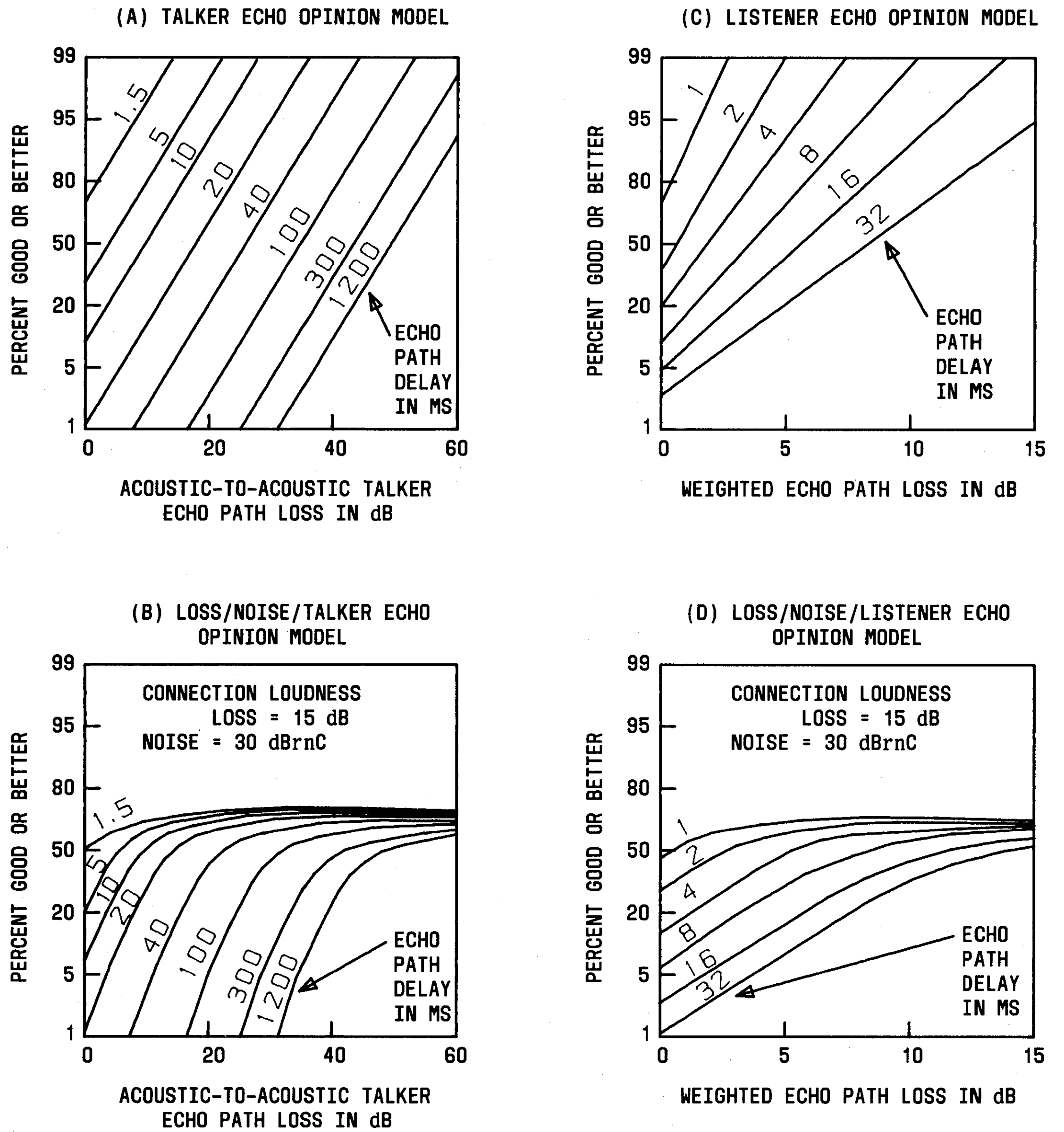
$$\text{Return Loss} = 20 \log_{10} \left(\frac{Z_1 + Z_2}{Z_1 - Z_2} \right) \text{dB}$$

This is a theoretical formula for the echo at a mismatch between any two impedances, Z_1 and Z_2. It is approximately correct for the echo reflected into the 4-wire path at a 4- to 2-wire junction, where Z_1 is the impedance of the balancing network and Z_2 is the impedance of the 2-wire path as seen from the hybrid. Return loss is generally a function of frequency.

2.04 Talker echo occurs when primary speech reflected at the far end returns to the talker along the talker echo path as indicated in Fig. 1. The talking customer, thus, hears his/her own voice delayed by the total delay of the echo path. If the reflected speech has sufficient amplitude and delay, it can be annoying and can interfere with the talker's normal speech process.

2.05 The amount of annoyance caused by talker echo depends on the amplitude and delay of the echo. Figure 2(A) shows the latest talker echo subjective opinion model. As the acoustic echo path loss of a connection decreases or the echo path delay increases, the curves show a decrease in the percent of opinions that would rate the connection good or better. The acoustic echo path loss includes the acoustic-to-electric transmitting and electric-to-acoustic receiving loudness loss of the telephone set plus loop, the round trip electrical loss from the loop to the reflection point and back, and the Echo Return Loss (ERL) at the reflection point. The ERL is defined as a weighted average of the return losses over the band from 500 to 2500 Hz. For loops with a 500-type telephone set, the sum of the transmitting and receiving loudness losses has a mean of about 9 dB and a standard deviation of about 3.5 dB.

2.06 If speech reflected from the far end is again reflected at a near-end impedance mismatch, it is heard by the listener. The effect is frequently referred to as near-singing distortion for short delays or, more generally, listener echo. For short



NOTE:

THE CONNECTION LOUDNESS LOSS AND, THUS, THE SUBJECTIVE OPINION MODEL IS IN TERMS OF AN OVERALL LOUDNESS RATING (OLR) IN dB ACCORDING TO RECENT BELL SYSTEM PRACTICE. CONNECTION LOUDNESS LOSS IS EXPRESSED AS OVERALL OBJECTIVE LOUDNESS RATING (OOLR) IN dB IN AN INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE) STANDARD. THE APPROXIMATE RELATIONSHIP IS OOLR=OLR-5. SIMILARLY, NOISE EXPRESSED IN TERMS OF A RECEIVING SYSTEM WITH A RECEIVING LOUDNESS RATING (RLR) OF 26 dB IN THE TERMS OF THE IEEE STANDARD, RECEIVING OBJECTIVE LOUDNESS RATING (ROLR) IS APPROXIMATELY EQUAL TO RLR PLUS 20.

Fig. 2—Loss-Noise-Echo Grade of Service

delays, listener echo can produce a "hollow" effect which is similar to talking into an empty barrel. Listener echo is generally of concern on relatively short-length connections. On longer connections, provisions to control talker echo will also control listener echo.

2.07 The amount of annoyance caused by listener echo depends on the delay of the listener echo path and the Weighted Echo Path Loss (WEPL). The listener echo path, shown by the broken line in Fig. 1, includes the return loss at both ends and the round trip electrical loss between the reflection points. The WEPL is the reciprocal (expressed in dB) of the average magnitude of the voltage gain of the listener echo path over the band from 200 to 3400 Hz. Figure 2(C) shows the latest listener echo subjective opinion model. (Figure 2 is further discussed in paragraphs 3.03 and 3.04.) Table A shows the objective for the distribution of the WEPL depending on listener echo path delay. A single-ended parameter termed Average Power Return Loss (APRL), which is simpler to measure, has been developed. Expression of the listener echo objective in terms of APRL is currently under study.

TABLE A

OBJECTIVE FOR WEIGHTED ECHO PATH LOSS (WEPL)

LISTENER ECHO PATH DELAY, MS	PERCENT OF CONNECTIONS/ MINIMUM WEPL IN dB			
	50%	95%	99%	99.9%
2	16	11	9	7
3	17	12	10	8
4	18	13	11	9
5	19	14	12	10
6	20	15	13	11
7	21	16	14	12
8	22	17	14	12

2.08 Singing can be caused by circulating power in the transmission path and occurs in the same manner as listener echo. It may result in a sustained loud tone on the connection. Referring to Fig. 1, singing arises if the gains in line repeaters or carrier channels are high enough and the return losses low enough so that the round trip gain at some frequency has magnitude greater than one with zero phase shift. This can also occur in a digital central office. If singing occurs, it normally occurs at frequencies near the band edges (200 to 500 Hz and 2500 to 3200 Hz) where impedances are not well matched. The singing margin of a connection is defined as the amount of gain which, added to the listener echo path, would just start it singing. Near-singing is the condition just before actual singing takes place.

2.09 To control talker echo in the 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 control devices. The use of each of these methods is discussed in Parts 3, 4, and 5.

2.10 Singing and listener echo can be controlled by the same methods as used for talker echo, but attention must be given to a wider bandwidth. The WEPL objective in Table A is used in the design of local switching systems that incorporate 4-wire paths, such as digital switching offices or Remote Switching Unit (RSU) arrangements. The singing margin objective for those arrangements is that all connections should have a singing margin greater than 4 dB. The objective for trunks is that the singing margin should be 10 dB or more in 95 percent of:

(a) All connections for trunks utilizing carrier facilities

(b) All cases for physical facility trunks with gain (eg, multirepeatered trunks).

In (a) above, singing margin performance depends more on terminating conditions (ie, impedance of customer loops) than on structural irregularities within the trunks. For a physical trunk with gain, structural irregularities (eg, load coils and gauge changes) within the trunk are important in determining singing margin performance.

3. LOSS

OPTIMAL LOSS

3.01 Network 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 listener echo paths. The loss combined with the return loss of impedance discontinuities attenuates echo power and, therefore, controls customer annoyance due to echo.

3.02 The loss plan as described in paragraphs 3.14 through 3.20 evolved primarily in terms of talker echo control. Early studies indicated that such design also provided satisfactory listener echo control on interoffice connections.

3.03 As indicated in Fig. 2(A), the amount of loss needed to achieve a given talker 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 estimated using loss-noise subjective opinion models. Percent good-or-better contours from a subjective opinion model are plotted in Fig. 3. For low values of noise, this model indicates that 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.

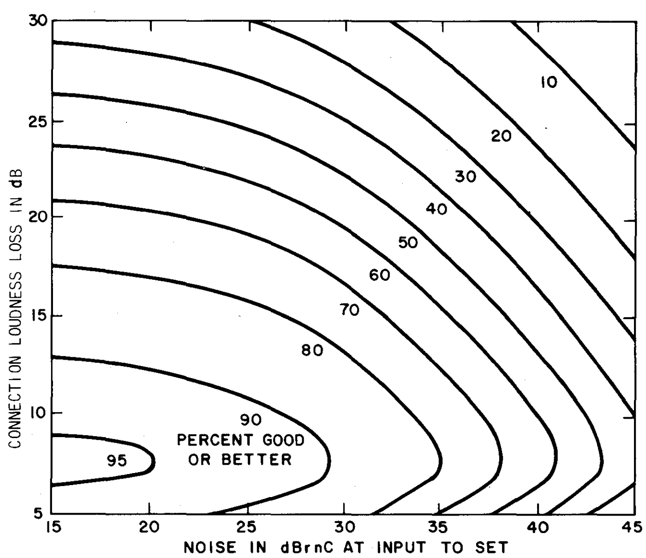


Fig. 3—Loss-Noise Grade of Service (See Note of Fig. 2.)

3.04 Actually, a customer's opinion of a call is based on a joint assessment of the effects since loss, noise, and talker echo are experienced during portions of the conversation. The joint effect is assessed through the loss-noise-echo grade-of-service measure. [See Fig. 2(B).] Quantitatively, the good-or-better value of the grade-of-service measure for the combined effects will be slightly lower than the value of either the loss-noise measure or the talker echo measure, whichever is individually lower. This effect can be seen by examination of Fig. 4. Plotted in this figure is an estimate of the percentage of customers who would rate a call good or better in terms of the connection loudness 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. For high loss values, the loss-noise-echo grade of service follows the loss-noise grade of service.

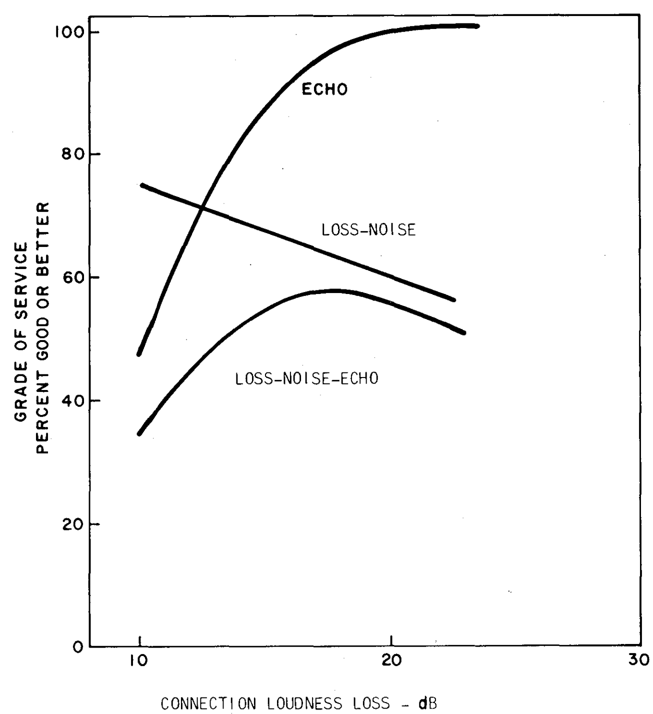


Fig. 4—Optimum Loss (1270 Airline Mile Connection) (See Note of Fig. 2.)

3.05 The grade of service as a function of loss increases to some maximum value and then decreases. The value of loss at which the 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, echo path loss, and echo path delay associated with that connection length.

3.06 Ideally, a loss plan should provide a value of connection loss which is close to the optimal value for all connection lengths. At the same time, a loss plan must be easy to implement and administer. 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 some cases, slightly better echo grade of service is obtained with some decrease in loss-noise grade of service or the opposite.

3.07 In order to provide loss close to the optimal values on all connections, there are currently two loss plans for the toll network. The first, called the Via Net Loss (VNL) plan, 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, called the Switched Digital Network (SDN) plan, is based on fixed loss design and is for connections carried on digital facilities and digitally switched without digital/analog conversions to encode/decode the signal. This type of connection was made possible with the introduction of the No. 4 Electronic Switching System (ESS) and will become increasingly prevalent with continued penetration of digital switching systems and digital transmission facilities. Although stated as two plans, the loss plans are compatible; connections can be established involving parts designed according to the VNL plan and parts designed according to the SDN plan with quite satisfactory performance.

DEFINITIONS

3.08 The basic loss design objectives are specified in terms of the Inserted Connection Loss (ICL). The ICL is the 1004-Hz transducer loss of the trunk referenced to the nominal impedance of the offices (600 or 900 ohms) which the trunk interconnects. It reflects all of the gains or losses from the originating outgoing switch appearance through the trunk to the outgoing appearance of the terminating switch with the trunk terminated in the nominal office impedance. Trunks terminating on digital switching systems are designed to the "center" of the switch.

3.09 Related to the ICL is the Expected Measured Loss (EML). The EML is the 1004-Hz loss that one would expect to measure between two readily accessible trunk test points with the proper terminating impedances at the test points. The EML includes switching (or cord circuit) loss, test pad losses when specified in the measuring circuit, and connection losses to the 1004-Hz generator and detector.

3.10 The Actual Measured Loss (AML) is the actual measured 1004-Hz loss between the same two access points for which the EML was computed.

3.11 The definition of trunk ICL in paragraph 3.08 is based on analog offices and analog trunks. This definition is illustrated in Fig. 5(A). Figures 5(B), (C), and (D) illustrate in general form the losses for trunks interconnecting with digital offices. Later paragraphs specify ICL values for trunks which are classified as analog, combination, or digital. Analog trunks are trunks which interface at voice frequency with switching systems at both ends. [See Fig. 5(A), (B), and (C).] Trunks which use analog and/or digital facilities and are at voice frequency at digital switching systems are analog trunks. Combination trunks are trunks which interface at voice frequency with a switching system at one end, utilize digital transmission facilities, and interface digitally with a digital switching system at the other end. [See Fig. 5(B) and (C).] Digital trunks utilize digital transmission facilities and interface digitally with digital switching systems at both ends. [See Fig. 5(D).]

> ***Note:*** A definition needs to be developed for trunks which utilize both analog and digital facilities and interface at voice frequency with a switching system at one end and interface digitally with a digital switching system at the other end. Such definition and consequent provisioning arrangements are under study.

3.12 Trunk ICL realization is based on application of the appropriate test tone power or digital test pattern [in accordance with the Transmission Level Point (TLP) for the offices] at the send office end of a trunk and adjustment of receive trunk pads to obtain the proper received signal power at the receive office end of the trunk. [See Fig. 5(A).] For combination and digital trunks, there are no receive trunk pads at the digital interface [DI of Fig. 5(B), (C), and (D)] to enable ICL realization; the required ICL is realized in terms of analog signal levels applied to and/or measured at test access points. These test points have TLPs defined and are called Encode Level Point (ELP) and Decode Level Point (DLP), rather than

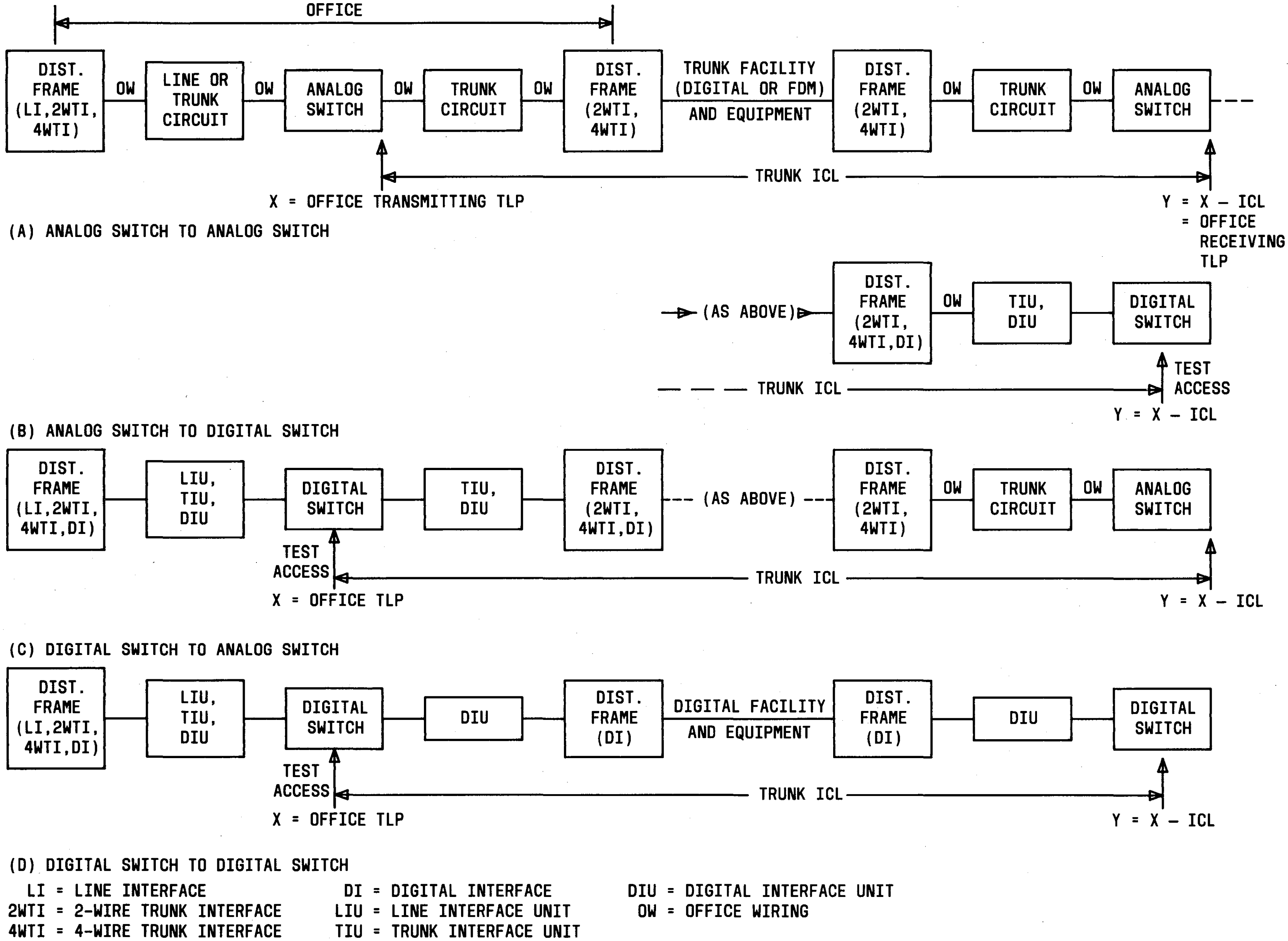


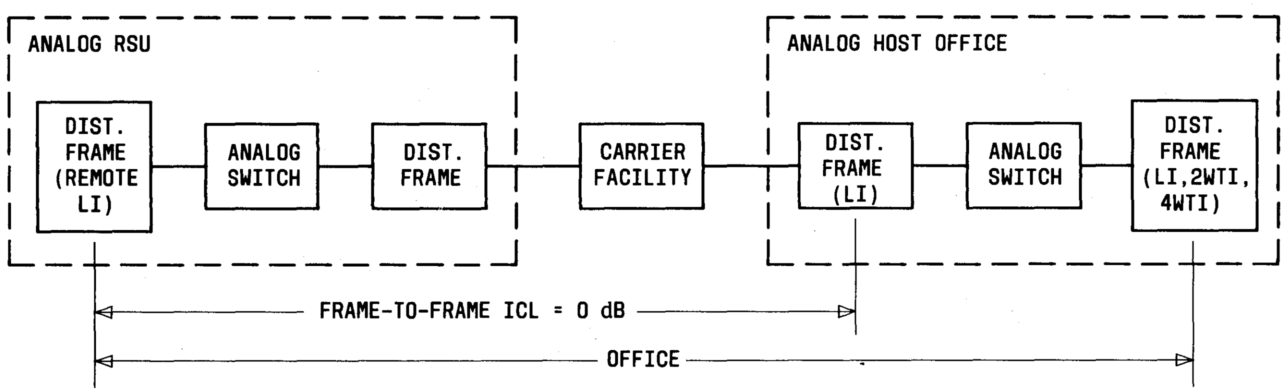
Fig. 5—General Office/Trunk Definitions

transmitting TLPs and receiving TLPs, to convey the digital nature of the switching system. (See paragraphs 3.40 through 3.44.)

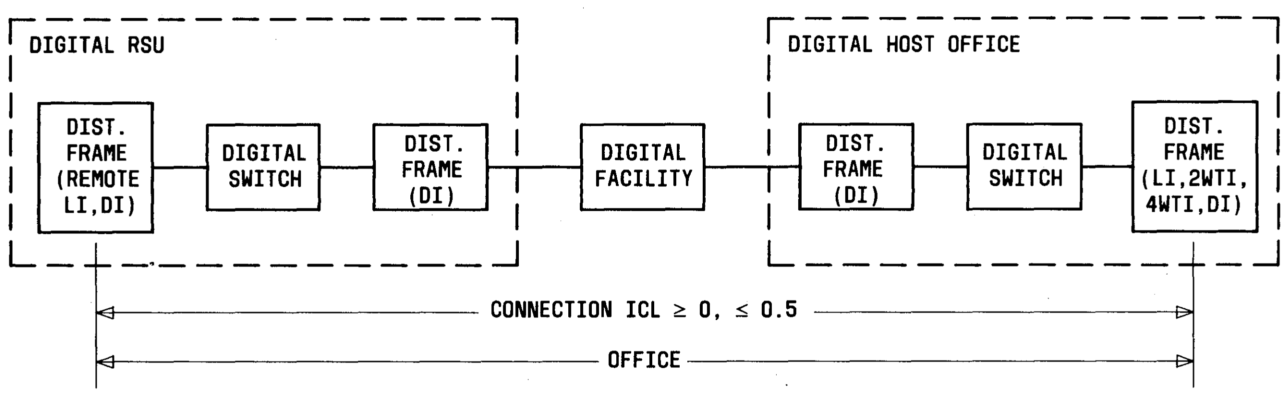
3.13 RSUs under the control of Stored Program Control (SPC) offices are being introduced into the network. The RSU is classified in the network hierarchy as part of the class 5 office that controls it. Figure 6(A) shows an example of an analog RSU [No. 10A Remote Switching System (RSS)] associated with an analog office, and Fig. 6(B) shows an example of a digital RSU associated with a digital office.

VIA NET LOSS PLAN

3.14 The Bell System standard loss plan for the analog network is the 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 study has compared the connection loss obtained with the VNL plan with that obtained through more recently developed optimal loss considerations. This comparison is shown in Fig. 7. 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



(A) ANALOG RSU/ANALOG OFFICE



(B) DIGITAL RSU/DIGITAL OFFICE

Fig. 6—Examples of Remote Switching Unit (RSU) Arrangements

optimum for short connections, the difference is not great enough 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.

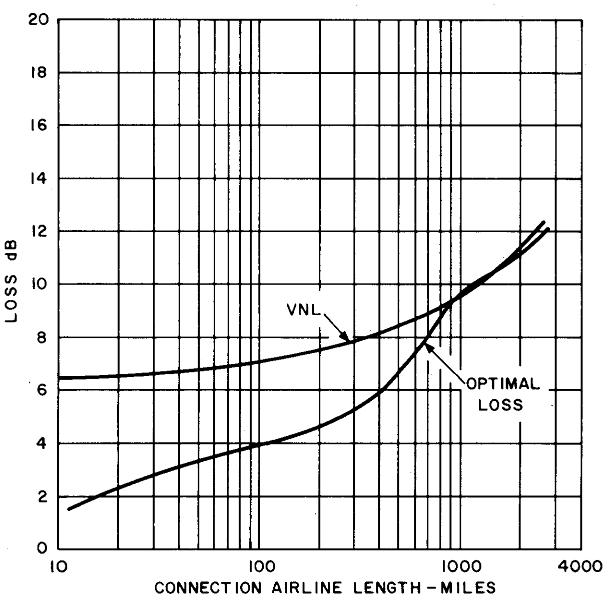


Fig. 7—Optimal Loss Compared With VNL

3.15 The VNL plan was developed using the available echo tolerance curves, the number of trunks in a connection, the expected random deviations in trunk losses from design values, and the expected ERL 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 and are plotted in Fig. 8.

> ***Note:*** The echo tolerance curves used to develop the VNL plan preceded by a number of years the loss-noise-echo subjective opinion model referred to in paragraphs 2.05 and 3.03.

3.16 The VNL allocation plan was developed using linear approximations to these curves. The approximation for a single trunk connection, also plotted in Fig. 8, 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 ms round trip delay; connections requiring greater loss would be equipped with echo control devices such as 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:

$$DB = 5.0 + .04N + .01D$$

Where: DB = Class 5 to class 5 loss (dB)

N = Number of trunks

D = Echo path loss (ms).

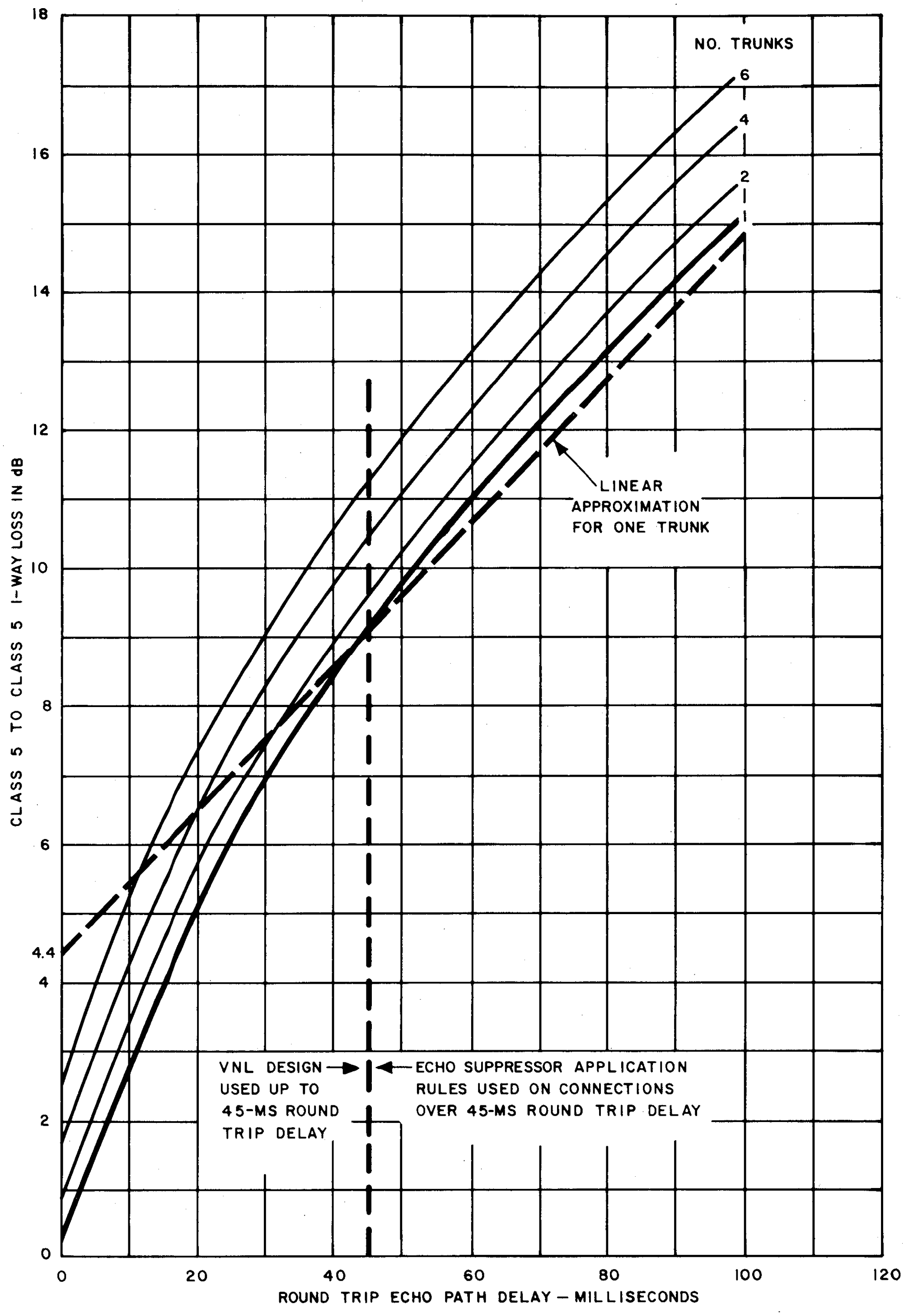
3.17 The trunk plan was developed to ensure that this required connection loss is achieved on all connection lengths. The procedure was to assign half of the constant 5-dB loss to each toll connecting trunk (TCT) and to assign the remainder to all trunks, including TCTs, in proportion to the echo path delay of each trunk. This remainder is called 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.

$$DB = (\Sigma VNL + 5)$$

Where: DB = Class 5 to class 5 loss (dB)

VNL = (.01D + .04)

D = Echo path delay (ms).



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. 8—Relationship Between Overall Connection Loss and Echo Path Delay (Class 5 to Class 5 Office)

3.18 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:

$$\text{VNL} = [\text{VNLF (1-way distance)} + 0.4]\ \text{dB}$$

$$\text{where VNLF} = \frac{2 \times 0.10}{\text{velocity of propagation (miles per second)}}$$

3.19 The factor "2" appears in this derivation because the factor 0.1 is the 1-way incremental loss in dB per unit delay while the 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 equipment as well as the velocity of signal propagation over the transmission medium (carrier, radio, or voice-frequency facilities). The accepted values for the VNLFs of typical facilities are as follows:

Carrier (all types including microwave radio)

4-wire circuits, 0.0015 dB per mile.

Exchange cable (H88 or other voice-frequency loaded and nonloaded)

2-wire circuits, 0.04 dB per mile

4-wire circuits, 0.017 dB per mile.

Although there has been some decrease in the delay of carrier systems since the VNLFs were established, the difference is not great enough to warrant a change in the factor and in the required loss.

3.20 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 that 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 B.)

TABLE B

VNL AND ICL VALUES FOR TRUNKS OPERATING ON ALL CARRIER FACILITIES

TRUNK LENGTH MILES	ICL = VNL dB (0.0015 X AVG. LENGTH + 0.4 dB)
0 — 165	0.5
166 — 365	0.8
366 — 565	1.1
566 — 765	1.4
766 — 965	1.7
966 — 1165	2.0
1166 — 1365	2.3
1366 — 1565	2.6
1566 — 1850	2.9
Any length with echo suppressor (Note 2)	0.0

Notes:

1. EML (dB) = ICL (dB) + 4 dB for analog offices having 2-dB pads in the measuring facilities at each end. For digital offices using 3-dB pads at both ends, EML (dB) = ICL (dB) + 6 dB. For trunks with a 2-dB office at one end and a 3-dB office at the other end, EML (dB) = ICL (dB) + 5 dB. (See combination trunk loss objectives [paragraphs 3.41 through 3.48] and digital trunk objectives [paragraphs 3.49 through 3.53]).
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 dB. In such cases, the ICL should be 0.5 dB and the EML should be 4, 5, or 6 dB greater in accordance with Note 1. However, newer echo control devices will allow the 0 dB objective to be met in all cases.

ANALOG TRUNK LOSS OBJECTIVES

3.21 This subpart states the loss objectives for the classes of analog trunks within toll and metropolitan networks. 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 C summarizes all of the loss objectives.

A. Toll Network-Intertoll Trunks

3.22 An intertoll trunk connects a toll switching office to another toll switching office (class 1, 2, 3, or 4). Due to balance requirements, the trunk must be 4-wire using physical (exchange cable) facilities or carrier. Use of long physical facilities is not recommended. Loss design is ICL = VNL dB.

> ***Note:*** Trunks between a class 4 office and a class 4X office (Section 3) are considered to be intertoll trunks. It is expected that the 4X office will be a 4-wire switching system (or equivalent) connected via 4-wire facilities to the class 4 office.

3.23 The loss of carrier trunks is rounded to the nearest 0.3-dB step. Since most intertoll trunks operate on carrier, Table B reflecting the 0.3-dB steps is provided as a convenient reference.

B. Toll Connecting Trunks

3.24 A TCT interconnects an end office (class 5) to a higher ranking toll office. The basic loss design objective is ICL = 2.5 + VNL dB.

> ***Note:*** Trunks between a class 5 office and a class 4X office (Section 3) are TCTs.

An alternative design is allowed which permits wide use of metallic facilities for TCTs less than 200 miles (constitutes most TCTs). Objectives for this alternate design are as follows:

TCT ICL Design Objectives (dB)*

	Without Gain	With Gain/Carrier Objective	Max.
<200 Miles	2.0 to 4.0	3.0	4.0
>200 Miles	—	VNL + 2.5	5.4

*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, variations in equipment/facilities due to environmental factors will cause AML to deviate from the design value.

3.25 Intertoll trunks between 4-wire switching systems generally have additional gain available which, if added to a connection, makes it possible to increase the loss of TCTs by an amount equal to the available gain. This involves gain transfer across the switch and is referred to as "high-loss design" for TCTs. Switching pads ("A" pads) are included in the intertoll trunks and the loss of TCTs 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 TCT. Steps must be taken to ensure 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 a high-loss trunk, the trunk may sing. Administrative difficulties and availability of lower cost gain devices make this approach less desirable for new switching centers.

C. End Office Toll Trunks

3.26 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 as shown:

TABLE C

LOSS DESIGN OBJECTIVES OF THE NETWORK

TRUNK TYPE			EQUIVALENT	ICL (dB)	MAXIMUM ICL (dB)	ECHO SUPP. MILES	REMARKS
ANALOG TRUNK	TCT			2.5 + VNL			(1) Trunks without gain < 200 miles ICL: Min. 2.0 dB Max. 4.0 dB (2) Trunks with gain <200 miles, Max.=4.0 dB >200 miles, Max.=5.4 dB
ANALOG TRUNK	ITT	HU		VNL	2.9	1850	With Echo Supp ICL — 0 dB
ANALOG TRUNK	ITT	Final		VNL	1.4		
ANALOG TRUNK	EOT: Class 5 — Class 5			6.0 + VNL	8.9 (200-4000 Route Miles)	No Echo Suppressors	(1) Trunks without gain < 500 miles ICL: Min. 0 dB Max. 5.0 dB (2) Trunks with gain <200 miles ICL = 3.0 dB (3) Trunks >1850 miles ICL = 8.9 dB
ANALOG TRUNK	EOT: Class 5 — Higher Class			2.5 + VNL	5.5 (200-1850 Route Miles)	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			
DIGITAL TRUNK	ITT			0		1850	
DIGITAL TRUNK	EOT: Class 5 — Higher Class			3.0		1850	With Echo Supp. ICL = 3.0 dB
DIGITAL TRUNK	EOT: Class 5 — Class 5			3.0 6.0			0 to 200 miles 201 to 1000 miles
COMBINATION TRUNK	TCT			3.0			
COMBINATION TRUNK	ITT			1.0		1850	
COMBINATION TRUNK	EOT: Class 5 — Class 5			3.0 6.0			0 to 200 miles 201 to 1000 miles
COMBINATION TRUNK	EOT: Class 5 — Higher Class			3.0		1850	With Echo Supp. ICL = 3.0 dB
OPERATOR SERVICE	Manual Switchboard	Class 5 — Switchboard	TCT	2.5 + VNL	4.0		
OPERATOR SERVICE	Manual Switchboard	Secondary ITT		0	0.5		
OPERATOR SERVICE	TSPS	RTA to TSPS Base Unit	ITT	0			See Fig. 17.
OPERATOR SERVICE	No. 5 ACD (See Fig. 18)	Local DA: Class 5 — ACD	Tandem Trunk	3.0			
OPERATOR SERVICE	No. 5 ACD (See Fig. 18)	Class 5 — Concentrator	Tandem Trunk	3.0			Unless gain transfer is used with ≠ 1 trunk concentrator.
OPERATOR SERVICE	No. 5 ACD (See Fig. 18)	Concentrator — ACD	Intertandem Trunk	0.5			
OPERATOR SERVICE	No. 5 ACD (See Fig. 18)	Intra-NPA DA: Tandem Office — ACD	Intertandem Trunk	0.5 1.5			From directional tandem From sector tandem
OPERATOR SERVICE	No. 5 ACD (See Fig. 18)	Toll — DA Class 3 — ACD	ITT	0.8	0.8		
OPERATOR SERVICE	AIS and No. 5 ACD Intercept (See Fig. 18 and 19.)	Class 5 — ACD	AIS Trunk	3.0			
OPERATOR SERVICE	AIS and No. 5 ACD Intercept (See Fig. 18 and 19.)	Class 5 — Concentrator	AIS Trunk	3.0			Unless gain transfer is used
OPERATOR SERVICE	AIS and No. 5 ACD Intercept (See Fig. 18 and 19.)	Concentrator — ACD or AIS	ITT	0.8			

Notes:

1. VNL = VNLF × (Avg. Length) + 0.4 dB.
2. VNLF, see paragraph 3.18.
3. Loss requirement for ITT on carrier facility can be found in Table B.

TYPE OF END OFFICE TOLL TRUNK	LENGTH (ROUTE MILES)	INSERTED CONNECTION LOSS
Class 5 to Class 5	0 to 200	Without Gain Min. = 0.0 dB Max. = 5.0 dB
		With Gain or Carrier 3.0 dB
	201 to 4000	VNL + 6.0 dB Max. = 8.9 dB*
Class 5 to Higher Class	0 to 200	Without Gain Min. = 2.0 dB Max. = 4.0 dB
		With Gain or Carrier 3.0 dB
	201 to 1850	VNL + 2.5 dB Max. = 5.5 dB
	>1850	3.0 dB (echo control device at higher class office)

*Class 5 to class 5 end office toll trunks longer than 1850 route miles should be designed to the maximum loss of 8.9 dB.

The design objective for class 5 to class 5 trunks longer than 200 miles provides about the same loss as that which would occur on an end-to-end connection switched through the network. Direct application of the VNL design formula would allow 1 dB less loss. The higher value was recommended in order to avoid the use of echo control devices on these trunks.

3.27 For trunks longer 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 shorter than 200 miles may be 2-wire. It is recommended that if any portion of the trunk is 4-wire (carrier) the entire trunk should be 4-wire.

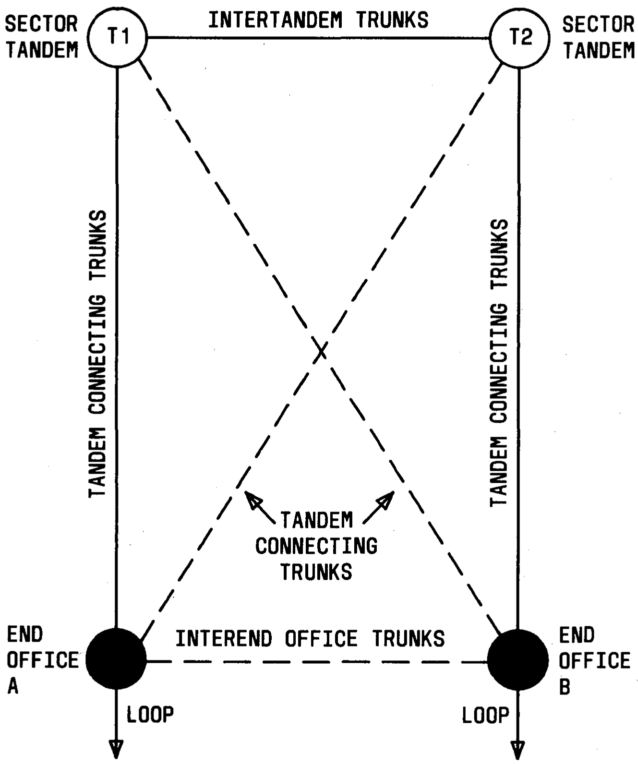
D. Metropolitan and Nonmetropolitan Local Networks

3.28 Both metropolitan and nonmetropolitan local networks often use configurations which differ from the 5-level North American Network. This permits, and in some cases results from, less sophistication in the switching systems used for metropolitan traffic. Small local networks may be nonhierarchical and contain no alternate routing. Large local networks will usually be a 2-level hierarchy and may employ automatic alternate routing. Metropolitan and nonmetropolitan local networks may be utilized to provide extended area service or local exchange service or to establish any other connection totally within a confined geographic area.

3.29 Two-level metropolitan networks are frequently integrated with the 5-level North American Network. Any trunks carrying toll traffic must be designed and maintained as part of the 5-level network.

3.30 Metropolitan local networks must be designed such that no connection contains more than three trunks (two tandem plus one intertandem). The maximum distance allowed between extreme points in a metropolitan network serving area is from 150 to 200 miles depending on the facility types to ensure that a round trip delay in excess of 10 ms is rarely exceeded.

3.31 The following definitions apply to trunks in the entire network, but the transmission objectives provided in Fig. 9 apply to trunks which carry only local traffic.



ICL DESIGN OBJECTIVES			
TRUNK	WITHOUT GAIN (dB)	WITH GAIN (dB)	
		OBJECTIVE	MAXIMUM
INTEREND OFFICE	0.0 - 5.0	3.0	5.0 (VOICE REPEATER ONLY)
TANDEM CONNECTING	0.0 - 4.0	3.0	4.0 (VOICE REPEATER ONLY)
INTERTANDEM	-	1.5*	-

* SEE PARAGRAPH 3.32

Fig. 9—Metropolitan Local Network

(a) ***Interend office trunk:*** A trunk connecting any two end offices. It should not be connected to another trunk.*

*For service restoration due to switching system or facility failures, a local interend office trunk may be connected to another trunk at one end. On Mother's Day, Christmas, and during a crisis, an interend office trunk with an EML of 3.0 dB or less may be connected to a toll ***completing*** trunk.

(b) ***Tandem connecting trunk:*** A trunk connecting an end office with a tandem switching system and having the capability to be connected to another trunk.

(c) ***Intertandem trunk:*** A trunk connecting any two tandem switching systems and having the capability to be connected to another trunk at each end.

3.32 Intertandem trunks must use 4-wire facilities and intertoll type relay equipment to provide singing protection. Intertandem trunks for local traffic only should be designed to have an ICL of 1.5 dB unless one or both ends terminate in a toll switching system or a sector tandem that meets balance requirements on intertandem trunk to tandem connecting trunk connections. In this case, the trunk design objective should be an ICL of 0.5 dB. Intertandem trunks that are terminated in a 2-wire toll switching system should have their Network Build-Out (NBO) capacitance adjusted to the same values as those used with intertoll trunks terminated in that same office.

SWITCHED DIGITAL NETWORK LOSS DESIGN

3.33 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- and short-haul digital facilities, it is possible to have an SDN in which the voice signal is digitally encoded and decoded at the class 5 office only and the bit stream is switched at digital offices. Such a network will be quite different from the analog network which requires all messages to be demodulated to voiceband analog form at each switching system. Paragraphs 3.34 through 3.58 discuss the SDN and the evolution to it.

3.34 The VNL design plan discussed previously is not well suited for the SDN 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 then 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.

3.35 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 at the local office ends of connections by digital processing before digital-to-analog conversion, by electrical loss after conversion, or by processes associated with conversion. 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.

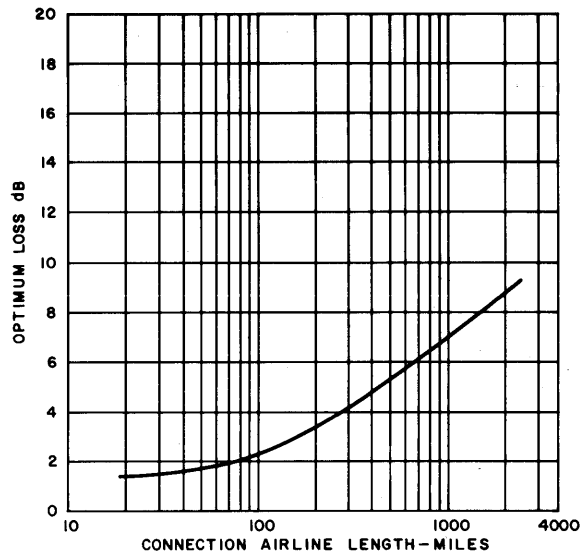


Fig. 10—Switched Digital Network Optimum Loss

3.36 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 systems. 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 less. The noise on a digital facility depends on the number of encodings 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 connection lengths. Furthermore, the talker echo performance of overall connections will be improved relative to that at present due to increased use of digital (4-wire) TCTs and their improved ERL.

3.37 Because of these factors (Fig. 10), 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 and high-loss values more appropriate.

3.38 A loss of 6 dB for all length toll connections was selected as the best compromise. In comparison with VNL design with the analog network, this plan has better loss-noise grade of 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.

3.39 Trunk loss objectives discussed in paragraphs 3.43 and 3.54 through 3.58 enable achieving 6-dB end-to-end connection loss on completely digital connections, obtaining approximately the same connection loss when digital trunks are connected in tandem with analog trunks, and satisfying maintenance considerations. The maintenance considerations are that:

(a) The measured loss, including test pads (EML), should be the same in each direction of transmission.

(b) Test tone levels should correspond to standard levels at the input and output of carrier systems.

(c) Standard loop-around tests for digital carrier systems should be preserved.

(d) The TLP of existing offices should not be changed.

3.40 Nominal trunk/connection loss objectives are expressed relative to the digital milliwatt which is defined by a particular bit stream in the μ=255 Pulse Code Modulation (PCM) format. This bit stream represents a 1000-Hz sine wave at a power level 3.17 dB below the level of a sine wave for which overload (peak clipping) begins to occur. The correspondence between the bit stream and the voiceband power level at a point in a circuit can be defined by an ELP or a DLP. The ELP is the power level in dBm of a sine wave that would be encoded into the digital milliwatt. The DLP is the power level in dBm of a sine wave that would result from decoding the digital milliwatt.

3.41 At an analog switching office, the DLP and ELP relate the power levels at the voiceband trunk terminations of combination trunks in the receive and send directions, respectively, to the bit streams on the digital transmission facilities. Since trunk loss is conventionally not inserted at the sending end, the ELP is equal to the TLP of the switch. At the receive end, the DLPs are adjusted by loss pads.

3.42 At a digital switching office, the DLP and ELP relate the power levels at the voiceband terminations of analog trunks or loops in the send and receive directions, respectively, to the digital stream within the switch. The ELP at the receive end of a trunk refers to the voiceband level after the ICL of the trunk has been realized. Generally, the ELP is fixed and the TLP is defined to be equal to the ELP. For a digital toll office, the ELP, TLP, and DLP are fixed at -3. For a local (class 5) digital office, the ELP and TLP are fixed at zero and the DLP is varied to control the connection loss. Table D summarizes the level points at digital and analog switching offices.

3.43 It follows from the definitions of ELP and DLP that the end-to-end loss for a connection through the SDN is

$$\text{Loss} = \text{ELP} - \text{DLP}$$

where the ELP is at the transmitting end and the DLP is at the receiving end. The same formula defines the loss of parts of the connection to or from intermediate digital switching offices using the ELP or DLP associated with the intermediate switch. Table E shows loss and levels for SDN trunks (digital and combination) and for some switch-to-switch connections through the SDN built up with such trunks.

TABLE D

LEVEL POINTS AT DIGITAL AND ANALOG SWITCHING OFFICES

SWITCHING OFFICE	TLP	ELP	DLP
Digital Class 5	0	0	0, −3, −5, −6, etc
Analog Class 5	0	0	Variable
Digital Toll	−3	−3	−3
Analog Toll	−2	−2	Variable

3.44 The fixed ELP and DLP of digital toll offices and the fixed ELP of digital local offices determine the loss of digital intertoll trunks to be 0 dB and the loss of TCTs from the local office to the toll office to be 3 dB. At least four distinct values of DLP must be selectable at digital local offices to complete the loss plan. Intraoffice calls require 0 DLP to provide 0 dB loss. Direct trunks between digital local offices require -3 DLP to provide 3 dB loss. To provide 3 dB loss from the toll office to the local office on TCTs, the local office requires -5 DLP if the toll office is analog (-2 ELP) and -6 DLP if the toll office is digital (-3 ELP).

3.45 The loss plan for digital offices that combine local switching functions with toll or tandem switching functions is under study.

COMBINATION TRUNK LOSS OBJECTIVES

3.46 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 network. Specifically, the following situations

TABLE E

LOSSES AND LEVEL POINTS FOR SDN TRUNKS AND CONNECTIONS

TRUNK OR CONNECTION	FROM SWITCHING OFFICE TYPE	TO SWITCHING OFFICE TYPE	ELP	DLP	LOSS
Intraoffice Connection	Class 5	Class 5	0	0	0
Interoffice Trunk	Class 5	Class 5	0	−3	3
Toll Connection	Class 5	Class 5	0	−3* −6†	3* 6†
Toll Connecting Trunk	Class 5	Toll	0	−3	3
	Digital Toll	Class 5	−3	−6	3
	Analog Toll	Class 5	−2	−5	3
Intertoll Trunk	Digital Toll	Digital Toll	−3	−3	0
	Analog Toll	Digital Toll	−2	−3	1
	Digital Toll	Analog Toll	−3	−4	1

* 0 to 200 miles.
† 201 to 1000 miles.

involving the interface of the VNL plan and the SDN loss plan will occur:

(a) 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.

(b) 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.

(c) Trunks on mixed analog and digital facilities which terminate on the digital interface of the switching system are also defined as analog trunks. Methods of provisioning such trunks are under study.

A. Intertoll Trunks

3.47 The definition of the voice-frequency interface of a digital toll 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. 11. This 1-dB minimum loss could have been avoided by having the digital office at a -2 TLP, but the class 5 offices would then 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.

> ***Note:*** Carrier TLPs (-16, +7) of Fig. 13, 14, 15, 16, and 17 apply for the D2 channel banks. The transmit and receive pads for other D channel bank types need to be specified in accordance with the TLPs: D1(-9.25, + 2.75); D3(-7.5, + 2.5); or D4(-8.5, + 4).

3.48 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

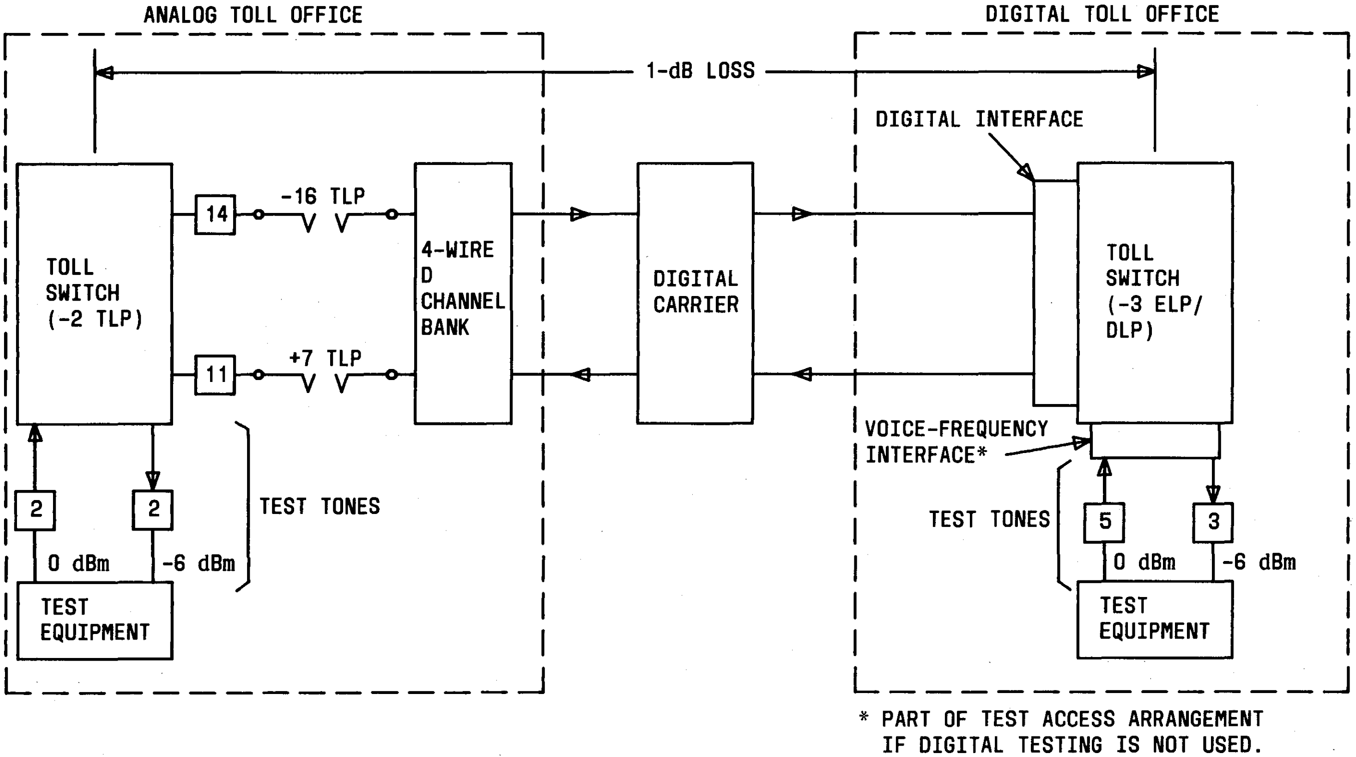


Fig. 11—Provision of Intertoll Combination Trunks (1 dB Only)

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.

B. Toll Connecting Trunks

3.49 Provision of combination TCTs is shown in Fig. 12.

C. End Office Toll Trunks

3.50 Combination end office toll trunks between class 5 and higher class offices have an ICL loss objective of 3 dB for the mileage band 0 to 1850 miles. They are provisioned as are TCTs. (See Fig. 12.) Trunks longer than 1850 miles should be designed to 3 dB and should be equipped with an echo control device at the toll office. Trunks between class 5 offices in different toll areas should be designed to 3 dB for the mileage band 0 to 200 miles and 6 dB for the mileage band 201 to 1000 miles. Loss objectives for trunks longer than 1000 miles are under study.

D. Intertandem Trunks

3.51 Design objectives and provisioning methods for combination intertandem trunks are under study.

E. Tandem Connecting Trunks

3.52 Design objectives and provisioning methods for combination tandem connecting trunks are under study.

F. Interend Office Trunks

3.53 Provision of combination direct trunks is shown in Fig. 13.

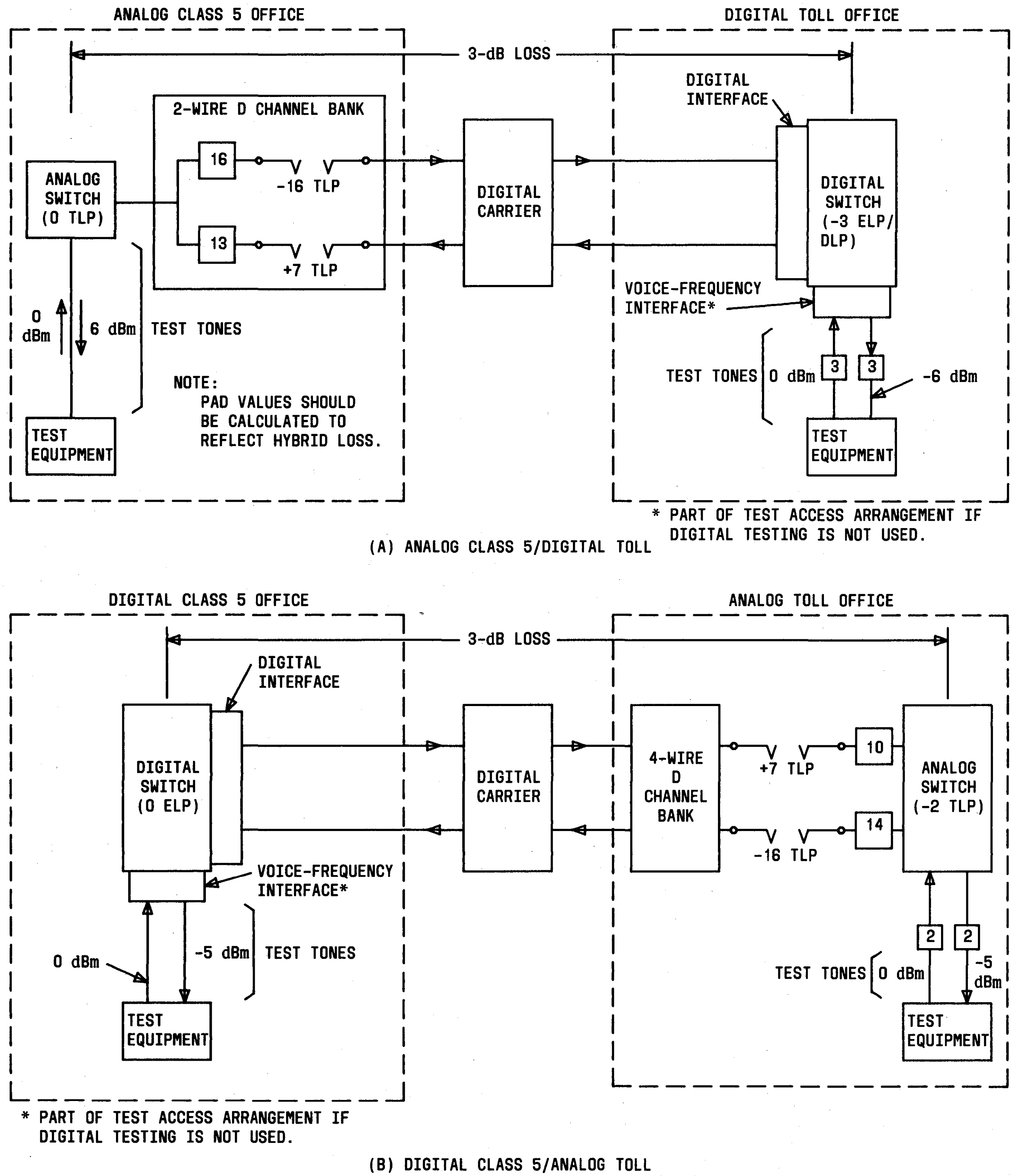


Fig. 12—Provision of Combination Toll Connecting Trunks

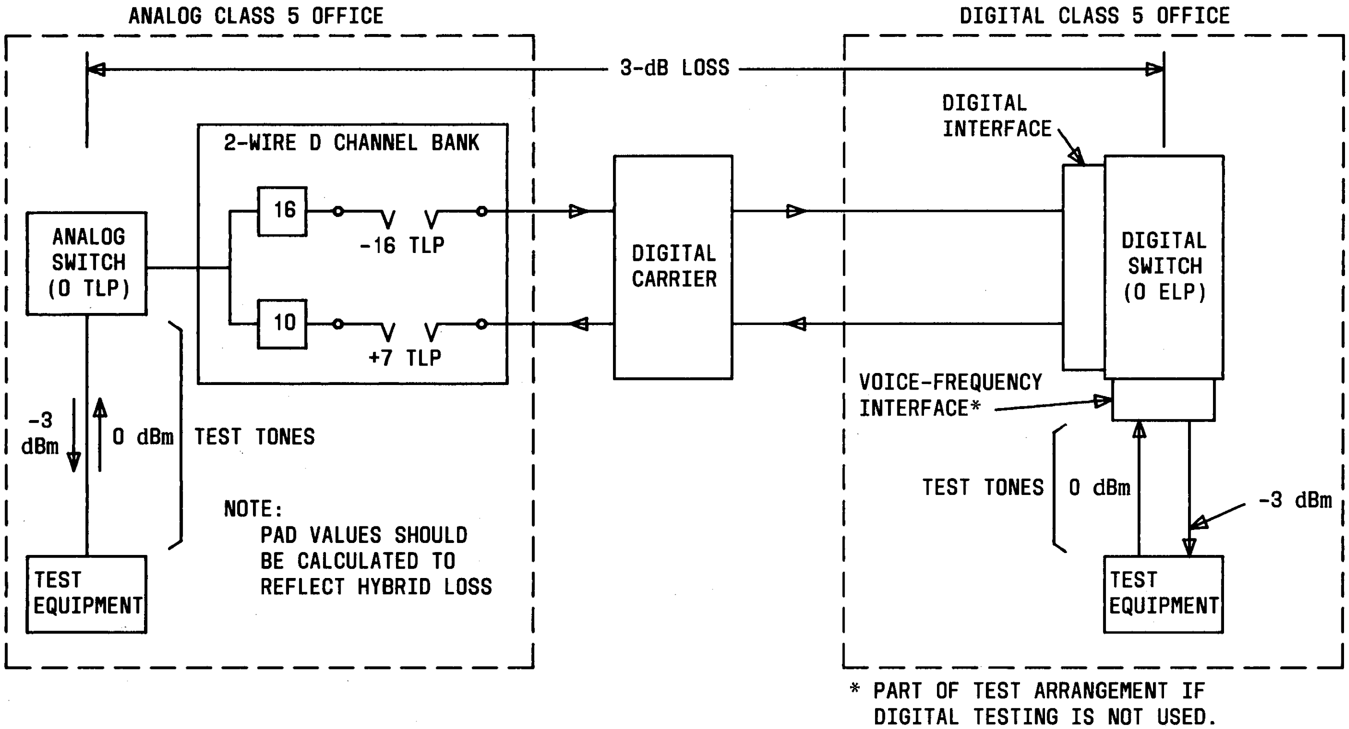


Fig. 13—Provision of Combination Interend Office Trunks

DIGITAL TRUNK LOSS OBJECTIVES

3.54 Since digital trunks are always derived on carrier facilities, the transmission distinction between toll and metropolitan trunks no longer occurs. Intertandem and tandem connecting trunks should be designed as intertoll trunks and TCTs. These objectives are summarized in Table C.

A. Intertoll Trunks

3.55 Intertoll trunks in the switched digital network are those which use digital facilities and terminate on digital switching systems at both ends without decoding. The loss on intertoll trunks between digital switches is by definition, ICL = 0 dB. Provisioning of digital intertoll trunks is shown in Fig. 14.

B. Toll Connecting Trunks

3.56 TCTs on digital facilities which terminate digitally at class 5 and class 4 or higher offices without decoding are designed to ICL = 3 dB. Provision of digital TCTs is shown in Fig. 15.

C. End Office Toll Trunks

3.57 Digital end office toll trunks between class 5 and higher class offices are designed as are digital TCTs to a loss of 3 dB for the mileage band 0 to 1850 miles. Trunks longer than 1850 miles should be designed to 3 dB and should be equipped with an echo control device at the toll office. Trunks between class 5 offices in different toll areas should be designed to 3 dB for the mileage band 0 to 200 miles and 6 dB for the mileage band 201 to 1000 miles. Loss objectives for trunks longer than 1000 miles are under study.

D. Metropolitan Networks

3.58 In the local portion of the SDN, it is desirable that all interoffice connection losses be 3 dB. Interim arrangements may have losses of 6 dB. Digital interend office trunks are designed as shown in Fig. 16.

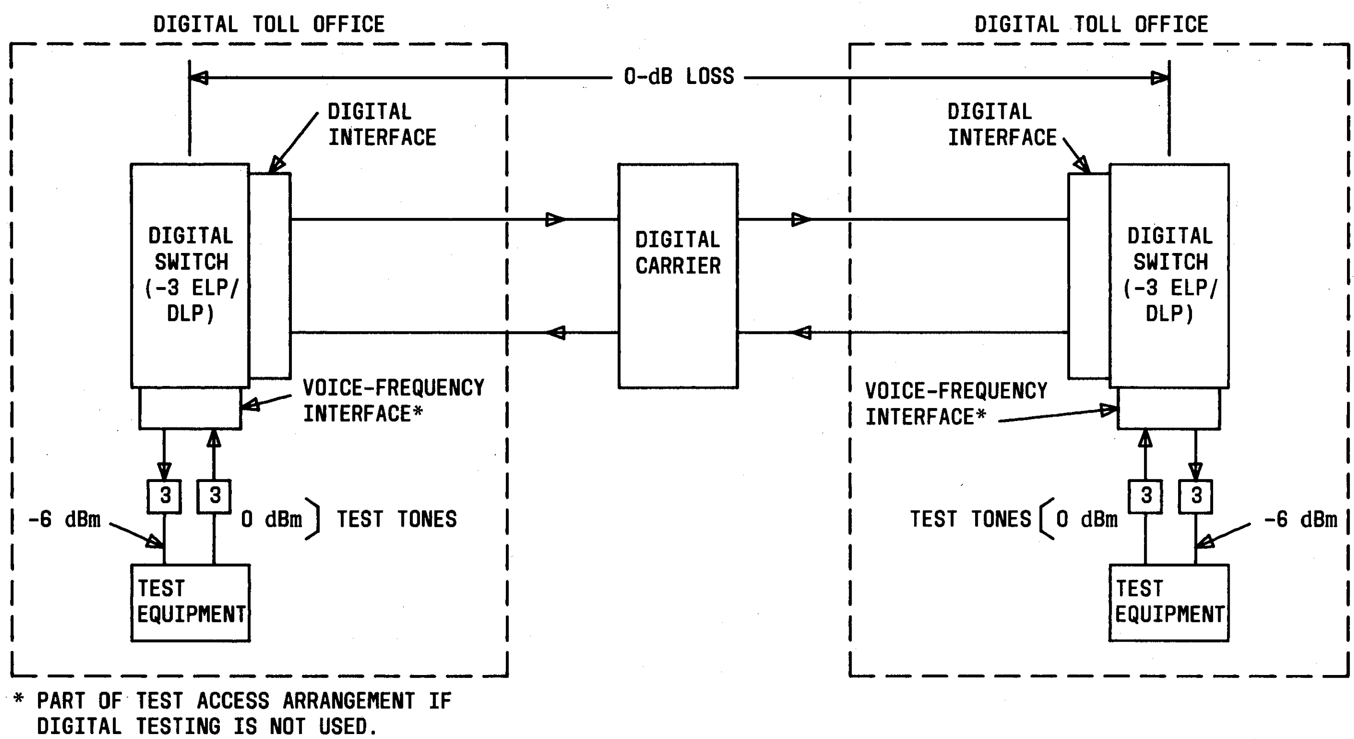


Fig. 14—Provision of Digital Intertoll Trunks

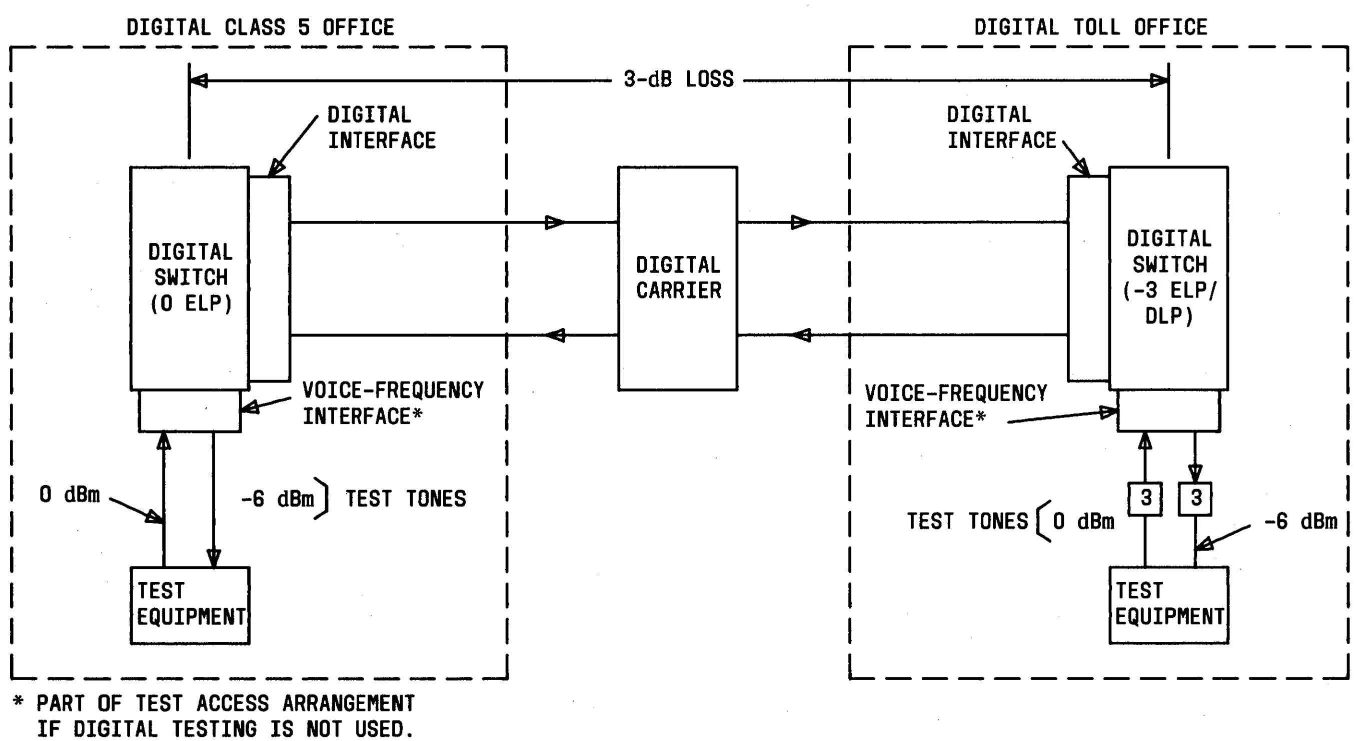


Fig. 15—Provision of Digital Toll Connecting Trunks

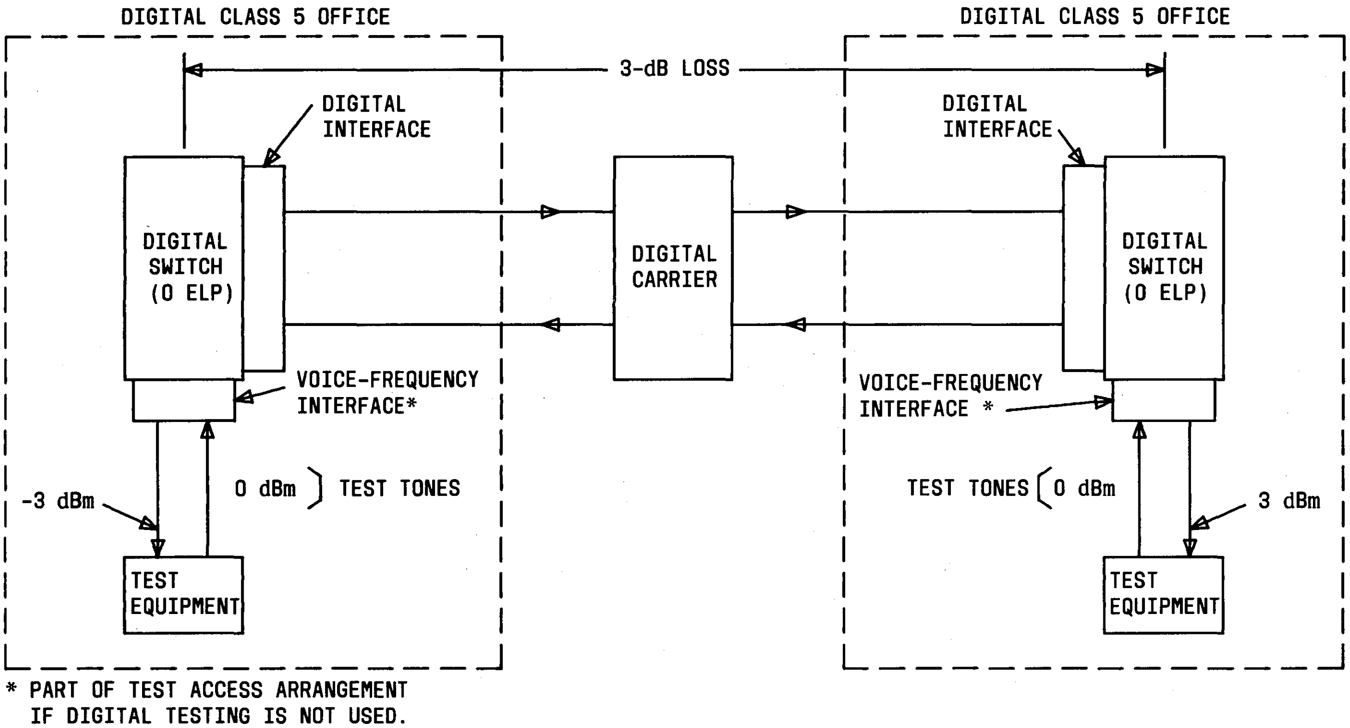


Fig. 16—Provision of Digital Interend Office Trunks

LOSS DESIGN—OPERATOR SERVICE

3.59 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.

3.60 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 Distribution (ACD) System capable in some instances of centralizing the DA 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.

3.61 The transmission performance objectives for operator-assisted calls should in principle be the same as for dial-direct calls. This means that transmission improvements for dial-direct calls should, where economically and technically justified, be accompanied by transmission improvements in operator services. However, this general principle should not be interpreted as precluding the introduction of improvements in dial-direct service without corresponding transmission improvements in operator services. For example, a call between two customers served by two separate RSSs with a common host office will have 0 dB nominal switch-to-switch loss when customer dialed (a loss reduction of 3 to 6 dB relative to the situation before Community Dial Offices [CDOs] were replaced by RSSs); but the loss might be 6 dB when operator assisted.

3.62 Loss design objectives in Table C for operator services are formulated on the basis of the general principle of paragraph 3.61. Thus, for traffic service type calls, the guideline is that the transmission performance between the operator and the calling customer should be equivalent to a short dial-direct call and the performance between the operator and the called customer should be about the same as that which the called customer will have once the call is established. Likewise, the objectives for number services are 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.

A. Manual Operator Switchboard

3.63 When operator service is established by trunks from class 5 offices to manual operator switchboards, these trunks are TCTs and their loss should be designed accordingly.

3.64 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 network 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. If due to consolidation the switchboard is located more than 50 miles from the toll office, trunks between that toll office and the switchboard are regular intertoll trunks; and the switchboard must be assigned a separate switching center rank conforming to the network hierarchy. This arrangement can be forced by the concentration of the special operator service traffic on the switchboard.

B. Traffic Service Position Systems

3.65 Figure 17 shows the facilities associated with a typical 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 (base unit or RTA) is bridged onto the TCT near the toll office end and the TLP of the TSPS is set to conform to the toll office TLP. The part of the connection between the TSPS bridge and the toll office has a 0 dB ICL objective. The ICL objectives for the TSPS together with its RTA are summarized in Table C.

> ***Note:*** Concentration of the TSPS traffic at a 4X office (Section 3) is not recommended.

3.66 Transmission design recommendations have been made to enable new flexibility in the TSPS arrangement. However, in order not to add large amounts of delay to a connection, it is required that an operator service loop, when added in tandem to a customer-to-customer connection, be no longer than 100 miles. Rules on location of base units and RTAs attempt to meet this requirement.

3.67 TSPS bridging access techniques may be 2-wire whenever the TCT or toll office which it serves is 2-wire; for 4-wire trunks to 4-wire toll offices, 4-wire bridging is required. Should 2-wire bridging result in unacceptable impedance balances for any reason, 4-wire bridging should be substituted.

3.68 If the toll office is remotely located from the TSPS, that portion of the TCT between the TSPS bridging access and the toll office shall be 4-wire and have one of the following general facility compositions listed in order of preference:

- A single intertoll grade T-Carrier system
- A single intertoll grade analog carrier system provided that the maximum facility route length does not exceed 50 route miles
- Any combination of two from the various types of intertoll grade T-Carrier systems and intertoll grade analog carrier systems used in tandem provided that the maximum analog carrier system facility route length does not exceed 50 route miles.

3.69 The ICL of that portion of the TCT extending from the TSPS base unit or RTA bridging access point through the remote toll office should be 0 dB. The ICL of that portion of the TCT between the class 5 office and the TSPS bridging point shall meet the requirements for a TCT (ICL, impedance balance, etc). (See paragraph 3.24.)

3.70 If the facility route length of the TCT extending from the class 5 office to the remote toll office exceeds 200 miles, the ICL of that portion of the TCT extending from the class 5 office to the TSPS bridging access point should be VNL + 2.5 dB (not to exceed a maximum of 4 dB).

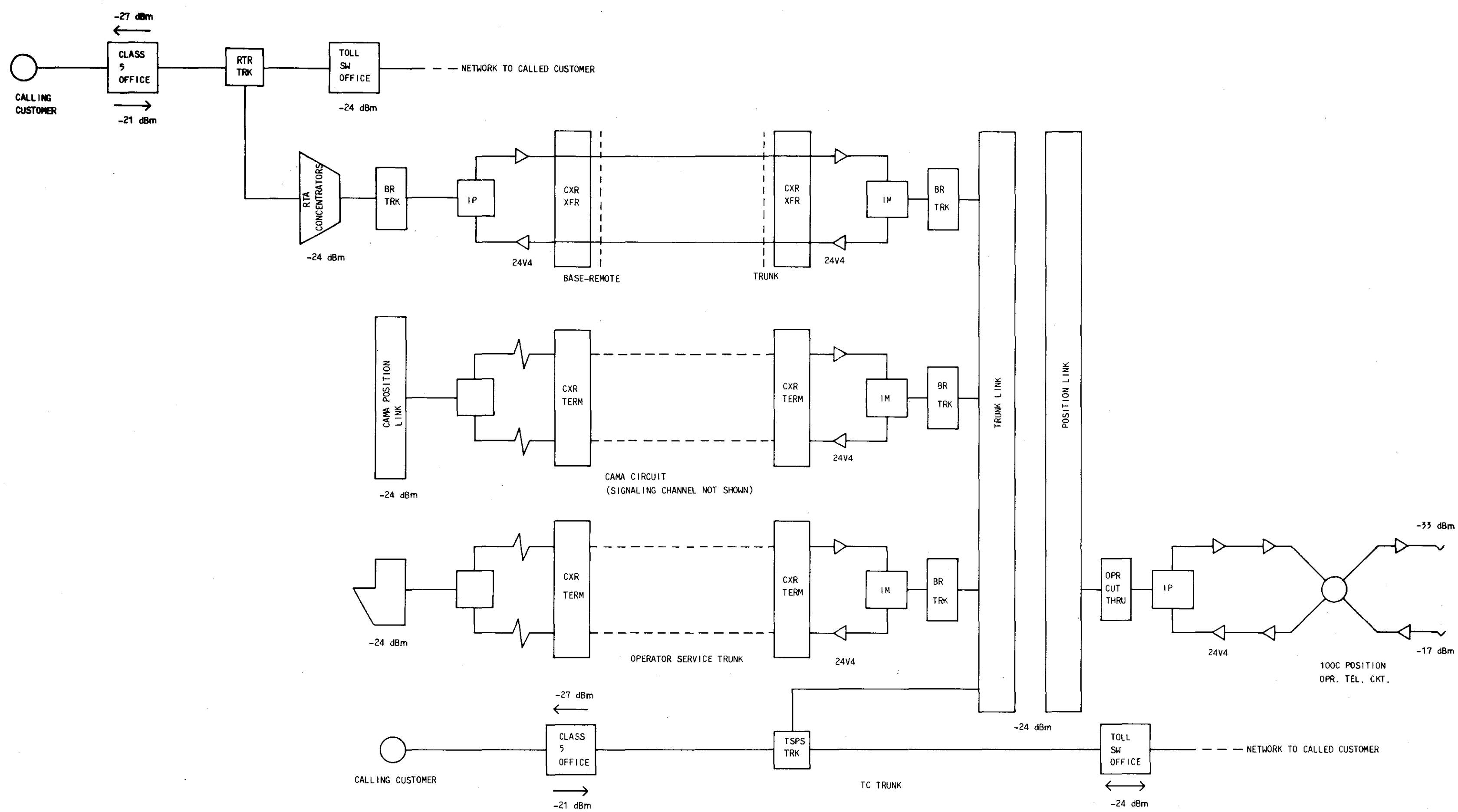


Fig. 17—TSPS and Remote Accessed TSPS

3.71 The overall trunk from class 5 office to toll office should not be comprised of more than three carrier systems.

C. Directory Assistance and Intercept Services

3.72 Referring to Fig. 18, the No. 5 ACD system network is basically similar to the regular message network. For example, toll DA is configured like the toll network and local and intra-NPA DA like the metropolitan network. The system is configured so that the No. 5 ACD switching system functions as a class 4 office or sector tandem office. In all cases, the insertion loss objective for the ACD switching system network is 3 dB total between the class 5 office originating the call and the No. 5 ACD switch. Concentrators, switchboards, or tandem offices may occur in the routing as seen in Fig. 18, and gain transfer trunks are allowed whenever the No. 1 Trunk Concentrator is used.

3.73 The No. 5 ACD switching system may be used for DA or intercept service. A more automated intercept service is provided by the artificial voice answer of the AIS. Its transmission plan is similar to the intercept portion of the No. 5 ACD plan but usually places operators on only a home Automatic Intercept Center (AIC) using the answering machine on the remote AIC (Fig. 19). The AIC switching machines must meet toll office transmission requirements.

TRUNK LOSS MAINTENANCE CRITERIA

3.74 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.

3.75 Before trunks are placed in service, losses are adjusted so that the 1004-Hz tone at the test point is as close to the desired level as the step sizes of the adjustable pads permit, typically within ±0.13 dB. The end-to-end trunk loss is required to be within ±0.5 dB of EML, although for nonrepeatered voice-frequency trunks and certain complex facility makeups ±1 dB is allowed.

3.76 In order to ensure that trunks are providing satisfactory service, loss is measured periodically. The results of these measurements are used in the quarterly Trunk Transmission Maintenance Index. To obtain a high index, the deviations from EML 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 3.0 dB must be removed from service until necessary corrective action is completed.

3.77 In order to meet the objectives of the index plan and to be consistent with the provision of good service, it is also necessary to take corrective action on trunks with deviations which are less than 3 dB. The deviation value at which corrective actions should be taken is left to the individual offices.

LOOP LOSS

3.78 The loops between the customer's telephones and the local central offices at both ends of a connection are important links of any telephone connection. Satisfactory transmission design of this loop is as important to the toll switching plan as is the design of intertoll trunks and TCTs. Because loop loss has been controlled by the use of design rules, objectives have not been explicitly stated. It is, however, desirable that the mean of the 1-kHz loop insertion loss distribution remain as it has been (based on the 1964 and 1973 loop surveys) and that the upper limit be 8 dB for newly designed plant. (However, current design plans do allow up to 9.5 dB.) Figures 20 and 21 show Transmit Loop Rating (TLR) and Receive Loop Rating (RLR) objective limits as a function of loop length. These limits have been used to evaluate new loop design plans. TLR is a measure of the conversion efficiency of the acoustic pressure input applied at the telephone transmitter to the electric voltage output measured at the central office where pressure and voltage are in loudness terms as specified by the Electro-Acoustic-Rating System (EARS). RLR is a measure of the conversion efficiency, in terms of the EARS, of the electric voltage input applied at the central office to the acoustic pressure output measured at the telephone receiver.*

*Exact conversions from the EARS loop ratings to objective loudness ratings as specified in the Institute of Electrical and Electronics Engineers Standard 661 are not available at present. However, approximate conversions are as follows: TOLR = TLR - 25; ROLR = RLR + 20.

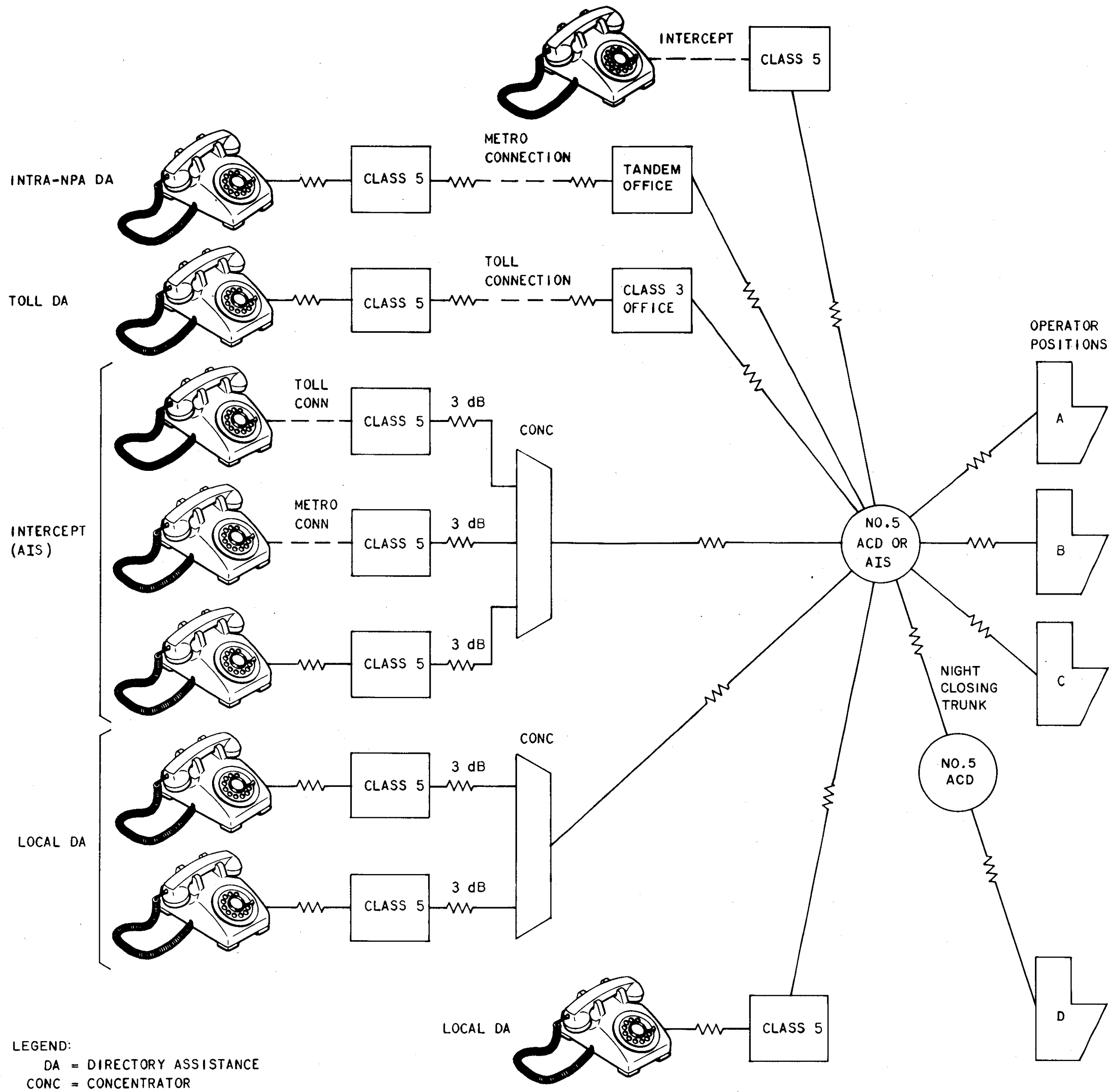


Fig. 18—Loss Plan for No. 5 Automatic Call Distribution

3.79 The following paragraphs describe the loop design plans used within the Bell System for voice-frequency cable facilities. Today, almost all loops are designed according to one of three loop design plans: Resistance Design (RD), 96 percent; Unigauge (UG) design, 1 percent; and Long Route Design (LRD), 3 percent. Each design plan has its particular area of application (urban, urban/suburban, and rural) and its corresponding set of specific outside plant design rules. Fundamental

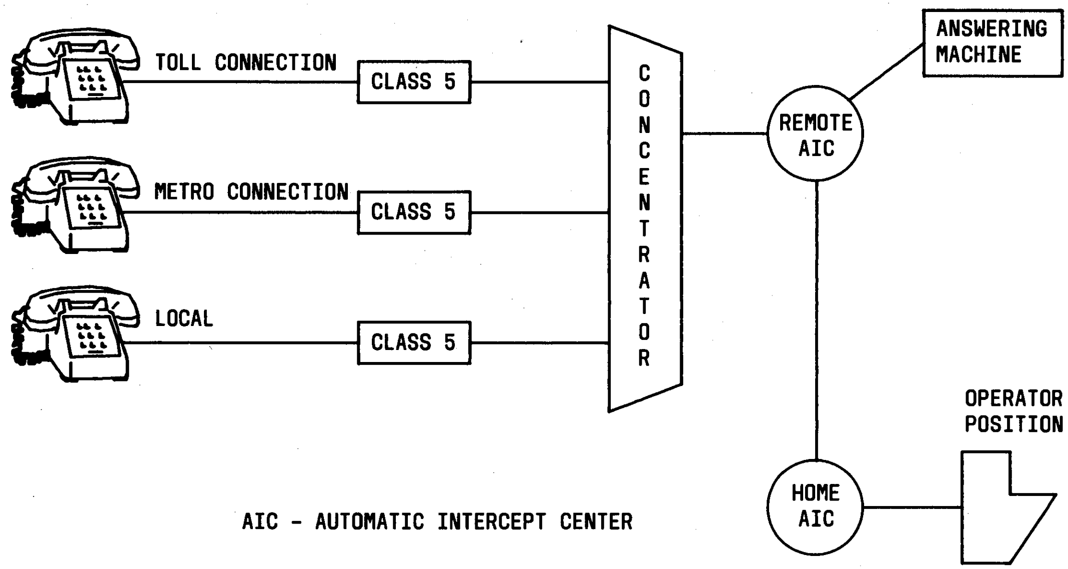


Fig. 19—Typical Automatic Intercept System

to all three plans is the notion that designing loop facilities on an individual basis is prohibitively expensive and operationally unadministrable. Instead, loops are designed on a global basis through the use of design rules that, when followed, guarantee that no loop within a distribution area exceeds the office signaling range and yields an overall satisfactory distribution of loop transmission losses.

3.80 While the global design method greatly simplifies the provisioning of loop facilities, the evolution of three distinct sets of design rules has led to a number of problems for Operating Telephone Company (OTC) outside plant planners and designers. Conversion from one design plan to another is difficult and costly because of the different outside plant requirements (eg, loading, cable gauge, etc). For example, the reluctance of OTCs to use the UG design plan as an alternative to the RD plan has in part been due to the incompatible outside plant designs. In addition, the inconsistencies among today's design rules have caused some confusion regarding gauge and loading requirements and have led to misapplications.

3.81 Unified Loop Design (ULD) is a recently introduced transmission design plan that may be used and is universally applicable on a forward-going basis (retroactive redesign not required). The new plan incorporates a modified version of the RD plan (MRD) for nonelectronic loops, a replacement for the UG design plan called Concentrated Range Extension With Gain (CREG), and a modified version of the LRD plan (MLRD) for per-line range extended loops. The ULD plan takes advantage of the enhanced supervisory and signaling capabilities of electronic offices and the low costs of electronic range extension circuits. It provides an outside plant design plan that is consistent, economical, operationally simple, and at the same time improves loop transmission performance.

3.82 Design rules for most loops currently in existence (RD, UG design, and LRD) are given in Table F and design rules for the new ULD plan (MRD, CREG, and MLRD) are given in Table G.

3.83 The major modifications to the RD plan in the ULD plan allow a higher maximum loop resistance (1500 ohms instead of 1300 ohms) and limit the maximum length of nonloaded loops (including bridged tap) to 15 kilofeet instead of 18 kilofeet. These rule changes result in transmission improvements and outside plant savings. However, in some cases, the MRD plan does result in reduced dc signaling operating margins because of the increase in maximum loop resistance to 1500 ohms. MRD is currently an optional design plan (pending the revision of RD BSPs) and, if implemented, should be applied universally in a wire center capable of supporting a 1500-ohm signaling range.

TABLE F

TODAY'S LOOP DESIGN RULES

MODIFICATION	RD	LRD	UG
Loop Resistance (Ohms)*	0 to 1300	1301 to 3600‡	0 to 2500
Load Coils	Full H88 > 18 KFT	Full H88	None to 24 KFT Partial 24 KFT
End Sections and Bridged Tap (Maximum)	Nonloaded: BT=6 KFT Loaded: ES+BT=15 KFT	ES+BT=12 KFT	Nonloaded: BT=6 KFT Loaded: ES+BT=12 KFT
Transmission Limitations	None	Central office gain required for loop resistances greater than 1600 ohms.	Central office gain applied to loop lengths > 15 KFT
Cable Gauging	Any Combination†	Any Combination†	Buffer Cable Needed§

* Includes only the resistance of the facility and loading coils.

† 19, 22, 24, or 26 gauge cable.

‡ Loops in the 2800- to 3600-ohm range require gain at the customer's premises or in the middle of the loop.

§ Requires specified amounts of 26-gauge cable adjacent to central office.

3.84 The major modifications to the LRD plan in the ULD plan involve the change of the loop resistance range from 1300 to 3600 ohms to 1500 to 2800 ohms. The range between 0 and 1500 ohms would be served by the MRD plan and the range beyond 1500 ohms by the MLRD plan. The 1500- to 2000-ohm range is designated as resistance zone 18 (RZ 18) and requires 3 dB of gain. The 2000- to 2800-ohm range (RZ 28) requires 6 dB of gain. With the introduction of the Western Electric 5A Range Extender With Gain (REG) or similar equipment, the need to maintain and administer separate transmission zones in the MLRD plan is not necessary because the 5A REG automatically switches its gain setting to provide from 3 to 6 dB net gain as required. From this standpoint, all of MLRD can be considered a single range extended zone. However, some companies which administer ringing range limitations by zone or which have a large number of old range extension circuits may still require zones 18 and 28 in the range extended region of the MLRD plan. In the new plan, MLRD (unlike LRD) is not limited to long rural loops and may be used anywhere in the wire center where economically justified. While existing loops need not be rebuilt to conform to the new plan, the gain application rules from Table G should be used for new loop designs that use existing cables.

3.85 The CREG plan in the new ULD plan is the replacement for the UG design plan that uses concentrated range extension. The CREG plan, like the UG design plan, allows for increased use of finer gauge facilities in the outside plant by providing a repeater behind a stage of switching concentration. Unlike the UG design plan, however, the CREG outside plant design is compatible with the loading employed with the MRD and MLRD plans. The CREG plan coupled with full H88 loading gives the CREG design better overall transmission performance than the UG design plan and offers significant potential savings for the outside plant. The CREG plan supersedes the UG design plan and is primarily for suburban applications.

3.86 The new loop design plans avoid the inconsistency and incompatibility problems

TABLE G

UNIFIED LOOP DESIGN RULES

MODIFICATION	MRD	MLRD	CREG
Loop Resistance (Ohms)*	0 to 1500	1501 to 2800	0 to 2800
Load Coils	Full H88 > 15 KFT	Full H88	Full H88 > 15 KFT
End Sections and Bridged Tap (Maximum)	Nonloaded: Total Cable+BT=15 KFT Maximum BT=6 KFT		Nonloaded: Cable+BT=15 KFT Maximum BT=6 KFT
	Loaded: ES+BT= 3 to 12 KFT	Loaded: ES+BT= 3 to 12 KFT	Loaded: ES+BT= 3 to 12 KFT
Transmission Limitations	None	Central office gain required for loop resistances greater than 1500 ohms.	Central office gain required for loop resistances greater than 1500 ohms.
Cable Gauging	Any Combination†	Any Combination†	Any Combination†

* Includes only the resistance of the facility and the loading coils.

† 19, 22, 24, or 26 gauge cable.

of the design rules used up to the present time. All three designs (MRD, CREG, and MLRD) employ the same loading scheme, the same end section and bridged tap rules, and are compatible with any cable gauge combination. The new plans offer improved transmission performance and all meet the Bell System interim loop transmission objectives which place limits on minimum loop ratings and which are intended for present and near future plant.

3.87 The results in Fig. 20 and 21 indicate that the new MRD plan meets the Bell System interim objectives for TLR and RLR and also indicate the transmission improvements that the plan offers compared to the RD plan. Similar transmission improvements are offered by the new CREG plan compared to the UG design plan. Performance offered by the new MLRD plan and the LRD plan is about the same except in the 1500- to 1600-ohm resistance range where the MLRD plan provides gain which results in better performance in that resistance region.

3.88 The most recent data available on loop design characteristics was obtained in a 1973 loop survey. Calculations from these data indicated that the average 900-ohm, 1-kHz loop insertion loss was 3.7 dB with 90 percent confidence limits at ±0.14 dB. Approximately 2 percent of the loops had loss between 8.5 and 10 dB. It is not possible to state the percentage of these loops that may have been incorrectly designed. However, design rules when properly applied permitted a small percentage of loops to be in this range but did not yield loop loss in excess of 10.5 dB. Any loop measuring more than 10.5 dB can be considered a service deficiency. Under the new ULD rules, no properly designed loop will have more than 8 dB loss at 1 kHz.

4. BALANCE

4.01 Echo can occur at any 4- to 2-wire junction or 2-wire impedance irregularity. The amount of echo returned is a function of the mismatch between the impedances at those points. Balance procedures are used to control the mismatch as a fundamental means of controlling echo. Impedance mismatch at different levels of the switching hierarchy is controlled by through balance,

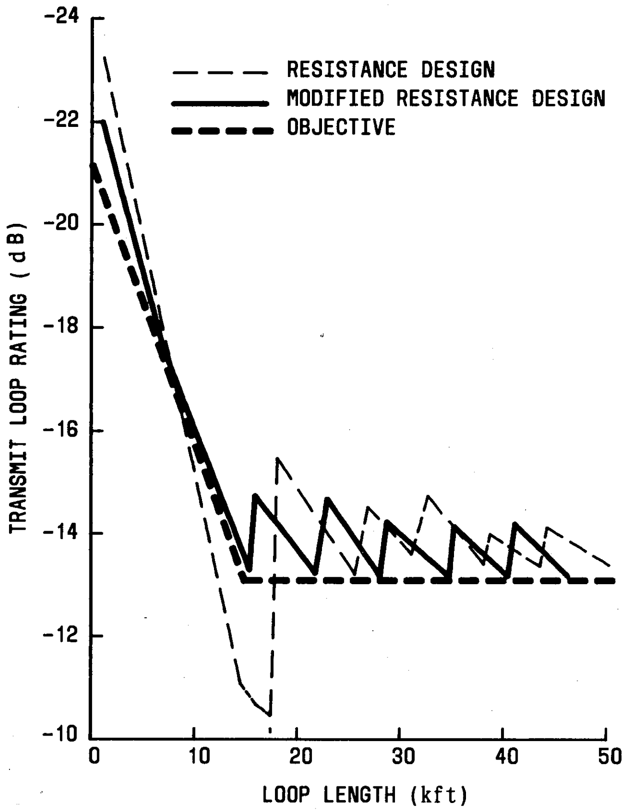


Fig. 20—Transmitting Loop Rating

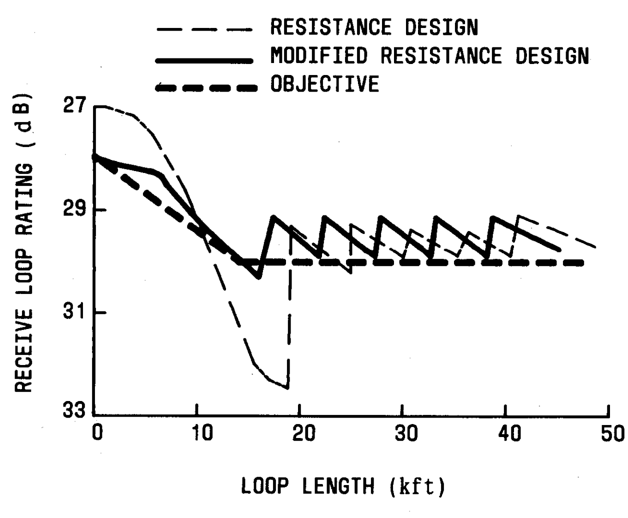


Fig. 21—Receiving Loop Rating

toll terminal balance, and loop terminal balance procedures.

4.02 Customer loops have more impedance variation than any other transmission facility. Therefore, the predominant echo normally occurs at the 4- to 2-wire junction (hybrid) closest to the subscriber loop. Any additional echoes would further degrade talker and listener echo.

4.03 Balance is controlled so as to meet objectives for the ERL, Singing Return Loss (SRL), and WEPL.

(a) ERL is the average of return loss over the echo band (500 to 2500 Hz) as weighted by a standard return loss measuring set or its equivalent.

(b) SRL is the lower of two average return loss measurements in the high and low singing bands, respectively (200 to 500 Hz and 2500 to 3000 Hz), as weighted by a standard return loss measuring set or its equivalent.

(c) WEPL is the reciprocal of the average magnitude of the round trip voltage gain of the listener echo path (including transmission loss in both directions and return loss at both ends) over the band from 200 to 3400 Hz.

For ERL and SRL, actual measurements are corrected by the circuit losses between the signal source and the detector before comparison to the objectives.

THROUGH BALANCE

4.04 Intertoll trunks are provided on 4-wire facilities to prevent intermediate echoes. However, through balance procedures are necessary to control echo at 4- to 2-wire conversions wherever a 2-wire switching system is used to interconnect intertoll trunks. The amount of echo returned at these conversions depends in part on the impedance on the 2-wire side of the intertoll terminating set. This impedance depends primarily on the amount of office cabling from this set through the switch to the outgoing terminating set. Through balance procedures are intended to make the impedance of all possible paths through the switching system nearly equal.

4.05 The through balance requirements at a 2-wire switching point are shown in Table H. The transmission elements involved in through balance are shown schematically in Fig. 22. The impedance of the office cabling can be approximated by 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, Drop Build-Out (DBO) capacitance is used on shorter paths to make them capacitively equivalent to the longest possible path taking into consideration growth which may occur. The 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 ensuring that 50 percent of the paths from the center of the switch to a hybrid are less than 1000 feet and the longest path is less than 1200 feet.

TOLL TERMINAL BALANCE

4.06 Toll terminal balance controls the echo at a toll switching office where an intertoll trunk is connected to a TCT. Toll terminal balance procedures are required in all toll offices having trunks to or from a class 5 office, except when the toll office, trunks, and class 5 offices are all 4-wire.

> ***Note:*** A class 4X office is 4-wire and is connected to the class 4 office by 4-wire facilities. In principle, the entire path from a class 4 office through a class 4X office to any class 5 office should meet terminal balance requirements.

4.07 Return loss associated with toll terminal balance is measured at the toll office with the TCT terminated in a quiet termination at the class 5 office. Figure 23 shows the possible combinations of 2- and 4-wire facilities involved in toll terminal balance measurements. If the class 5 office is a 2-wire office (such as a conventional analog switch), the quiet termination is 900 ohms in series with 2.16 microfarad. The return loss then includes all impedance irregularities up to

TABLE H

OFFICE BALANCE REQUIREMENTS

	ERL, dB		SRL, dB	
	MEDIAN AND CIRCUIT ORDER LIMIT	MINIMUM AND TURNDOWN LIMIT	MEDIAN AND CIRCUIT ORDER LIMIT	MINIMUM AND TURNDOWN LIMIT
TERMINAL BALANCE:				
Analog Switch:				
2-wire facilities:				
Interbuilding	18	13	10	6
Intrabuilding	22	16	14	10
4-wire facilities	22	16	15	11
Digital Switch:				
2-wire facilities:				
Interbuilding	18	16	13	11
Intrabuilding	22	16	15	11
4-wire facilities	22	16	15	11
THROUGH BALANCE	27	21	20	14

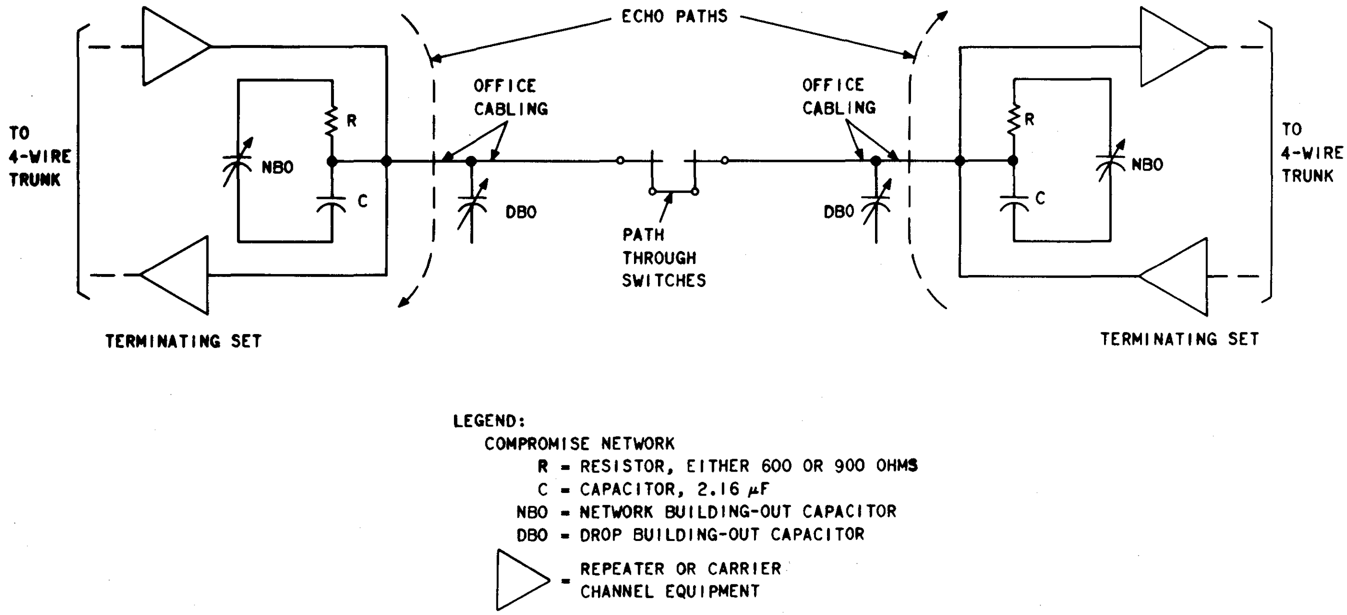


Fig. 22—Switching of 4-Wire Trunks at a 2-Wire Switching Office

and including the class 5 office. If the class 5 office is a 4-wire office (such as a digital switch), the quiet termination should be either a 4-wire termination which returns no echo or any other termination which will have insignificant influence upon the measurement of return loss at the toll office. The return loss measurement then includes the effect of impedance mismatch at hybrids, as in through balance, as well as the effects of cable irregularities on 2-wire metallic facilities.

4.08 The return loss values obtained for terminal balance are highly dependent on proper design and installation of the TCT. This includes the use of pads in short trunks, impedance compensators on loaded trunks, and gain devices located at class 5 offices.

4.09 Present TCTs should meet the toll terminal balance requirements in Table H. The requirement headed "Digital Switch" applies to all types of TCTs connected to a digital toll switching system. This higher return loss is needed because the SDN plan uses less loss for control of talker echo. The analog requirement applies to all other TCTs.

4.10 The study which reaffirmed the use of VNL design for the analog network also indicated that considerable echo improvement would be realized if the terminal balance requirements could be tightened. Thus a long-term balance objective was established for all TCTs of:

50 percent: 22 dB ERL, 15 dB SRL
Minimum: 16 dB ERL, 11 dB SRL.

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.

TOLL BALANCE MAINTENANCE CRITERIA

4.11 To meet balance requirements, a toll office must have at least 50 percent of all trunks meeting or exceeding the median requirement and none below the appropriate minimum requirements for ERL and SRL. For initial installation of a trunk, no trunk below the circuit order limit should be turned up for service unless the staff transmission engineer specifically agrees. This approval would be based in part on knowing that the median for the trunk group category would still meet the median requirement. On subsequent testing, any trunk measuring below the turndown limit should be removed from service.

4.12 Every office which has met initial balance requirements should be surveyed at 1- or

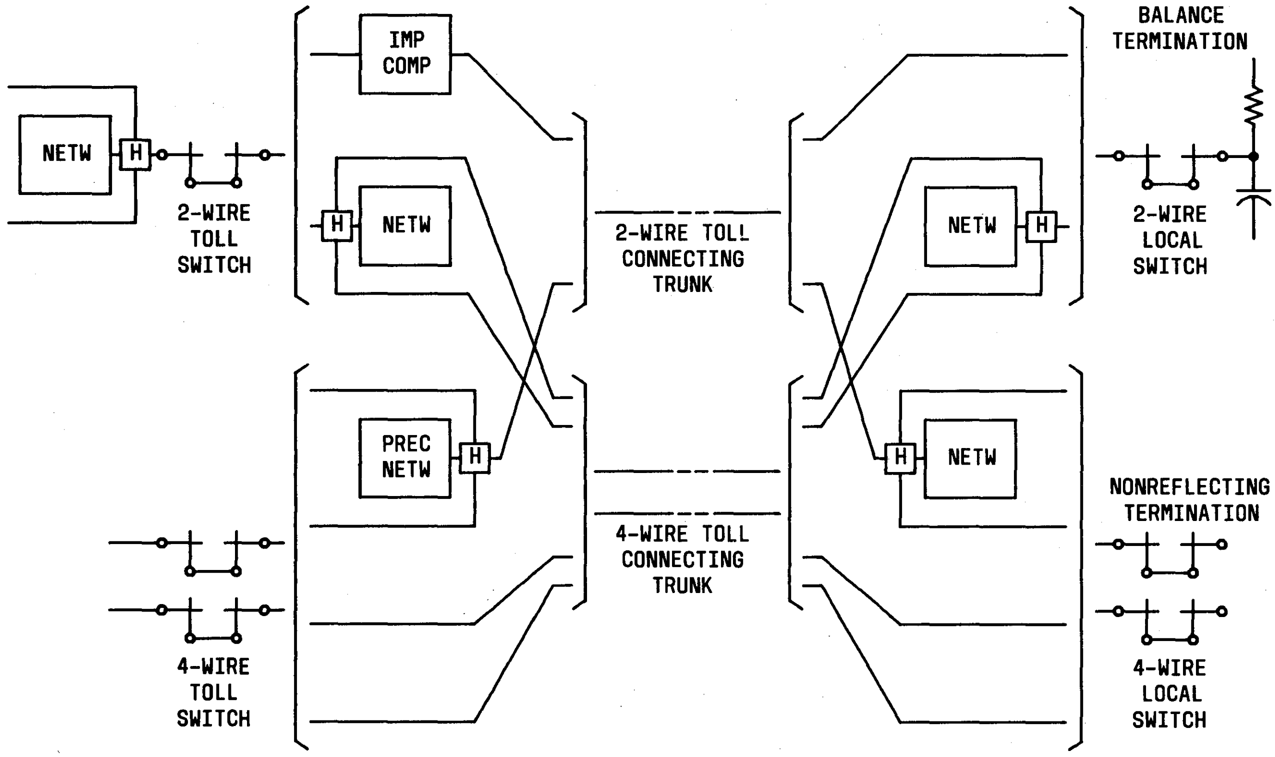


Fig. 23—Terminal Balance Arrangements

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 the measurements greater than the median requirement and none below the minimum in each through balance and toll terminal balance category. The results constitute the balance component of the Bell System Trunk Transmission Maintenance Index.

TANDEM OFFICE BALANCE

4.13 Tandem switching offices perform switching functions in metropolitan networks similar to the functions of toll offices in the toll network. A sector tandem connects tandem trunks to other tandem trunks or to intertandem trunks. Toll office balance requirements are applicable to any tandem switching office that also performs toll office functions.

LOOP TERMINAL BALANCE

4.14 Loop terminal balance controls the echo from the hybrids interfacing customer loops within a class 5 switching system. Listener echo can occur in certain 4-wire arrangements in class 5 offices such as digital switching systems or RSUs. An intraoffice call at such an office forms a listener echo path consisting of a low-loss 4-wire path within the office with a hybrid at each end at the junctions to the 2-wire loops. Control of echo at such offices requires particular attention to loop terminal balance.

4.15 Loop terminal balance is accomplished principally by using the appropriate compromise network at the hybrid in the 2- to 4-wire junction, as well as verifying that the hybrid itself meets appropriate requirements. Proper design of loops also contributes to good loop terminal balance.

4.16 The present standard compromise network for 2-wire loops and trunks at a class 5 office is 900 ohms in series with 2.16 microfarads. Study has shown that a better impedance match for loops can be obtained with a parallel network consisting of 1100 ohms in parallel with the series combination of 0.03 microfarad and 100 ohms. An even better match can be obtained with loop segregation and dual compromise networks. Nonloaded loops are matched with 800 ohms in parallel with the series combination of 0.05 microfarad and 100 ohms. Loaded loops are matched with 1650 ohms in parallel with the series combination of 0.005 microfarad and 100 ohms.

4.17 A digital central office is 4-wire and, therefore, requires attention to loop terminal balance in order to control listener echo. If the standard compromise network is used for all loops and zero loss is provided, intraoffice calls will not necessarily meet the objective for the WEPL listed in Table A. Digital end offices could, therefore, use loop segregation with dual compromise networks for loops to ensure satisfactory performance. The standard series compromise network is still recommended for trunks. This procedure will also result in improved talker echo performance on connections to digital end offices.

4.18 An RSU controlled by a host class 5 office is considered to be part of the host office for transmission purposes. The link between an RSU and host has zero loss and appreciable delay. A listener echo path is formed if this link is provided on a 4-wire facility. In order to meet the WEPL objectives on this path, loop segregation and dual compromise networks could be used at the RSU.

4.19 A 4-wire RSU-host link terminating on a 2-wire host switch requires a hybrid at the host switch. The balance network at this hybrid may have to match either a trunk or a loop, depending on the connection. To minimize echo from this hybrid into the listener echo path, the balance network should ideally be selected for each connection to provide either the series compromise network or one of the dual parallel networks as appropriate. Where the network cannot be selected for each connection, the single parallel compromise network is recommended.

5. ECHO CONTROL DEVICES

5.01 As discussed previously, echo control devices are used in conjunction with transmission loss design and impedance matching procedures to control echo in the message network. These devices are used in cases of high end-to-end transmission delay where the VNL required for talker-echo satisfaction would result in an unacceptable reduction in loss-noise grade of service. In general, such devices are required on long terrestrial trunks and on all trunks routed on satellite transmission facilities. Paragraphs 5.02 through 5.08 discuss two types of devices (namely, the echo suppressor and the echo canceler) and outline the current application rules.

ECHO SUPPRESSORS

5.02 An echo suppressor is a voice-activated device which senses the presence of speech in each direction of a 4-wire circuit, decides which party is talking, and inserts a very high loss in the return path to block the echo. Compromise actions are taken when both parties "double-talk" (speak simultaneously). Two typical compromise actions are the closure of both paths (removing all echo suppression) until one party is silent and insertion of moderate loss (typically 6 dB) in both paths to reduce echo at the expense of primary speech. Echo suppressors are usually designed to disable themselves in response to certain tone sequences to permit the transmission of full duplex data.

5.03 Echo suppressors may be provided as ***split pairs*** (one device at each end of a trunk protecting the talker at the opposite end) or as ***full suppressors*** (a single device on one end protecting both talkers). They may process signals internally in analog or digital form, the form usually corresponding to the type of switch (analog or digital) on which the trunk is terminated. Regardless of type, echo suppressors cause some mutilation of speech bursts during conversational transitions and permit some echo to pass during double-talking. These impairments are generally not serious on terrestrial circuits but, in extensive field subjective tests, they have been found to result in a serious customer-perceived degradation on satellite circuits.

ECHO CANCELERS

5.04 An echo canceler is a more sophisticated device which adaptively estimates the properties of the echo path, predicts the echo signal, and subtracts this prediction from the signal returned to the far end. The transmission path is never broken in either direction and the adaptation logic permits echo cancellation to proceed normally during double-talking. As a result, cancelers are the preferred echo control devices for satellite circuits.

5.05 Cancelers must be provided as split pairs, since their method of operation limits the end-delay (round trip echo path delay between the canceler and the near-end customer) which they can accommodate. Care must be taken to avoid connection structures (routes) which result in near-end echo paths with excessive end delays. In addition, echo paths must not be characterized by severe time variations or nonlinearities. These conditions are generally satisfied within the network. Echo cancelers used in the network, unlike echo suppressors, do not disable themselves in response to the usual echo-suppressor disabling tone sequence. Disabling is not considered necessary in this application because cancelers do not interrupt transmission paths and, therefore, do not obstruct the flow of full duplex data.

APPLICATION RULES FOR ECHO CONTROL DEVICES

5.06 ***Terrestrial intertoll trunks*** longer than 1850 circuit miles and certain trunks of lower mileage which interconnect specific pairs of Regional Centers should be equipped with echo suppressors or cancelers and designed with 0 dB of insertion loss.

5.07 ***Intertoll trunks routed on satellite facilities*** must always be equipped with split echo control devices (echo cancelers whenever possible) and designed for zero loss.

5.08 ***End office toll trunks*** from class 5 offices to toll offices should be equipped with echo suppressors or cancelers (where end delays permit) and designed with an insertion loss of 3 dB if their facility mileages exceed 1850. End office toll trunks between class 5 offices need not be equipped with echo control devices; the loss design specified elsewhere in this section spans all mileages within the continental United States.

6. MESSAGE CIRCUIT NOISE AND CROSSTALK

6.01 Noise in voiceband transmission is, in the most general sense, any unwanted signal present in a communication channel simultaneously with the desired 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, or equivalent, equipped with a frequency weighting called "C-message weighting." Figure 25 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.

PERFORMANCE OBJECTIVES

6.04 The Bell System customer-to-customer message circuit noise objectives were originally based solely on noise subjective tests and system-wide noise survey results. These objectives have been confirmed using the loss-noise subjective tests. Figure 24 shows the Bell System message circuit noise objective. Actual noise performance should be less than or equal to that shown. These customer-to-customer objectives are allocated to various physical parts of a connection. On customer loops, an upper limit (measured from the customer end) of 20 dBrnC is specified. For trunks on carrier facilities, the objectives are specified as a function of trunk length as shown in Fig. 26. Actual noise performance should be less than or equal to that shown. 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 distance 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 and interference) is primarily design controlled. Included are such techniques as the design limits on applied channel load of individual transmission systems and the layout and

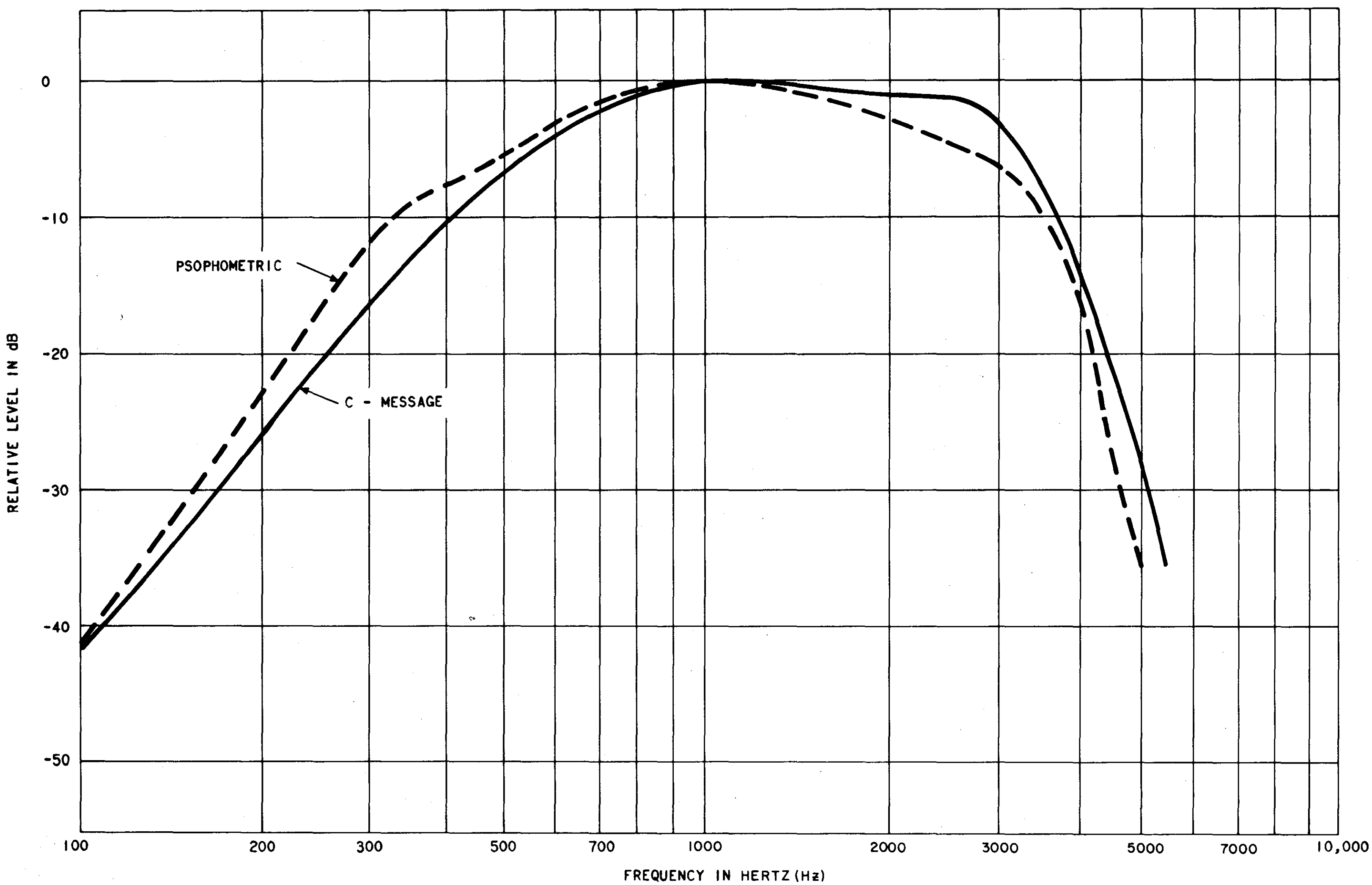


Fig. 24—Comparison Between Psophometric and C-Message Weighting

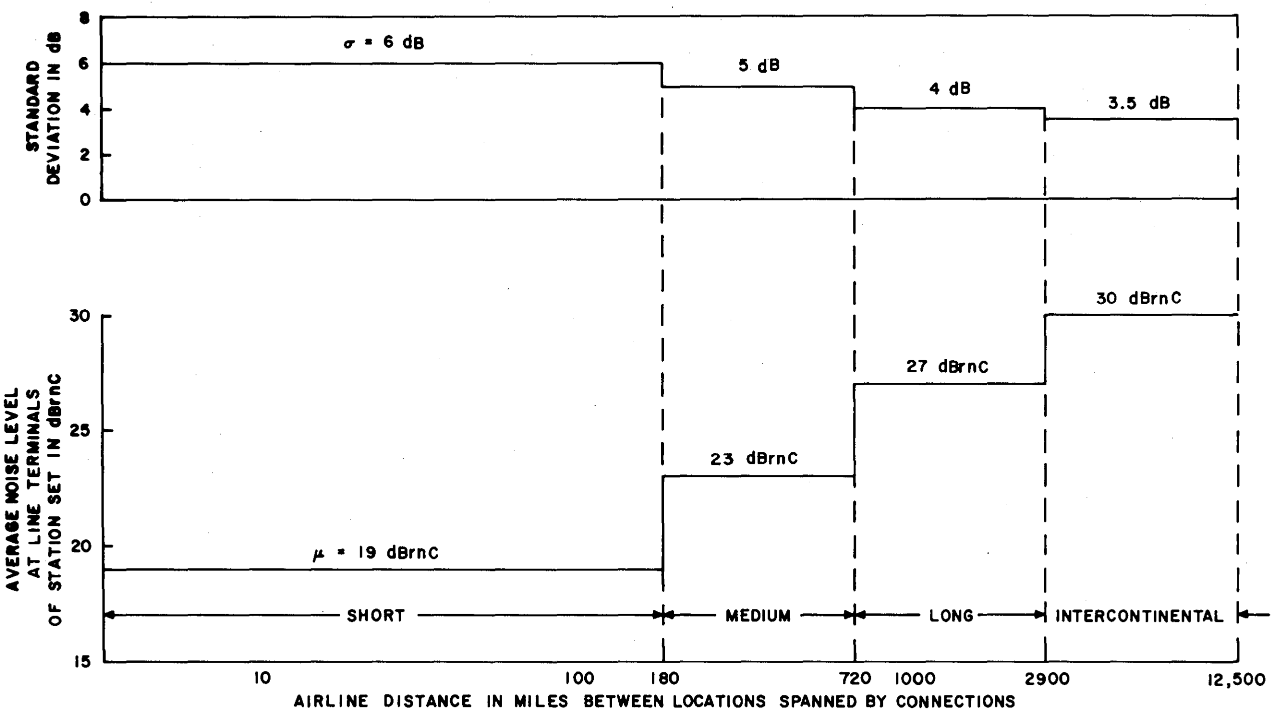


Fig. 25—Noise Objectives for Customer-to-Customer Connections

construction of associated outside plant. Noise control in carrier, repeatered voice, and radio systems requires care in locating repeaters and terminals, inclusion of suppression devices to nullify disturbances, and coordination not only with other telephone systems but also with 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 suitable splicing practices. In open wire (both voice frequency and carrier), it is necessary to employ transposition layouts adequate for the frequencies utilized and to maintain sufficient clearances with power lines.

MAINTENANCE CRITERIA

6.06 Once a circuit is installed, the noise must be kept within well-defined performance limits. The Bell System message circuit noise maintenance requirements are stated in terms of a maintenance threshold and an immediate action limit. The maintenance threshold specifies the value beyond which maintenance action should be initiated. The immediate action limit specifies the value beyond which a circuit should be removed from service immediately. Figure 27 shows the action recommended in relation to measured noise on subscriber loops. Figure 28 contains charts which show the noise thresholds and limits for message trunks. Charts B through E show the message noise criteria by both mileage of the trunk and the EML. Test pads are already included in the EML; therefore, the limits do not have to be adjusted to take them into account. The only adjustment which may be required to the criteria given in Charts B through E is when noise measurements are made without a test pad on a trunk at an office which utilizes a test pad when measuring loss on the same trunk. In this case, the value of the test pad should be subtracted from the measurements before making comparisons with the requirements shown in the charts.

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, analog-to-digital conversions, and corrosion or maladjustment of switching equipment 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

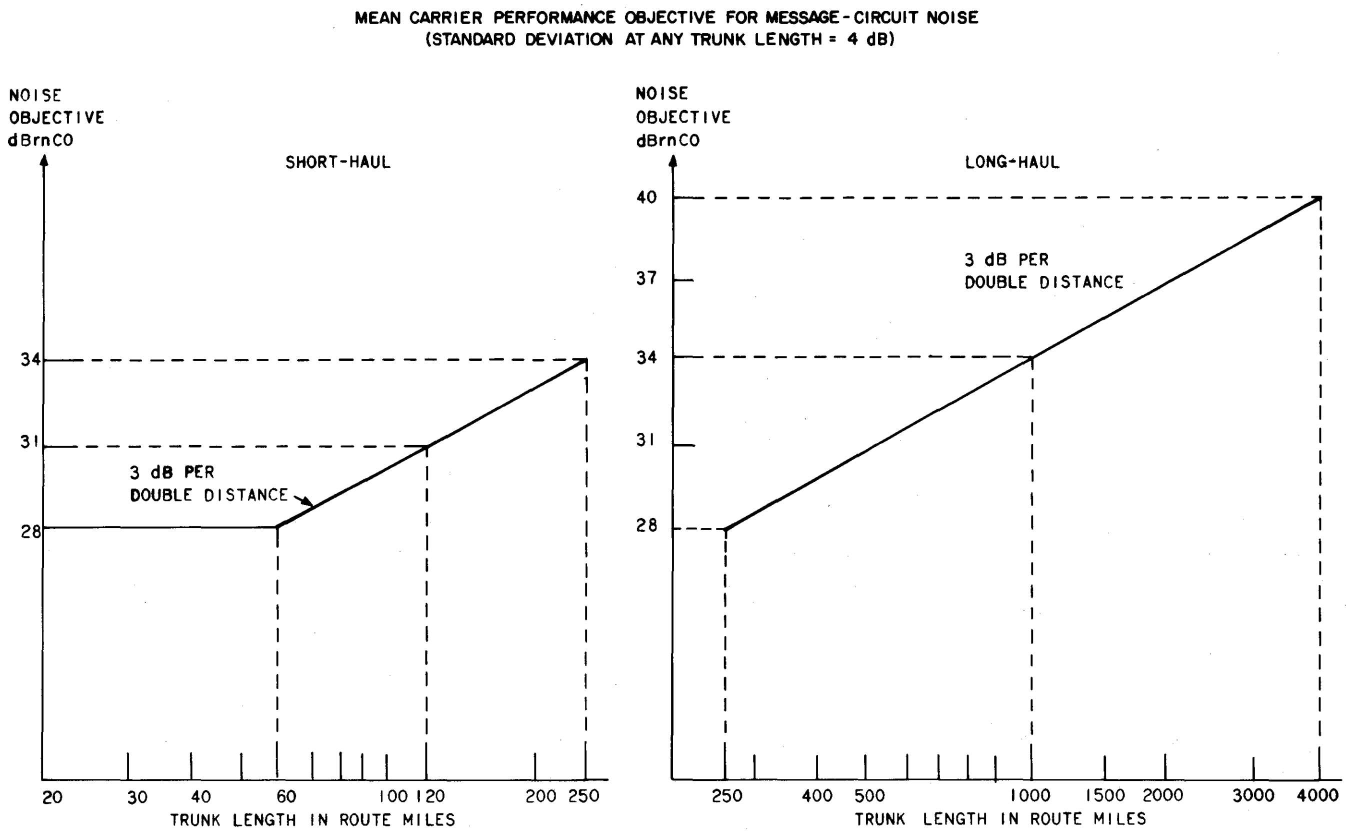


Fig. 26—Message Circuit Noise Performance Objectives for Trunks on Analog Carrier

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. 27—Loop Noise Objectives and Requirements

NOISE LIMITS FOR MESSAGE TRUNKS
LIMITS SHOWN IN dBrnC

NOTES:

1. THIS CHART ALSO APPLIES TO CIRCUITS LONGER THAN 1500 MILES AND ONE DIRECTION OF TRANSMISSION IS VIA A SATELLITE (1/2 HOP).
2. THIS CHART ALSO APPLIES TO CIRCUITS SHORTER THAN 1501 MILES AND ONE DIRECTION OF TRANSMISSION IS VIA TERRESTRIAL FACILITIES (1/2 HOP).

ALL VALUES ARE dBrnC AND ARE TO BE UTILIZED DIRECTLY.

NOISE MEASUREMENTS MADE WITHOUT A TEST PAD ON A TRUNK AT AN OFFICE WHICH UTILIZES A TEST PAD WHEN MEASURING LOSS ON THE SAME TRUNK SHOULD HAVE THE VALUE OF THE TEST PAD SUBTRACTED FROM THE NOISE MEASUREMENT BEFORE MAKING COMPARISONS WITH THESE CHARTS.

WHEN THE TRUNK IS ROUTED OVER MULTIPLE FACILITY TYPES, SELECT THE REQUIREMENT WITH THE HIGHEST dBrnC VALUE APPLICABLE.

FOR TSPS-RTA/PSS 2 TRUNKS ON A COMBINATION OF NONCOMPANDORED ANALOG CARRIER AND DIGITAL CARRIER WITH A TOTAL LENGTH EXCEEDING 400 MILES, THE NOISE LIMIT SHOULD BE OBTAINED FROM THE 201 TO 400 MILEAGE CATEGORY.

THOSE VALUES THAT ARE SHADED ARE THE NOISE LIMITS IN dBrnCO.

B
A

A = CIRCUIT ORDER LIMIT AND MAINTENANCE THRESHOLD

B = IMMEDIATE ACTION LIMIT

CHART A
VOICE FREQUENCY METALLIC FACILITIES

HIGH LOSS (TOLL CONNECTING TRUNK WITH EML GREATER THAN 6 dB)	20/30
ALL OTHER	25/36

CHART B
(SEE NOTE 1)
ANALOG CARRIER – TERRESTRIAL NONCOMPANDORED

EXPECTED MEASURED LOSS (EML)	MILEAGE 0 – 50	51 – 100	101 – 200	201 – 400	401 – 1000	1001 – 1500	1501 – 2500	2501 – 4000
0.0-0.5	31/40	33/40	35/40	37/42	40/44	42/46	43/48	45/50
0.6-1.5	30/38	32/38	34/38	36/40	39/44	41/46	42/46	44/48
1.6-2.5	29/38	31/38	33/38	35/40	38/42	40/44	41/46	43/48
2.6-3.5	28/36	30/36	32/36	34/38	37/42	39/44	40/44	42/46
3.6-4.5	27/36	29/36	31/36	33/38	36/40	38/42	39/44	41/46
4.6-5.5	26/34	28/34	30/34	32/36	35/40	37/42	38/42	40/44
5.6-6.5	25/34	27/34	29/34	31/36	34/38	36/40	37/42	39/44
6.6-7.5	24/32	26/32	28/32	30/34	33/38	35/40	36/40	38/42
7.6-8.5	23/32	25/32	27/32	29/34	32/36	34/38	35/40	37/42
8.6-9.5	22/30	24/30	26/30	28/32	31/36	33/38	34/38	36/40

Fig. 28—Noise Limits for Message Trunks

NOISE LIMITS FOR MESSAGE TRUNKS
LIMITS SHOWN IN dBrnC (Contd)

CHART C
(SEE NOTE 1)
ANALOG CARRIER – TERRESTRIAL
COMPANDORED

EXPECTED MEASURED LOSS (EML)	MILEAGE							
	0 – 50	51 – 100	101 – 200	201 – 400	401 – 1000	1001 – 1500	1501 – 2500	2501 – 4000
0.0-0.5	26 / 34	28 / 34	30 / 34	32 / 36	35 / 38	37 / 40	38 / 42	40 / 44
0.6-1.5	25 / 32	27 / 32	29 / 34	31 / 36	34 / 38	36 / 40	37 / 40	39 / 42
1.6-2.5	24 / 32	26 / 32	28 / 32	30 / 34	33 / 36	35 / 38	36 / 40	38 / 42
2.6-3.5	23 / 30	25 / 30	27 / 32	29 / 34	32 / 36	34 / 38	35 / 38	37 / 40
3.6-4.5	22 / 30	24 / 30	26 / 30	28 / 32	31 / 34	33 / 36	34 / 38	36 / 40
4.6-5.5	21 / 28	23 / 28	25 / 30	27 / 32	30 / 34	32 / 36	33 / 36	35 / 38
5.6-6.5	20 / 28	22 / 28	24 / 28	26 / 30	29 / 32	31 / 34	32 / 36	34 / 38
6.6-7.5	19 / 26	21 / 26	23 / 28	25 / 30	28 / 32	30 / 34	31 / 34	33 / 36
7.6-8.5	18 / 26	20 / 26	22 / 26	24 / 28	27 / 30	29 / 32	30 / 34	32 / 36
8.6-9.5	17 / 24	19 / 24	21 / 26	23 / 28	26 / 30	28 / 32	29 / 32	31 / 34

CHART D
(SEE NOTE 2)
SATELLITE

EXPECTED MEASURED LOSS (EML)	
0.0-0.5	42 / 46
0.6-1.5	41 / 46
1.6-2.5	40 / 44
2.6-3.5	39 / 44
3.6-4.5	38 / 42
4.6-5.5	37 / 42
5.6-6.5	36 / 40
6.6-7.5	35 / 40
7.6-8.5	34 / 38
8.6-9.5	33 / 38

CHART E
DIGITAL CARRIER

EXPECTED MEASURED LOSS (EML)	
0.0-0.5	28 / 34
0.6-1.5	27 / 32
1.6-2.5	26 / 32
2.6-3.5	25 / 30
3.6-4.5	24 / 30
4.6-5.5	23 / 28
5.6-6.5	22 / 28
6.6-7.5	21 / 26
7.6-8.5	20 / 26
8.6-9.5	19 / 24

Fig. 28—Noise Limits for Message Trunks (Contd)

random occurrences of excessive noise become too frequent, the noise performance at the average station terminal may become unsatisfactory. Noise in the 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. During the measurement, the far end of the connection should be properly terminated.

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 I. 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. Now if no more than 3 of the 40 measurements exceed the lower limits, the office is acceptable. On the other hand, if 4 or more of the 40 measurements exceed the lower limits, the office is unacceptable and needs corrective action.

REMOTE SWITCHING SYSTEM

6.11 The Western Electric No. 10A RSS is a switching entity controlled by a host ESS. The RSS is classified in the network hierarchy as part of the class 5 electronic central office which controls it. In many respects, the operation of an RSS remote terminal is analogous to the operation of a typical peripheral frame within the host ESS. The RSS should be transparent to a subscriber served by it relative to a subscriber served by the host ESS directly. Hence, the grade of service for the RSS-served subscriber should be equivalent to that of the host ESS-served subscriber. From the point of view of the noise impairments, loops from the subscriber to the RSS should satisfy usual loop requirements; but the composite of the remote terminal, linking channel, and host ESS is considered as a single unit even though the linking channel is a normal facilities group of either T or N Carrier. To maintain the necessary grade of service, the noise level of the channel must be kept below 20 dBrnC. The No. 10A RSS will contain a miniresponder which will be able to automatically measure channel noise without dispatching craft to the remote terminal.

INTELLIGIBLE CROSSTALK

6.12 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 by the disturbed party. 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/her own conversation.

TABLE I

CENTRAL OFFICE NOISE MAINTENANCE 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

6.13 Intelligible crosstalk can occur as interchannel interference within 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) energy coupling between adjacent PAM samples when a shared CODEC is used in PCM systems, and (3) electromagnetic coupling between various transmission media.

6.14 Whether a telephone user will actually receive intelligible crosstalk or not is a probabilistic event. The crosstalk index is defined as the probability, expressed in percent, of a telephone user hearing one or more intelligible crosstalk words during a call. The Bell System intelligible crosstalk objectives for trunks specify that a crosstalk index of 0.5 and 1 should not be exceeded on TCTs and intertoll trunks, respectively. For the loop plant, the performance objective recommended for the purposes of network planning and equipment design specifies that a crosstalk index of 0.1 should not be exceeded for 99 percent of the loops in the plant.

6.15 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 applied to a channel is one of the factors which affect 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 at a rate of 2 and 3 dB, respectively, for each dB by which the signal is increased. Since the noises are added in power, the amount of change in the 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 analog toll switching offices operate at -2 dB TLP and are separated from the serving central offices by TCTs 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 power 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 trunks and TCTs is that a 5-dBm0 tone would be just on the threshold of being clipped.

7.07 In PCM systems, interference signals, which are normally at a low level, can be enhanced due to the discrete steps in the quantizing characteristics. 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 PCM 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 PCM channel banks and digital switching systems.

8. SLOPE-FREQUENCY RESPONSE

8.01 The loss of a channel is measured at three different frequencies: 404, 1004, and 2804 Hz. The loss of 1004 Hz is then subtracted from the loss at 2804 Hz and that at 404 Hz. These differential losses are referred to as the slope at 2804 Hz and at 404 Hz. These two slopes are a measure of the frequency response of the channel under consideration. Higher loss at 2804 Hz or 404 Hz in comparison to loss at 1004 Hz results in positive slope value. Slope tests are made using an oscillator and a signal power measuring device.

8.02 Slope affects both voice and data transmission. Measurements at 404 Hz are made primarily to assure voice-frequency transmission quality including margin against low-frequency singing; slope at 404 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 14 dB of slope at 2804 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 14 dB of maximum allowable slope at 2804 Hz for a data connection, 3 dB of slope is allocated to each local loop,* leaving 8 dB for all the trunks and switching equipment between the two 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.

*The slope requirement on loops is applicable to loops equipped with data jacks.

9. IMPULSE NOISE

9.01 Impulse noise is defined as any excursion of the noise waveform on a channel which exceeds a specified level threshold. Impulse noise is evaluated on channels by counting the number of excursions during a predetermined time interval. In order to minimize contributions due to thermal noise, the minimum threshold is set 12 to 18 dB above the RMS value of the noise. Impulse noise level is designated to be that threshold at which the average counting rate is equal to one per minute.

9.02 The measuring instruments used to count noise impulses may employ either electromechanical or electronic counters. In some sets, the maximum counting rate is controlled to be seven per second.

9.03 Impulse noise may cause errors in data transmission. The contribution to error rate becomes significant when 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. The Bell System impulse noise specification is that no more than 15 counts in 15 minutes are to be tallied at a level above a threshold which is 6 dB below the received data level. 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 hardware and 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 dB 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 running total, 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 J 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 probably 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 K. Column 1 is simply a count of the trunks measured. Column 2 (Remarks) shows 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 J. 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 K), the trunk group passed after seven tests as

TABLE J

DECISION NUMBERS OF 0s AND 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	—
5	3	4	4	4	4	5
6	4	4	4	4	4	6
7	4	5	5	5	5	6
8	5	5	5	5	6	7
9	5	6	6	6	6	7
10	6	6	6	6	6	8
11	6	7	7	7	7	9
12	6	7	7	7	8	9
13		7	8	8	8	10
14		8	8	9	9	10
15		8	9	9	9	11
16		9	9	10	10	12
17		9	10	10	10	12
18		9	10	11	11	13
19			10	11	11	13
20			11	12	12	14
21			11	12	13	14
22			12	12	13	15
23			12	13	14	16
24			12	13	14	16
25				14	14	17
26				14	15	17
27				15	15	18
28				15	16	18
29				15	16	19
30				15	17	19
31					17	20
32					18	21
33					18	21
34					19	22
35					19	22
36					20	23
37					20	23
38					20	24
39					21	24
40					21	25
41					21	26
42					21	26
43					21	26
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 group if equal 0s and 1s after maximum tests.

TABLE K

SAMPLE TEST SHEET FOR A 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	2
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.	

indicated by the fact that five zeros 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 1 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. Maintenance limits for carrier- and voice-frequency trunks, as well as facilities (from voice-frequency patch to voice-frequency patch, or equivalent), are given in Table L. The levels in this table assume that the difference between AML and EML for each trunk is within deviation limits and the impulse counter is additionally calibrated to reflect this difference.

SAMPLING FOR SWITCHING SYSTEMS

9.12 Paragraphs 9.12 through 9.17 describe a sampling plan and method for measuring impulse noise within 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 Main Distributing Frame (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.

9.13 There is an extremely large number of possible paths that may be taken, within the equipment of a central office, for a connection between two arbitrary MDF terminations. Furthermore, there are N(N-1) possible directed pairs of MDF

TABLE L

IMPULSE NOISE REQUIREMENTS
(6-TYPE COUNTER)

<table>
<tr><th></th><th>CONDITIONS</th><th colspan="2">LEVEL</th></tr>
<tr><td>LOOP</td><td>No more than 15 counts in 15 minutes on all loops.
Level at central office or referred to central office through 1000 Hz-loss.</td><td colspan="2">59 dBrnC</td></tr>
<tr><td>CONNECTION</td><td>No more than 15 counts in 15 minutes on at least 50 percent of calls.</td><td colspan="2">5 dB below signal level</td></tr>
<tr><td rowspan="3">SWITCHING OFFICE</td><td>No more than 5 counts in 5 minutes on 50 percent of test calls (use sampling plan).</td><td>Crossbar</td><td>54 dBrnC</td></tr>
<tr><td>Immediate action limit: 20 counts or more in 5 minutes.</td><td>Step-by-step</td><td>59</td></tr>
<tr><td>Level at central office.</td><td>ESS</td><td>47</td></tr>
<tr><td rowspan="4">VOICE FREQUENCY AND CARRIER TRUNK</td><td rowspan="4">No more than 5 counts in 5 minutes on 50 percent of trunks in group (use sampling plan).
Immediate action limit: 20 counts in 5 minutes.
* With −13 dBrnC0 holding tone.</td><td>Voice Frequency</td><td>54 dBrnC0</td></tr>
<tr><td>Compandored or Mixed</td><td>66 dBrnC0*</td></tr>
<tr><td>T Carriers</td><td>62 dBrnC0 (See Note.)</td></tr>
<tr><td>Noncompandored
0-125 Miles
126-1000 Miles
1001-2000 Miles
Over 2000 Miles</td><td>
58 dBrnC0
59 dBrnC0
61 dBrnC0
64 dBrnC0</td></tr>
<tr><td rowspan="4">FACILITIES</td><td rowspan="4">No more than 5 counts in 5 minutes on 50 percent of channels (use sampling plan).
Immediate action limit: 20 counts in 5 minutes.
* With −13 dBrnC0 holding tone.</td><td>Voice Frequency</td><td>52 dBrnC0</td></tr>
<tr><td>Compandored or Mixed</td><td>64 dBrnC0*</td></tr>
<tr><td>T Carriers</td><td>67 dBrnC0*</td></tr>
<tr><td>Noncompandored
0-125 Miles
126-1000 Miles
1001-2000 Miles
Over 2000 Miles</td><td>
56 dBrnC0
57 dBrnC0
59 dBrnC0
62 dBrnC0</td></tr>
</table>

Note: Do not use holding tone when measuring trunks on T-Carrier facilities.

terminations, where N is the total number of such terminations. Therefore, 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.

9.15 As mentioned in paragraph 9.14, the population from which a test sample is to be drawn is all of the spare MDF terminations included in a single exchange number. Two line-finder groups or two trunk link frames are picked at random. One spare terminal in each group is assigned a directory number and designated as the called terminal. Ten other spares are picked arbitrarily (strict random sampling is not necessary) within each group. In offices with a high fill, 11 spares may not be available in any one group. In these cases, any 22 spares may be used. Calls are established sequentially from each of the ten spares within each group to the called terminal within the group. On each call, measure impulse noise; if the count at the end of 5 minutes is five or less, a 0 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 the 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-by-step offices, cleaning and adjusting the switches according to standard practices usually result in improved performance. Maintenance limits for impulse noise in switching offices, connections, and loops are given in Table L.

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 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, network 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 The Bell System is currently exploring the use of peak-to-average ratio (P/AR) measuring apparatus in order to increase control of envelope delay distortion in the field. A P/AR reading of 48 or better on end-to-end connections is considered to indicate satisfactory envelope delay characteristics for data transmission.

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 for the frequency band of 20 to 300 Hz and 15 degrees peak to peak for the band of 4 to 300 Hz. Individual carrier terminals are allotted 1.3 degrees.

NONLINEAR DISTORTION

10.07 Nonlinear elements in transmission equipment give rise to harmonic and intermodulation distortion which are more generally referred to as nonlinear distortion. Nonlinear distortion measurements are made usually in terms of intermodulation distortion measurements.

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; ie, it appears as tones at 2A, 3A, etc. 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 Historically, two different methods of measuring nonlinear distortion on voiceband channels have been used: the single-tone method and the 4-tone method. However, the single-tone method is no longer used; only the 4-tone method is used. For the 4-tone method, four equal level tones are transmitted at a composite signal power of data level (-13 dBm0).

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.

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. 29.

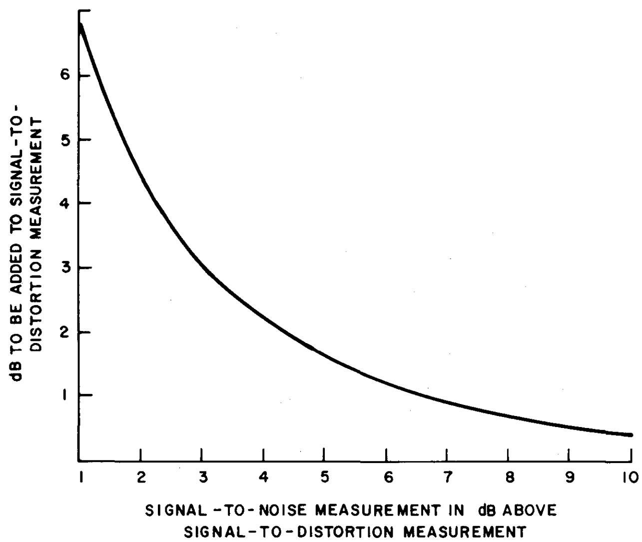


Fig. 29—Diagram of an Exponential Curve

10.14 The single-tone method, not recommended for use in the Bell System, is the simplest to apply; 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 An advantage of the 4-tone method, the method currently used in the Bell System, is that the 4-tone test signal has an amplitude density function quite similar to that of a data signal. However, because of the relatively wide (50 Hz) passband of the receiver filters, the measurements with the 4-tone method are 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 using the 4-tone method of measurement is 27 dB minimum for R2 and 32 dB minimum for R3.

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 -16, -13, or -10 dBm0 tone 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 tone 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 factors 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 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 telecommunication 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 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 ms 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 ms 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 their magnitude is about 20 to 25 degrees. The end-to-end objective for gain hits is to have no more than eight gain hits exceeding 3 dB in 15 minutes; the objective for phase hits is to have no more than eight phase hits in 15 minutes at a threshold of 20 degrees. Dropout is defined as a decrease in level greater than or equal to 12 dB lasting at least 10 ms. The objective for dropouts is to have no more than two dropouts per hour.

10.27 The gain hit, phase hit, and dropout objectives allotted to individual trunk facilities are given in Table M.

AMPLITUDE MODULATION

10.28 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.

TABLE M

GAIN AND PHASE HIT AND DROPOUT OBJECTIVES FOR TRUNKS

OBJECTIVES	SHORT-HAUL FACILITIES (N, ON, OR T)	COAXIAL CABLE, RADIO, OR SHORT-HAUL RADIO (TJ)
Gain Hits ($\geq$ 3dB)	0 in 15 minutes	No more than 2 in 15 minutes*
Phase Hits ($\geq$ 20)	0 in 15 minutes	No more than 2 in 15 minutes
Dropouts	No more than 1 in 30 minutes	No more than 1 in 30 minutes

* No more than 1 in 15 minutes for counters with 4 dB threshold.

11. IMPACT OF NEW FACILITIES

SATELLITE FACILITIES

11.01 Message trunks which are routed via analog geostationary satellite facilities are characterized by round trip propagation delays of approximately 540 ms and by message circuit noise levels, independent of trunk airline mileage, which are typical of terrestrial analog facilities between 1000 and 1500 miles long. Generally, satellites are deployed with application rules based on economics. However, to provide satisfactory transmission quality, two general restrictions are placed on their domestic use: (1) there should not be more than one satellite circuit in any connection within the network, and (2) trunks routed via satellites should be equipped, wherever possible, with echo cancelers properly positioned in the network to assure that the cancelers are operating within their end-delay capabilities.

11.02 In certain cases where echo cancelers are unavailable, "half-hop" operation may be used in conjunction with conventional echo suppressors as a temporary measure. In half-hop operation, one direction of a 4-wire circuit is routed via terrestrial facilities and the return path is routed via satellite. To augment the echo protection provided by the suppressors, such trunks are usually designed with 3 dB of insertion loss. Field subjective tests have indicated that such circuits, which are characterized by round trip delays of approximately 300 ms, provide adequate transmission quality.

11.03 The combined effect of economic and performance considerations is that domestic satellites tend to appear only on interregional high-usage intertoll trunks whose terrestrial facility routes would otherwise exceed approximately 1000 miles. Exceptions may occur in cases involving points off the United States mainland.

TIME ASSIGNMENT SPEECH INTERPOLATION (TASI)

11.04 Time Assignment Speech Interpolation (TASI) is a terminal device which permits a given number of trunks, called a ***clique,*** to time share a smaller number of analog facility channels with trunk-to-channel ratios ranging from 1.5 (36 trunks on 24 channels) to 2 (240 trunks on 120 channels). It operates by reassigning channels connected to trunks which are momentarily silent (because of conversational pauses and turnarounds) to trunks which are currently active.* This raises the possibility of clipping speech or voiceband data signals. Such clipping is due to the combined effect of the time required to detect signals and reassign channels (processing clip) and to the time a previously disconnected, newly active trunk might have to wait until a facility channel is available (competitive clip). TASI-E is equipped with several features to preserve transmission quality for voice and data customers.

*Under light traffic load, TASI-E will still switch trunks to different channels in order to enhance privacy.

11.05 To reduce the probability of clips long enough in duration to affect service, a fixed delay of 50 ms is inserted in each direction of transmission. This delay functions as an offset against the clipping which would otherwise occur. It is adequate to cancel all of the processing clip and, additionally, a significant amount of competitive clip. On domestic message trunks, echo cancelers are used with TASI-E to maintain the echo grade of service in the presence of the additional delay.

11.06 Full-duplex and certain half-duplex data sets can avoid TASI processing by using the tone sequence normally used to disable echo suppressors, namely, the emission of a special tone followed by continuous energy in at least one direction of transmission (no simultaneous gaps longer than 192 ms). This sequence causes TASI-E to lock the affected trunk to a facility channel and removes the TASI delay, providing a TASI-free 4-wire path. On rare occasions, a significant fraction of the trunks in a clique may be carrying recognized data calls during a busy hour, reducing the pool of facility channels available for assignment to other trunks. To limit the increased clipping from this and any other source, a dynamic-load-control feature is provided which senses excessive clipping and limits the further flow of traffic to the overburdened trunk clique until the congestion is relieved.

11.07 To prevent fluctuations in noise as trunks are connected and disconnected, a noise-matching feature injects typical noise levels into the receiving paths of trunks which have been disconnected from their facility channels.

11.08 A channel check feature is provided to detect excessive noise levels and deviations from nominal loss. Loss corrections of ± 2 dB are made automatically, as needed. In the case of loss deviations greater than this amount, or noise levels above predefined limits, TASI-E locks the offending channels to predetermined trunks, rendering them visible to normal trunk maintenance systems.

TASI-E APPLICATION RULES

11.09 Application rules for TASI-E, like those for satellites, are the result of economic and performance considerations. In general, TASI-E is restricted to interregional, high-usage Common Channel Interoffice Signaling (CCIS) intertoll trunks between No. 4 ESS switching machines. The trunks must be routed on analog terrestrial facilities over about 1000 miles long or on analog satellite facilities. Since TASI-E is always accompanied by echo cancelers, the associated trunks should be designed with zero insertion loss. Only one TASI-E trunk may appear in a domestic connection, except during network management activities in response to rare traffic conditions.

11.10 Because of the combination of performance features and application rules described in previous paragraphs, TASI-E should not significantly degrade voice and data services.

12. DIGITAL NETWORK PLANNING

12.01 Digital facilities in the telecommunications network include digital transmission facilities, digital switching systems, PCM channel banks, and digital multiplexes. Selection of digital facilities is determined by economic and technical factors in meeting requirements for present and future service. The SDN evolves through the introduction and interconnection of these facilities.

12.02 In the present switched analog network, the fundamental interface between switching and transmission equipment is a 4-kHz baseband voice channel. In the SDN, the fundamental channel interface is a 64-kb/s digital channel organized in 8000 8-bit words per second in which voice is encoded according to a μ=255 PCM law. For convenience and economy, switching and transmission equipment in the SDN interface at the digroup multiplex level, consisting of 24 digital channels in a 1.544 mb/s stream.

12.03 The economies of terminating transmission facilities on digital switches at the digroup level greatly reduce the use of voice-frequency cable in the toll connecting plant and stimulate the use of digital carrier. Maintenance is simplified in the SDN through opportunities for automatic error monitoring in digital facilities and for testing the digroup rather than each channel as the basic unit. Effective utilization of digroup provisioning will require at least partial segregation of public message trunks and special service circuits.

12.04 Within the SDN, connections can be established that will transmit a bit stream from a local (class 5) switching office through the network to a distant local office. While the SDN evolves, some voiceband connections will include paths through the SDN combined with paths through the existing analog network.

BIT INTEGRITY

12.05 Bit integrity (the capability to transmit bit streams end-to-end through the network without changing any bits) is an objective for the SDN. Loss on connections through the SDN is inserted only at the receiving end of the connection so as to avoid digital processing or digital-to-analog conversion within the path. The impact of this constraint has been indicated in paragraph 3.34 and subsequent paragraphs discussing the SDN loss plan. Devices (such as digital echo cancelers) which perform digital processing to meet the requirements of voice services, if used in the SDN, should have the capability of being disabled when necessary to preserve bit integrity.

ERROR RATE

12.06 The error rate on a digital connection is the fraction of bits received that differ in binary value from the corresponding bit in the transmitted stream. An objective for end-to-end connections through the SDN is that the error rate should be less than 10^{-6} on at least 95 percent of connections.

12.07 Most digital facilities and connections have error rates many times smaller than 10^{-6}. When a higher error rate occurs on a connection, it is usually caused by a high error rate in one facility. The error rate objectives for digital facilities are, therefore, designed to control the probability that one or more facilities in a connection will have an error rate greater than 10^{-6}. The allocated objective for each digital facility specifies the percent of such facilities, or the percent of time for each facility, for which the error rate should be less than 10^{-6}. The specified percentage is chosen so that on representative connections, the total probability that any facility has an error rate greater than 10^{-6} rate will be about 5 percent.

SLIPS AND SYNCHRONIZATION

12.08 Digital transmission through the SDN requires that all 64-kb/s channels everywhere in the network be operated at exactly the same digital speed. If channels arrive at slightly different speeds at the same point (such as a digital switch) where they are to be multiplexed on the same digroup, digital words must be inserted in, or deleted from, one or more channels to bring them to the same digital speed. Each such insertion or deletion is called a slip. A slip is usually not noticed on a voice connection but can impair the operation of some voiceband data sets for several seconds.

12.09 Slips will occur if digital sources (such as analog-to-digital converters) in different locations are not precisely synchronized. Digital sources in the SDN are controlled by means of a clock at each digital switch, synchronized with the Bell System Reference Frequency Network (BSRFN), so that slips do not occur. The objective for slips in the SDN in case of failure of synchronization to the BSRFN is at most one slip in 5 hours on an end-to-end connection. To meet this objective, clocks at different digital switches should never differ in speed by more than 1.7 parts in 10^9 before synchronization to the BSRFN is restored.

END OFFICE LOOP BALANCE

12.10 Considerations of listener echo at a digital local office require more careful balancing of loops than at conventional analog local offices. On intraoffice calls, the digital switch is a 4-wire transmission path with delay (but without loss) connected between two 2-wire loops through hybrids. To meet objectives for the WEPL on the listener echo path, loop segregation with dual balance networks can be used as indicated in paragraphs 4.14 through 4.17.

NOTES ON THE NETWORK

SECTION 8

MAINTENANCE REQUIREMENTS

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Figures

1. GENERAL

1.01 The objective of an effective overall maintenance plan is to provide high quality service at a reasonable cost. To accomplish this, a maintenance program must take advantage of the accuracy and speed afforded by modern automated operations support systems and of the efficiencies possible from the centralization of skilled craft persons at centralized work locations.

1.02 The overall maintenance plan for network dialing in particular must evolve toward mechanization and centralization of maintenance and administrative control in order to maintain the precision and stability required of the network of interconnecting switching systems. The growing sophistication of switching systems and the network as a whole together with the proliferation of stored program control switching systems with real-time trouble detection and analysis capabilities require commensurate maintenance test equipment, methods, and organization.

1.03 While inadequate maintenance at one office or center can result in excessive trouble at that location, it can also have adverse reaction elsewhere in the network. It is essential that each company have a well-organized maintenance plan in effect 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 responsibilities assigned to each work position and control center and to each operating company.

1.04 The continued evolution of maintenance procedures is motivated by the implementation of technical advances available to the operations support systems and by the continued growth of the communications network both in size and in capabilities. The following trends are anticipated:

(a) Increased use of automated procedures and self-alarming arrangements which automatically indicate troubles in the switching and transmission networks

(b) More widespread use of stored program control switching systems with real-time trouble detection and analysis capabilities

(c) Formation of control centers which have responsibility for maintenance as well as other operations for trunks and facilities associated with a number of central offices

(d) Gradual interconnection of the centralized operations support systems to create an operations support network.

1.05 The administration and control of mechanized maintenance arrangements which normally would be performed at a number of separate work locations may be conducted more efficiently by consolidation at a central control location. The creation of control centers permits personnel at the centers to retain a high level of expertise because of the greater exposure to various and difficult maintenance problems. In addition, personnel at the centers are afforded a broader view of the network which may be beneficial in detecting and repairing troubles which affect a number of elements in the network.

1.06 Centralized trunk and switching system maintenance functions are the responsibilities of a Switching Control Center (SCC). Personnel at the center are organized into various work positions and teams. Each work position is assigned a particular set of maintenance functions and is generally supported by an automated system. Trunk-related problems are handled by a trunk maintenance position. Craft persons at this position may perform remote tests on circuits and correct certain types of problems.

1.07 Facility maintenance may be monitored, directed, and administered from centralized locations. In areas with high concentrations of T-Carrier facilities, a T-Carrier Restoration Control Center (TRCC) directs and coordinates the activities associated with restoration of service using spare facilities. Intercity facility network operations are controlled by a High Capacity Facility Control Center (HFCC).

1.08 The maintenance process may be considered to consist of seven steps:

(1) ***Trouble Detection:*** Is accomplished through use of one or more of the following basic strategies:

- Constant performance monitoring
- Per-use testing
- Routine periodic testing
- Data analysis
- User observations.

(2) ***Trouble Verification:*** Is necessary to ensure that a trouble actually exists and to determine the nature of the trouble more precisely

(3) ***Service Protection:*** Involves the removal from use of a defective circuit or shared equipment in order to prevent further degradation of customer service

(4) ***Trouble Sectionalization:*** Includes the activities required to identify the section of a circuit or system that contains the offending element

(5) ***Trouble Repair:*** May involve readjustments, cleaning, replacement of parts, or actual repair of a broken item

(6) ***Repair Verification:*** Normally requires activities similar to trouble verification to confirm that the circuit or system has been restored to a useful state

(7) ***Restoral to "Available for Use":*** Is applicable to a circuit or shared equipment that was in an out-of-service or maintenance-busy state because of a trouble condition which has since been corrected.

2. TRUNK MAINTENANCE

A. General

2.01 The trunk maintenance process ensures that trunks are accessible to traffic, that they function properly during call setup and termination, and that they provide a proper transmission path during the call. Trunk maintenance procedures may involve manual operations conducted from a test position as well as fully mechanized testing via the Centralized Automatic Reporting On Trunks (CAROT) system and switch diagnostics. In both instances, test lines provide far-end test termination functions.

B. Test Positions

2.02 Test positions provide an assortment of capabilities associated with manual trunk testing. The capabilities vary substantially in their level of sophistication and features provided depending on the type and vintage of the switching system and on local practices. The fundamental functions of a test position are to provide access to trunks for transmission and operational testing and to control the maintenance state (ie, availability for service) of the trunks. Test positions are normally located at the "ends" of trunks or at a centralized control location.

2.03 Trunks may be accessed for manual testing by either jack arrangements associated directly with the trunk or by special switching access arrangements controlled by the associated common control switching system. Jack access is employed on certain testboards associated with older design electromechanical switches. Switched access is used with common control (electromechanical or stored program control) switching systems. In electromechanical switching systems, generally only the outgoing or 2-way trunks can be accessed; while in stored program control systems, all trunks (incoming, outgoing, and 2-way) can be accessed.

2.04 All test positions have the capability to talk or monitor on the trunks under test and to perform certain transmission, operational, and signaling tests. Tests may be conducted between two different test positions or between a test position and a test line. The maintenance state of a trunk may be controlled at a trunk test position; ie, a trunk may be made "active," or available for service, or it may be placed in an out-of-service state.

2.05 In addition, access to control the signaling on a trunk from a test position is generally provided. The outgoing supervision (on- or off-hook) may be controlled and monitored and the incoming supervision may be monitored. Also, the ability to outpulse (multifrequency pulsing, dial pulsing, and dual tone multifrequency signaling) is provided. Equivalent functions are provided for Common Channel Interoffice Signaling (CCIS) trunks where required. Stress signaling test conditions may be applied to the near end while the signals received at the far end are compared with expected results to detect marginal troubles. Trunks which do not pass this pulsing test are subjected to further analysis and repair. Measurements of dc characteristics (resistance, capacitance, and voltage) of trunks may be performed at test positions associated with switching systems that connect trunks through conducting paths.

2.06 Operational testing features are provided at test positions. An echo suppressor measuring set is used in conjunction with a 108-type, loop-around test line to test echo suppressors on trunks equipped with echo suppressors. Far-end echo cancelers are tested by access to a 109-type test line. The ring forward function on intertoll trunks is tested by a termination at a supervisory and signaling test circuit (103-type test line). Ringing, tripping, and supervisory functions on incoming trunks are tested via synchronous and nonsynchronous test lines.

2.07 For transmission testing of trunks, test signals may be originated at the test position. These signals include 1004 Hz at various levels (0, -10, or -16 dBm0), 404 Hz, 2804 Hz, and quiet. The Bell System goal to lower the test tone level to -16 dBm0 will continue to be pursued. Transmission measurements performed at a receiving end test position include level of a received test tone; C-message, C-notch, and impulse noise; frequency; and balance (echo return loss and singing return loss). Transmission tests may be conducted between one test position and another (particularly for trouble sectionalization) or from a test position to a far-end test line.

2.08 On-site trunk test positions provide most or all of the above capabilities for each type of central office. For certain types of offices (ie, large stored program control and exchange electromechanical), there are associated remote trunk maintenance positions at SCCs which provide many of the testing functions that are found at the on-site positions.

C. Test Lines

2.09 Test lines are part of the basic plan for the maintenance of trunks. Test lines range in complexity from those providing simple tones and terminations to those providing the relatively complex functions of: (1) applying marginal signaling tests and transmission tests and (2) recognizing and replying to specific signals received. All of the test lines discussed below may be accessed from manual test positions, although some may require control features not found in all positions.

2.10 Test lines are currently accessed by:

(a) ***Toll Office, Intertoll Trunks:*** A 3-digit 10X code corresponding to the specific type of test line

(b) ***Toll Office, Toll Connecting Trunk:*** A 3-digit NNX code assigned from among the spare NNX codes available in the Numbering Plan Area (NPA)

(c) ***Class 5 Offices:*** A 7-digit subscriber number.

For transmission test lines, the digits received (and in some machines, the incoming trunk class) are used by the switching system to:

(a) Connect to the proper type of test line

(b) Choose a line of the proper signaling type, impedance, and transmission level point

(c) Place the incoming trunk unit in the correct state to simulate a local terminating or through switched call.

2.11 Two NNX codes, 958 and 959, are reserved for maintenance. The code 958 is used for communications between switching offices. It provides access to a test line which terminates on a test frame or switchman's desk cabinets. These test locations are provided with means for both originating and terminating calls for handling intermachine troubles. Calls are directed by outpulsing up to nine digits which include the NPA and the TTC (Terminating Toll Center; a 0XX-type code): NPA + TTC + 958.

2.12 Currently, the code 959, plus three or four additional digits, is assigned for access to office test lines in some of the stored program control switching systems (No. 4 ESS and TSPS).

2.13 Test lines should wait until the originating office has completed pulsing and then provide off-hook supervision unless off-hook supervision is part of the test sequence. Following off-hook supervision, test lines that send tones provide a 300-ms 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.

2.14 The stated frequencies of test line tones include an additional 4 Hz above the nominal frequency to avoid the modulation by-products which may be produced in Pulse Code Modulation (PCM) type carrier.

D. Transmission Test Lines

2.15 ***Balance (100 type)*** is recommended for industry-wide use to facilitate connection to a termination for balance and noise testing. [See Fig. 1(A).] The requirements for this termination are as follows:

(a) Provides off-hook supervision to the calling end as long as trunks are held by the calling end. In the newer version of the 100-type test line, a 1004-Hz tone at 0 dBm0 for 5.5 ±0.1 seconds is provided followed by a quiet termination. The frequency should be accurate to 1 Hz and the level to 0.03 dB. One-way loss and noise measurements may be made with one dial-up.

(b) Provides a termination (600 or 900 ohms plus a capacitance) which simulates the nominal office impedance.

2.16 ***Communications (101 type)*** provides a communication and test line into a testboard

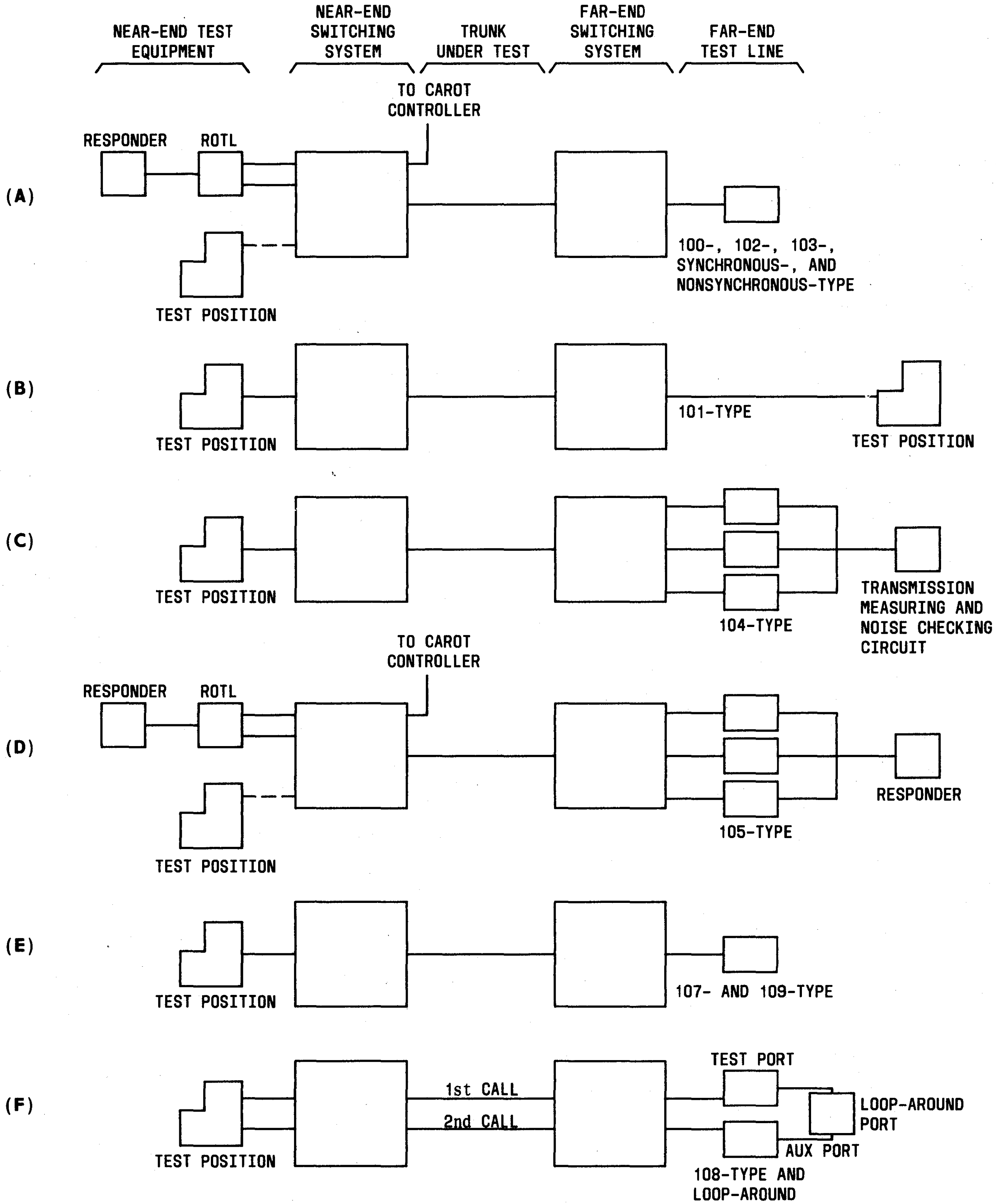


Fig. 1—Test Line Arrangements for Interoffice Trunk Testing

or test position which can be reached over any trunk incoming to the switching system served by that test position. [See Fig. 1(B).] It is used for reporting trouble, making transmission tests, etc.

2.17 ***Milliwatt (102 type)*** provides a 1004-Hz tone at 0 dBm0 for 1-way transmission measurements. [See Fig. 1(A).] The features of this termination are as follows:

(a) Some early versions provide continuous tone through a sequence consisting of a 9-second, off-hook signal during which 1004-Hz test power is applied followed by a 1-second, on-hook interval with no test power.

(b) Other versions provide a 9-second, off-hook signal with test power followed by a steady on-hook signal without test power until released.

(c) All versions provide an idle circuit termination during the on-hook condition.

(d) All versions furnish the necessary pad switching signals and test power level for intertoll trunks terminated on stored program control toll switching systems.

2.18 ***Transmission Measuring and Noise Checking (104 type)*** provides a test termination for 2-way transmission testing and 1-way noise checking. This termination can be used to test trunks from offices equipped with automatic trunk test frames but cannot be used by the CAROT system. (See paragraphs 2.30 through 2.40.) It may also be used for manual 1-person, 2-way transmission measurements from a testboard or maintenance center. [See Fig. 1(C).] The features of the 104-type test termination are:

(a) Provides test pads as required by the office in which it is located.

(b) Provides off-hook supervision.

(c) Measures the 1000-Hz loss of the trunk from originating end to far end.

(d) Adjusts a transmitting pad to equal the trunk loss measured in (c). If this loss exceeds 10 dB, the transmitting pad value is reduced by 10 dB and a subsequent "wink" signal indicates this fact to the originating end.

(e) Makes a recheck of the trunk loss. By means of a local loop, checks to determine if the pads have been properly adjusted. In case of failure in either of these checks, a repetition of the measurement is requested.

(f) Applies 1000-Hz test power directly to the trunk to permit a receiving measurement at the originating end.

(g) After a timed interval, sends 1000-Hz test power through the transmitting pad adjusted in (d) 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. The accuracy of this type measurement is degraded by companders or any nonlinearity over the range of the measurement. The degradation is proportional to the amount of nonlinearity and/or inaccuracy in the symmetry of the compression and expansion.

2.19 ***Automatic Transmission Measuring Test Line (105 type)*** provides far-end access to a responder and permits 2-way loss and noise measurements to be made on trunks from a near-end office equipped with a Remote Office Test Line (ROTL) and responder. Any number of 105-type test lines up to a maximum of 15 may be associated with one common responder. The test lines act as parking circuits for calls awaiting connection to the responder. [See Fig. 1(D).] The near-end ROTL and responder are directed by a CAROT controller or a manually operated ROTL control unit. In an integrated 105-type test line/responder unit, the 105-type test line performs several of the responder functions in addition to its normal functions.

2.20 When a 105-type test line at a far-end office is called and seized, timing functions are initiated and an off-hook supervisory signal and test progress tone are returned to the originating office. If the responder is idle, the test line is connected to the responder and the test progress tone is removed. If the responder is busy and/or other test lines in preferential positions in the parking chain have already been seized, test progress tone continues to be sent back to the originating end to indicate that the call is parked and awaiting connection to the responder. When the responder becomes available to the test line under consideration, the connection is made and the test progress tone is removed.

2.21 ***Data Transmission Test Line (107 type)*** provides connection to a signal source which provides test signals for 1-way testing of data and voice transmission parameters. [See Fig. 1(E).] The test line provides a peak-to-average ratio (P/AR) signal, gain-slope frequencies, quiet termination, and intermodulation distortion test signals. The test line also allows measurement of return loss, frequency shift, phase jitter, C-notched noise, impulse noise, gain hits, phase hits, and dropouts.

2.22 The P/AR 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 dBm0 permit measurement of the trunk frequency characteristic. A 1004-Hz, -16 dBm0 tone permits measurement of frequency shift, phase jitter, C-notched noise, impulse noise, gain hits, phase hits, and dropouts.

2.23 The ***loop-around test line*** in a class 5 office enables one person in a toll office to make 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. [See Fig. 1(F).] After having measured the far-to-near end loss of all trunks in the group (using a 102-type test line), one trunk is selected as a reference trunk. Using the reference trunk, one termination of this test line is dialed. Taking each of the remaining trunks in turn, the other termination of this test line is then 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:

(a) Trips machine ringing

(b) Provides idle circuit termination on each test number

(c) When second connection is made, removes both idle circuit terminations

(d) Provides direct connection between two test numbers

(e) Provides a holding circuit through the sleeve to prevent switchtrain release during supervision changes

(f) Provides off-hook supervision after both test numbers have been selected.

E. Operational Test Lines

2.24 ***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. 1(A).]

(a) On seizure, the test trunk returns an off-hook signal.

(b) On receipt of a ring forward (rering) signal, the test trunk returns an on-hook signal.

(c) On the receipt of a second ring forward (rering) signal, the test trunk returns a 120-IPM flash.

2.25 ***Synchronous*** 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. [See Fig. 1(A).] In stored program control 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 follows:

(a) Test for application of the ringing signal.

(b) Test for pretripping of machine ringing during the silent interval.

(c) Provide interrupted audible ringing tone during one 2-second ringing interval

(d) Test for tripping machine ringing during a 3-second silent interval

(e) Provide the following supervisory tests:

(1) An off-hook signal of approximately 1.3-second duration for synchronizing with automatic progression test equipment in originating offices is returned. During the off-hook period, soak current is applied to supervisory relays.

(2) 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.

(3) 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 this period, the release current is applied to the supervisory relays.

(4) 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.

(f) Send tone signals to the originating office as follows:

(1) Audible ringing tone for 0.3-second intervals interrupted for 0.2 second as an indication that the trunk circuit tripping features operated on the pretripping test.

(2) 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.

2.26 A ***nonsynchronous*** test line is required for all dial-type class 5 offices, including those having the synchronous test line. [See Fig. 1(A).] This line provides an operational test which is not as complete as the synchronous test but can be made more rapidly. The nonsynchronous type is the only type 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 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:

(a) Starts to function under control of ringing signal.

(b) Permits audible ringing signal to be returned for a minimum of 0.5 second to originating office.

(c) Causes ringing to trip.

(d) After ringing is tripped, returns the 60-IPM line busy signal which consists of alternate 0.5-second off- and on-hook signals with low tone applied during each off-hook period until disconnection. Where the synchronous test line is provided, only the 60-IPM line busy signal is required.

2.27 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:

(a) Starts to function under control of the ringing signal.

(b) Permits audible ringing signal to be returned for 1 to 1.5 seconds.

(c) Returns an initial off-hook signal of 1 to 1.5 seconds duration during which time ringing is tripped.

(d) Provides the following supervisory signals sequentially after the initial off-hook tests are applied:

(1) 0.5 second on-hook.

(2) 1 to 1.5 seconds off-hook.

(3) 0.2 second on-hook.

(4) 0.3 second off-hook.

(5) 0.2 second on-hook.

(6) 0.3 second off-hook.

(7) 0.2 second on-hook.

(8) 0.3 second off-hook.

(9) 2-second on-hook period to permit disconnection from the test line.

(10) Alternate 5.5-second off-hook and 2-second on-hook intervals are repeated until disconnection takes place. The first two 5.5-second intervals are provided to facilitate testing of the ring forward (rering) and control features provided on some operator-selected trunks to end offices and are desirable where these features are provided.

2.28 ***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. 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. [See Fig. 1(F).]

2.29 ***Echo Canceler Test Line (109 type)*** provides a 4-wire trunk termination and loop-around path for testing far-end echo canceler operation from a manual test position. Upon access, the test line signals back confirmation of the connection and cycles through three conditions automatically: trunk terminated, trunk looped around on itself, and trunk looped around with 10-dB attenuation. Double talk detector and echo canceler functions are tested. [See Fig. 1(E).]

F. Centralized Automatic Reporting on Trunks (CAROT) System

2.30 The CAROT system performs end-to-end routine or demand transmission and operational tests on trunks within a defined geographical area. The system consists of a minicomputer-based CAROT controller which performs mechanized administrative and control functions, a ROTL in most central offices which seizes and places test calls over specific outgoing trunks, 105-type test lines which terminate test calls received on incoming trunks, and responders which may be shared by the ROTL and 105-type test lines. In more recent designs, the ROTL, test line, and responder equipment functions may be combined in a single circuit. Similarly, the test line and responder functions may be combined into single circuits that do not contain a ROTL function. Without the ROTL function, 1-way outgoing trunks cannot be accessed for testing via the CAROT system. Figure 2 shows a functional diagram of the CAROT system.

2.31 The CAROT controller has the capability to:

(a) Cause the seizure of trunks by the ROTL

(b) Cause test equipment (eg, responders, test lines) to be connected to each end of the trunks seized

(c) Cause the test equipment to perform measurements on trunks

(d) Receive and store results of measurements

(e) Analyze test results and compare with test limits contained in the data base

(f) Report trouble indications and compile statistics on test schedule and trunk performance.

2.32 The ROTLs provide the means for remote access of trunks over the network. Access is provided to all outgoing and 2-way trunks in an office with the exception of operator trunks. Access is provided to idle trunks and, if desired for a particular test call, to maintenance-busy trunks.

2.33 The ROTLs associated with stored program control switches and other ROTLs specially equipped may control the maintenance state of trunks under the direction of a ROTL control unit at a manual test position. Idle trunks may be made maintenance busy and busy trunks may be restored to service. A verification of the completion of either action is returned to the test positions.

2.34 Remote manual access to and testing from a ROTL are provided by means of an interrogator or a responder/ROTL control unit at a test position. This allows craft persons to conduct the same transmission tests that are conducted on an automatic basis, ie, calls to 100-, 102-, and 105-type test lines on a demand basis.

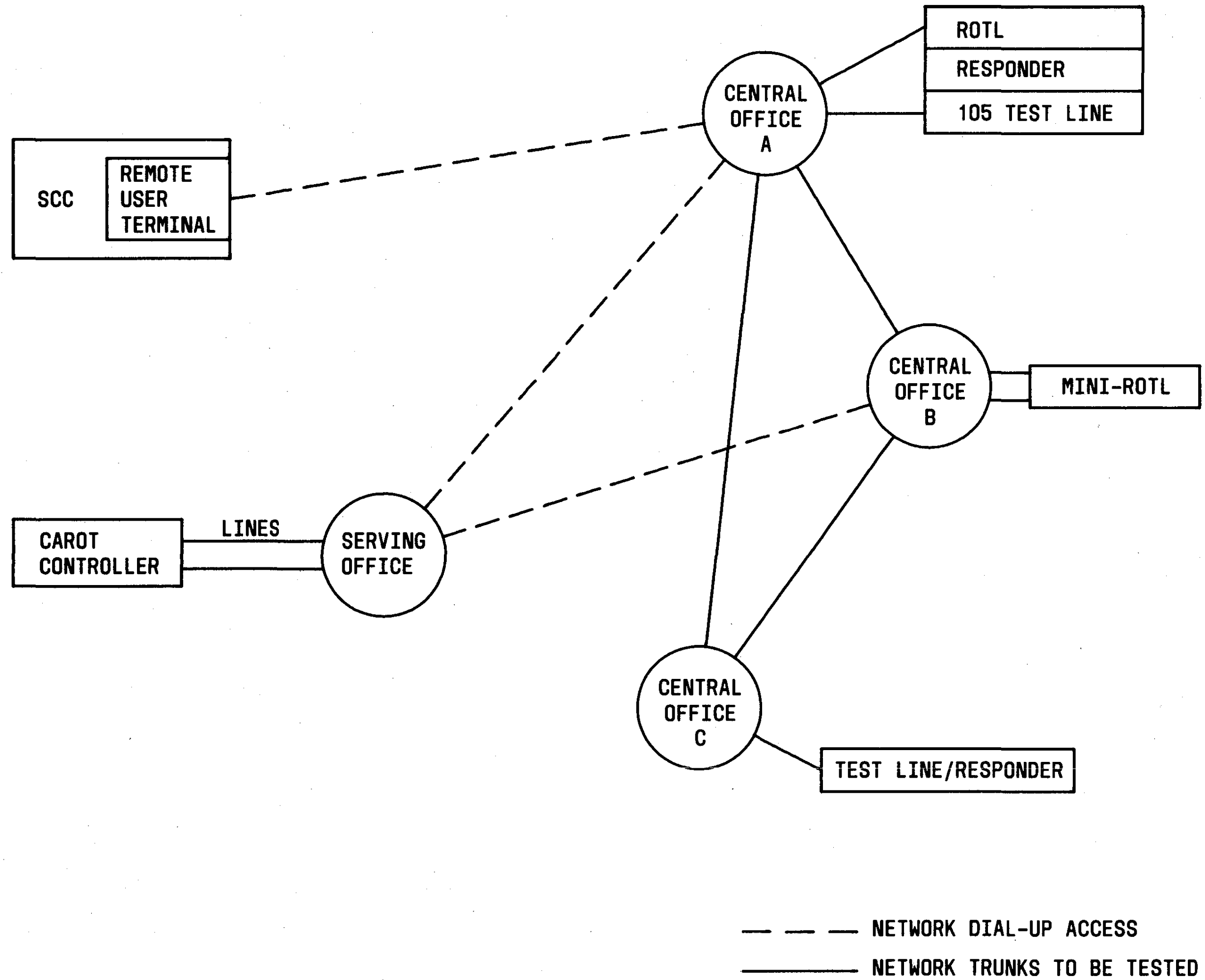


Fig. 2—CAROT System

2.35 Conventional ROTLs (including "expanded ROTLs" and "small ROTLs") have functions separate from test lines and responders. MiniROTLs are single-microprocessor units which incorporate the functions of the conventional ROTL, 105-type test line, and 52A responder. Miniresponders are microprocessor-controlled units which incorporate the functions of the 105-type test line and 52A responder.

2.36 The CAROT system conducts routine automatic testing by commanding a near-end ROTL to access a far-end test line. For transmission testing, 100-, 102-, and 105-type test lines are called; for operational testing from electromechanical ROTLs, 103, synchronous, and nonsynchronous types are used.

2.37 The basic sequence of operation of the CAROT system may be illustrated for the case of the conventional ROTL. The CAROT controller has access to a ROTL via switched dialed-up connections. Under the direction of the CAROT controller, a ROTL seizes a particular trunk and sets up a test call to a test line with a given directory number. When the far-end connection is set up, the ROTL seizes the near-end responder. The controller then commands the ROTL responder and far-end responder to perform tests. Test signals are exchanged and measured and the results are reported to the controller. The ROTL is then commanded to release the trunk and responder.

2.38 The three basic CAROT end office test equipment arrangements shown in Fig. 2 are illustrated in more functional detail in Fig. 3. Central office A is equipped with a conventional ROTL with separate responder and 105-type test line (an arrangement which may be used with most types of switching systems). When central office A is used as a near end, the CAROT controller dials up the ROTL which connects to the responder through the access circuit. The ROTL then connects the responder with the outgoing trunk to be tested and measurements are made. When central office A is used as a far end, the 105-type test line is dialed up on an incoming trunk by the originating (distant) end. The 105-type test line may be parked on until it gains access to the responder. The responder is then connected to the incoming trunk and testing commences under the direction of the originating end. The responder is the only equipment common to both near- and far-end testing functions.

2.39 Central office B, equipped with a miniROTL, is also capable of both near- and far-end CAROT testing. In this case, the miniROTL performs the combined functions of the conventional ROTL, 105-type test line, and responder except for performing the terminal balance measurement. MiniROTLs are typically utilized in class 5 offices and are equipped to provide a termination which enables balance measurements to be made from a class 4 office.

2.40 Central office C is equipped with a combined 105-type test line/responder (miniresponder). Since there is no ROTL, central office C can only function as a far-end test termination. Central offices which contain test lines separate from the responder also can fulfill only the far-end function.

G. Switch Diagnostics

2.41 Stored program control switching systems in large exchange offices are designed to conduct routine automatic operational tests and to analyze trunk faults. In addition, per-call tests are made. Application of these programs can result in error messages indicating possible trunk troubles. In certain cases, the switching system will automatically take equipment out of service.

2.42 Automatic progression testing is the primary mode of routine testing. Under program control, the diagnostic is performed on trunks and other equipment with trunk network appearances. Depending on the type of trunk and its operational record, various standard tests are initiated. Trunks are not necessarily tested daily.

2.43 An automatic continuity and polarity test is run daily or on a scheduled basis for each outgoing trunk. This test is to check that the correct voltages appear on the tip and ring of the trunk. The test does not require placing a call to a distant office.

2.44 Trunks which fail either routine tests or per-call tests are placed on a trunk maintenance list for further testing and analysis. Trunks which do not pass tests at this point may be removed from service, depending on the number of trunks already out of service.

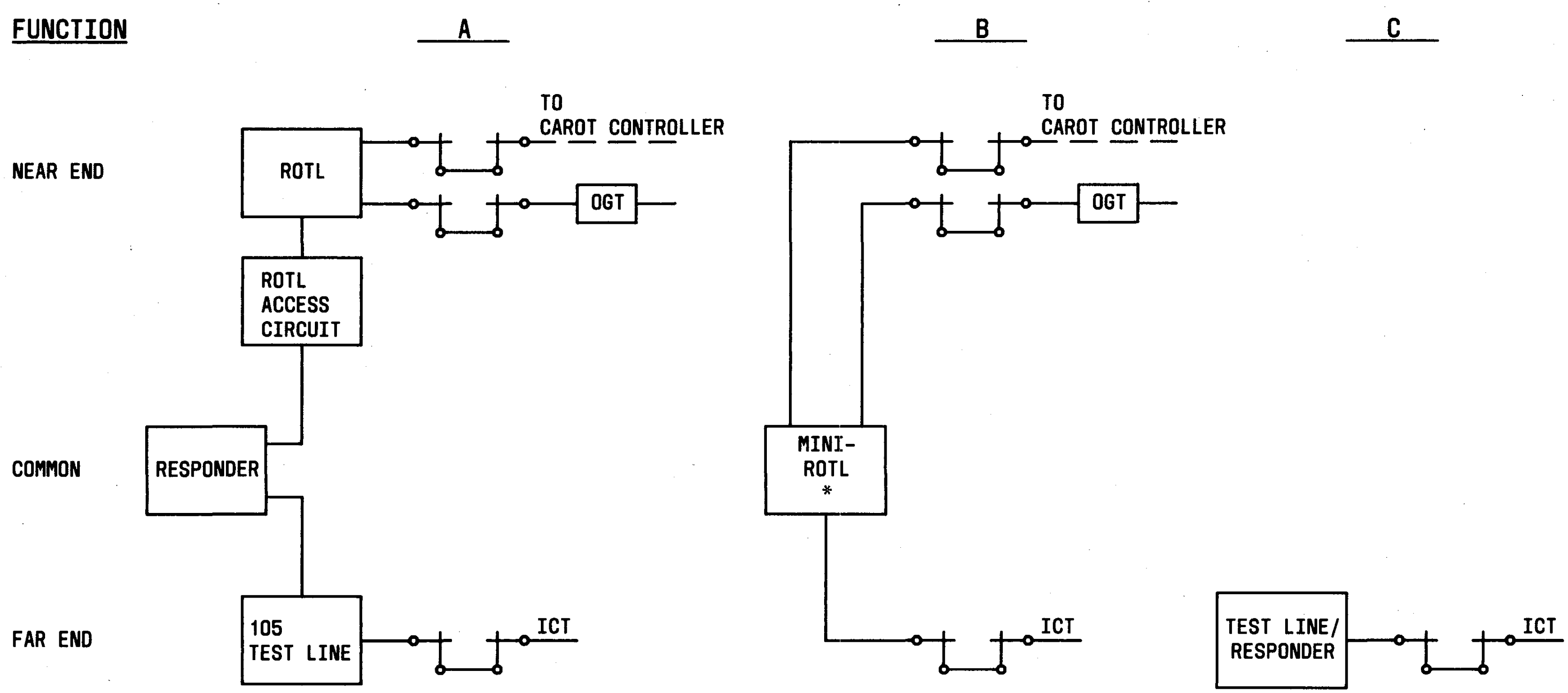
2.45 The results of tests conducted by the switch are transmitted to the SCC. An SCC system may then undertake further, more thorough tests of a trunk.

2.46 In exchange offices with electromechanical switching systems, similar testing functions may be performed by the machine under the control of a paper tape reader. Test results are punched out on cards at the central office by the switch. In electromechanical offices equipped with an automatic trunk analysis system, test results are transmitted to a central data processor. The central processor performs analyses, generates trouble reports, and gives summaries of central office activity. This information is transmitted over data links to work stations at SCCs.

H. Digital Systems

2.47 At present, there are relatively few all-digital trunks in the Bell System and no specific study of their failure modes and rates is yet available. Since digital offices will be embedded in a primarily analog switching environment, it is planned that they will have ROTLs and 105-type test lines and that these maintenance systems will be used on all trunks.

2.48 In the future, when appropriate performance monitoring features and administrative arrangements are available, it may be possible to eliminate the requirement for performing analog tests on all-digital circuits. It is recommended, therefore, that digital switching systems be capable of monitoring and reporting slips, bipolar violations, and out-of-frame conditions. These three indicators,



A - SEPARATE ROTL, 105 TEST LINE, AND RESPONDER.

B - MINI-ROTL WITH COMBINED ROTL, 105 TEST LINE, AND RESPONDER CAPABILITIES.

C - TEST LINE/RESPONDER (MINI-RESPONDER) WITH COMBINED 105-TYPE TEST LINE AND RESPONDER CAPABILITIES FOR FAR-END TERMINATION ONLY.

* IN STEP-BY-STEP OFFICES, MINI-ROTL ACCESSES OUTGOING TRUNKS THROUGH TEST CONNECTOR.

Fig. 3—Near-End, Far-End, and Common CAROT Testing Functions of Equipment Within an End Office for Three Types of Test Equipment

along with appropriate administrative methods, should be adequate to ensure proper performance of circuits on T1 Carrier.

2.49 Circuits which are multiplexed on carrier systems operating above the DS1 rate cannot be monitored for bipolar violations, since bipolar violations are removed by multiplexers. At this time, alternative monitoring arrangements have not been developed for this situation.

2.50 Circuits which are demultiplexed below the DS1 rate for purposes such as cross-connection or digital signal processing are also not covered. Maintenance requirements for terminals employing these techniques are still being developed.

I. Miscellaneous Arrangements

2.51 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, a test battery, a voltmeter, and a Wheatstone bridge.

2.52 Secondary testboard positions are used for monitoring, talking, and signaling on circuits as desired and for patching or making operational 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.

2.53 Other miscellaneous arrangements include:

(a) ***Testing Jacks:*** Used with E&M signaling equipment, carrier terminal equipment, etc

(b) ***Pulsing Test Sets:*** Used for pulsing over circuits

(c) ***Transmission Test Equipment:*** Designed to be portable

(d) ***Carrier Alarm Facilities:*** Designed to release all connections to a faulty facility, make carrier channels busy, and provide alarms as an aid to trunk maintenance.

3. SWITCHING SYSTEM MAINTENANCE

3.01 An SCC is responsible for the switching system maintenance within a specific geographical area. There are two basic types of SCCs: those that serve only stored program control system entities (SPCS SCC) and those that serve only electromechanical switching entities (EM SCC). In some instances, a single SCC may serve both types of switching entities where the relative geographical locations and sizes of the switching systems involved make such combinations economically attractive.

3.02 Switching system maintenance ensures that line-to-line, line-to-trunk, and trunk-to-trunk connections are available to traffic and are properly completed within a switching system. Switching system maintenance is divided into two categories:

(a) ***Corrective Maintenance:*** The detection verification, sectionalization, and repair of network troubles

(b) ***Preventive Maintenance:*** The scheduled routine testing of trunks and common equipment units associated with switching systems.

3.03 The operational support system for the SPCS SCC utilizes the No. 2 Switching Control Center System (#2 SCCS) to automate many of the maintenance tasks. In a similar manner, the EM SCC uses two systems, the Automatic Trouble Analysis (ATA) and the Telecommunications Alarm Surveillance and Control (TASC) systems to automate their maintenance tasks. These systems monitor EM and SPCS offices on a real-time basis and record any alarm conditions which may occur. Depending upon the nature of the alarm, the SCC can take corrective action from the SCC or dispatch a repairperson to the office experiencing the alarm. Error indicators and low priority alarms can be compared to a predetermined threshold level and sound an alarm if the level is exceeded. Some basic trouble analysis is automated in both the EM system and SPCS system. Administrative tasks associated with switching maintenance are performed in the SCC.

4. FACILITY MAINTENANCE

A. Control Centers

Exchange Environment

4.01 A TRCC controls facility maintenance and administration within a geographical area that has sufficiently high density of carrier networks (eg, metropolitan areas). The TRCC has control over all facility networks within the area including T-Carrier, N-Carrier, and FT3 light guide systems. In some companies, the designation Facility Maintenance and Administration Center-Metropolitan (FMAC-M) is used instead of TRCC. The maintenance actions are categorized as either preventive or corrective.

4.02 Preventive maintenance responsibilities of the TRCC include scheduling all routine maintenance, performance of all line routines for digital carrier facilities, and analysis of maintenance activity results to enhance carrier network performance. Corrective maintenance actions include detection and verification of facility troubles, outage notification to the appropriate center, sectionalization and repair of troubles, and repair verification.

Toll Environment

4.03 An HFCC is established to centralize control of maintenance and administration operations for the intercity high-capacity facility network. The geographical area of responsibility may include one or more states. In some companies, the HFCC is called the Facility Maintenance and Administration Center-State (FMAC-S).

4.04 Preventive maintenance responsibilities of the HFCC include scheduling and performance of routine tests of critical equipment, analysis of corrective maintenance records to detect trouble trends and testing of associated equipment, and combined analysis of corrective and preventive procedures. Corrective maintenance includes detecting troubles, recording details of trouble reports, sectionalizing and repairing trouble, and recording details of troubles for further analysis.

B. Operations Support Systems

Exchange Environment

4.05 The operations of a TRCC are supported by a mechanized T-Carrier Administration System (TCAS). This system uses real-time surveillance and telemetry to monitor the status of T-Carrier systems which are in the TRCC geographical area of responsibility. 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, when fully implemented, provides the following features:

(a) Automatically detects T-system failures and analyzes the nature of the alarm (outage or intermittent)

(b) Automatically sectionalizes failures to a defective terminal or span

(c) Rapidly identifies major route failures

(d) Monitors the status of maintenance lines and backbone lines required for restoration

(e) Makes routine periodic digital transmission performance measurement on all T1 lines being monitored

(f) Provides periodic management reports on the performance of the metropolitan digital network.

Toll Environment

4.06 The HFCC is supported by several mechanized systems. A TASC system is used to provide centralized alarm reporting, status surveillance, and remote control of the telecommunications equipment comprising the Bell System plant.

4.07 The TASC system is used to permit unmanning of telephone company buildings containing radio and carrier transmission equipment; electromechanical switching equipment; and associated building, power, and miscellaneous equipments.

4.08 TASC central automates many operations including responding to alarms and presenting the processed information to TASC central operators, logging of all events, selective log retrieval, administration of trouble tickets, and administration of other support tasks. TASC central also accommodates computer communication links to remotely located control terminals and/or computers and provides the ability for each link to control selected parts of the monitored plant. These features permit a single TASC system to support multiple centers (eg, HFCC and SCC).

4.09 The TASC system provides the tools and procedures to:

(a) Consolidate existing telemetry and alarm centers and automate most of the existing manual operations and routine clerical functions that an alarm center performs

(b) Allow the establishment of end-to-end switch section alarm surveillance and remote control

(c) Provide real-time access to alarm information and control functions needed for more efficient management of broadband facility utilization.

4.10 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.

4.11 Depending on the environment, a system for the Surveillance and Control of Transmission Systems (SCOTS) may be used as a facility surveillance support system. This system has most of the capabilities that are found in the TASC system.

4.12 Beyond the surveillance and control functions provided by the TASC system or SCOTS, a Carrier Transmission Maintenance System (CTMS) may be used with long-haul analog carrier systems and associated multiplex terminal equipment to provide automated testing capabilities. This system permits 1-person fault locating in facility offices by use of a broadband switched access network connected to equipment access points throughout the office. Tests which a CTMS performs include:

(a) Periodic level and gain measurements of terminal equipment.

(b) Daily measurements of facility line pilots. (If equipped with a Local Alarm Scanning System [LASS], measurements can be made automatically in conjunction with loss-of-pilot alarms.)

(c) Measurement and analysis of transmission data to develop a carrier performance index.

(d) Frequency response, white noise, fluctuation noise, and spurious tone measurements on radio facilities.

(e) Demand measurements to localize facility transmission problems.

(f) Demand measurements to localize problems on Private Line Services.

5. LOOP MAINTENANCE

A. General

5.01 Many of the trouble conditions occurring in the network, such as those affecting the switching systems or the interconnecting trunks and facilities, are detected by means of automatic alarm indicators or as a result of a routine testing operation. Trouble conditions occurring in the customer's terminal equipment or on the loop facility connecting the customer's terminal equipment with the serving central office are usually detected by the customer who reports the condition to a Repair Service Bureau (RSB) usually by dialing "611".

5.02 Upon accepting the trouble report, the Repair Service Attendant (RSA) secures pertinent data and proceeds to verify and sectionalize the trouble. Until recently, the data procurement and the testing and trouble sectionalization procedures were basically manual operations. However, many of the RSB functions have now been automated. Significant developments are the Automated Repair Service Bureau, the Loop Maintenance Operations System, and the Mechanized Loop Testing System.

B. Automated Repair Service Bureau (ARSB)

5.03 The ARSB represents the latest in mechanized repair service administration, records, analysis, and testing. It is comprised of the Loop Maintenance Operations System and Mechanized Loop Testing System. The major objectives of the ARSB are to:

(a) Improve RSB efficiency and reduce the cost of repair operations

(b) Improve customer service by the more rapid detection, location, and repair of troubles

(c) Improve customer contact handling by providing the RSA with timely customer-oriented information.

C. Loop Maintenance Operations System (LMOS)

5.04 The LMOS mechanizes RSB customer line records and produces basic management and trouble history reports. Specific primary functions include trouble report processing, control of automated testing and analysis of past trouble reports via Trouble Report Evaluation and Analysis Tool (TREAT). A secondary function is the provision of equipment utilization reports. The system acts on data derived from customer calls (trouble reports), status entries relative to open troubles, and trouble history.

D. Mechanized Loop Testing (MLT) System

5.05 The MLT system is an automated testing system that, in conjunction with the LMOS, comprises an ARSB. The MLT system will access a customer's loop, on which a trouble has been reported, using no-test trunks to the NNX served by the MLT system. It will verify the condition of the loop and characterize any trouble by performing numerous tests under computer control. Measured values will be analyzed by the computer and both pass/fail and analog measurement outputs will be made available for RSB personnel. Access to LMOS records during the measurement cycle aids in decision-making concerning valid termination of the loop being tested. The MLT system is composed of two subsystems:

(a) Loop Testing Frame (LTF) which accesses the subscriber loop via the test trunks

(b) MLT Measurement Module (MMM) which contains the test packages for making loop measurements.

NOTES ON THE NETWORK

SECTION 9

WIDE AREA TELECOMMUNICATIONS SERVICES

CONTENTS PAGE

Figures

1. GENERAL

1.01 Outward Wide Area Telecommunications Service (Outward WATS) and 800 Service (Inward WATS) are telephone services designed to meet the needs of customers who make or receive substantial volumes of long distance calls. These services are available by geographical regions called service areas. Within the 48 contiguous states, a customer may subscribe to any of the ***interstate*** service areas. Coverage ranges from adjacent states to all 50 states plus Puerto Rico and the Virgin Islands of the United States. Statewide or ***intrastate*** service is also available in all states except Alaska.

1.02 Special Outward WATS or 800 Service lines connect subscribers to the network. Generally, each such line is arranged to provide either inward or outward service, but not both. Some states, however, do provide tariffs for 2-way service on the same access lines (intrastate only). Both inward and outward access lines provide service at various tariffed rates per hour as provided in the interstate and intrastate tariffs. Since the operational requirements for 800 Service and Outward WATS are completely different, these services are described separately.

1.03 The rates for both Outward WATS and 800 Service are based on the 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/800 Service Coordinators in each Bell System Company.

1.04 The customer must subscribe for the service area which contains the desired call originating points (800 Service) or terminating points (Outward WATS). In addition, usage may be charged at either full-time or measured-time rates. Each arrangement permits up to a specified number of calls and hours of calling per month at a minimum charge. Each call is considered to be at least 1 minute for calculating monthly hours of use. The greater of the measured or calculated hourly usage is used for charging purposes. Overtime charges are applied for each hour or fraction of an hour above the specified amount. The two basic arrangements presently are as follows:

(a) Full Business Day (FBD) lines can have up to 240 hours of calling per month and up to 14,400 messages per month at a minimum charge.

(b) Measured-Time (MT) lines can have up to 10 hours of calling per month and up to 600 messages per month at a minimum charge.

SERVICE AREAS—INTERSTATE

1.05 Service areas are arranged roughly in concentric circles around the home area. The exact service areas for each state are found in the appropriate tariff. The following general descriptive comments apply:

- Interstate service starts with service area one containing the states contiguous to the 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, five, and six. Each successive service area includes the previous service area plus its own states.

- Service area five includes the 48 contiguous states plus Puerto Rico and the Virgin Islands of the United States.

- Service area six, the largest service area, includes the 50 United States plus Puerto Rico and the Virgin Islands of the United States. However, as with the other ***interstate*** service areas, the subscriber's home state is ***excluded.***

SERVICE AREAS—INTRASTATE

1.06 The serving arrangements for intrastate Outward WATS and 800 Service vary according to the state and the company. Listed below are examples of some of the arrangements now used to serve intrastate Outward WATS and 800 Service:

(a) Total state coverage

(b) Home Numbering Plan Area (HNPA) only in a multiple Numbering Plan Area (NPA) state

(c) HNPAs and adjacent NPAs in a multiple NPA state.

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 from offices that 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, all NPA codes not included in the serving area, various service codes, and the Special Area Code (SAC) "800" associated with 800 Service will be blocked to all Outward WATS subscriber access lines. This blocking will prevent double charging on calls from Outward WATS to 800 Service lines. Screening is also required to prohibit completion of calls to 911 emergency service codes.

2.02 Outward WATS lines may:

(a) Dial station-to-station calls direct to points within the selected service area

(b) 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, switchboards, telephone keysets, data sets, various other terminal devices, 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. Once a given 7-digit Outward WATS number is put into service, it must not be duplicated within the NPA.

(a) The first digit of the code (0/1) indicates whether the number is for an FBD or MT service. An initial digit 0 indicates an FBD access line, whereas the digit 1 is for an MT access line.

(b) 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 purposes. A maximum of ten identities can be assigned.

(c) The third digit (Y) will designate the service area subscribed to by the Outward WATS customer as 1, 2, 3, 4, 5, or 6 for interstate calls. The digits 0, 8, and 9 are available for assignment by the companies for intrastate Outward WATS.

(d) The remaining four digits (XXXX) represent the specific billing number for the line. This number is an arbitrary assignment.

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:

(a) The effect of Outward WATS lines on the load-balance status of the serving central office. Most Outward WATS lines experience high hundred–call–seconds (CCS) usage during their busy hour and careful attention must be given to the line assignments made for these lines.

(b) 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.

(c) Trunk access to the toll network must be continuously evaluated for those offices with Outward WATS because of the high CCS load offered by this service.

(d) 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 determine 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.

(e) The details of all Outward WATS calls should be placed on Automatic Message Accounting (AMA) tape or equivalent recording devices to collect hours of use and message count. Operator-assisted calls are recorded on an operator-prepared ticket or on Traffic Service Position System (TSPS) AMA tape. 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. 800 SERVICE

3.01 800 Service is a telecommunications service which allows a subscriber to receive telephone calls originated within specified service areas without a charge to the originating party. The boundaries of the service areas for 800 Service are identical to those for Outward WATS. This service is provided on two or more "terminating only" access lines arranged in a hunting series. These lines receive calls as follows:

(a) Dialed station-to-station calls from points within the selected service area

(b) 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.

3.02 800 Service requires the customer to subscribe for a minimum of two lines per service area and charging arrangement. This is regarded as one line for billing purposes but consists of two access lines arranged in a hunting series. However, if traffic conditions warrant additional lines, the customer has the option of adding additional lines at tariffed rates. Usage and calls for the second line are included with usage on the first line for determining excess usage.

3.03 Directory assistance for both interstate and intrastate service is provided on a centralized basis and may be obtained by dialing (800) 555-1212.

NUMBERING PLAN

3.04 800 Service is handled by means of a special code assignment, consisting of an SAC "800" followed by one or more specific NXX* code(s) for each telephone NPA. Of the 792 codes available, all NX2 codes are reserved for ***intrastate*** service. The remaining codes are reserved for ***interstate*** service.

*Where: N is any digit 2 through 9
X is any digit 0 through 9

3.05 An 800 Service 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.

800 Special Area Code (SAC).

NXX Interstate—This central office type code represents the terminating NPA for an 800 Service call and the designated Terminating Screening Office (TSO) in that NPA.

NX2 Intrastate—This central office type code identifies the 800 Service number as intrastate service. A total of 80

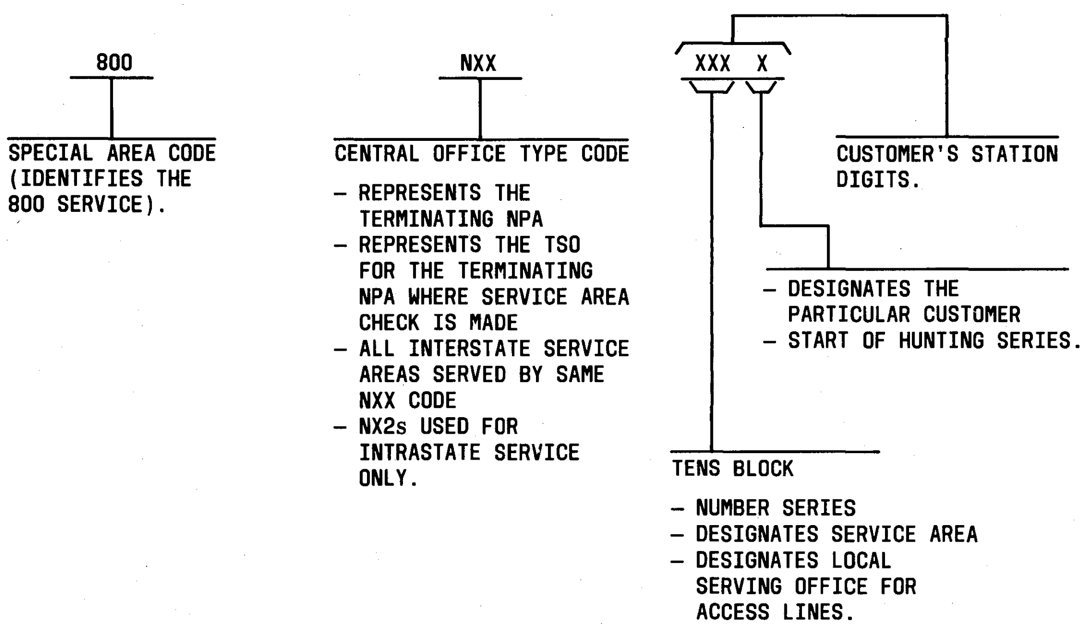


Fig. 1—800 Service Address Dialed

NX2 codes are available for assignment in each state.

These codes can be used to:

(a) Represent the total state

(b) Represent an NPA in a multiple NPA state

(c) Represent a particular terminating serving central office within the state.

XXXX These digits represent the customer station digits. The first three digits, known as the "tens block," specify:

(a) The service area subscribed to

(b) The local serving central office for the access line.

The last digit of the XXXX is used to designate the particular customer and start of hunting series.

ROUTING—INTERSTATE

3.06 When a customer dials an 800 Service number (800 + NXX + XXXX), the call will preferably be routed to an office within the originating NPA 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 800 Service subscriber is located. As the call is forwarded toward the terminating NPA, it must retain its identity of "800 Service" and must also indicate the service area of the originating rate state to the terminating NPA where the 800 Service customer is located.

3.07 An 800 Service call must be directed to the designated TSO for the NPA in which the customer is located. The TSO must be capable of 6D translation and must determine the following:

(a) If the called number is a working 800 Service number series assignment

(b) Whether or not the call is from an allowable service area

(c) The routing to the customer's serving office if the call is from an allowable service area.

This general description of call routing is illustrated in Fig. 2. The following describes the basic functions at the various switching systems involved in the progress of the call.

A. Originating Screening Office (OSO)

3.08 The OSO must be a common control office with 6D translation capabilities. The OSO can be a crossbar tandem, No. 4 crossbar, No. 5 crossbar, No. 1/1A Electronic Switching System (ESS), No. 4 ESS, or other suitable type of equipment.

3.09 There is at least one OSO to serve originating 800 + calls from each NPA. The OSO will, by 6D translation of the SAC and NXX, route the call to or toward the designated TSO of the terminating NPA where the subscriber is located. The following is included in the information sent to or toward the terminating NPA:

(a) An indication that the call is 800 Service

(b) The service area indication of the originating state with respect to the terminating NPA.

3.10 An 800 Service call may be routed either as a ***direct routed*** call or as a ***tandem routed*** call. (See Fig. 2.)

(a) ***Direct routed call:***

(1) The OSO will 6D translate the 800 + NXX to select the direct trunk group to the distant 800 Service TSO.

(2) The 800 + NXX is code converted to the 1NB format where the 1N represents the 800 + NXX code and identifies the call as 800 Service; the B is the service area indication described above.

(3) A 7-digit number, 1NB + XXXX (the converted NXX code, the service area indication, and the four digits of the 800 Service subscriber's number), is now sent forward.

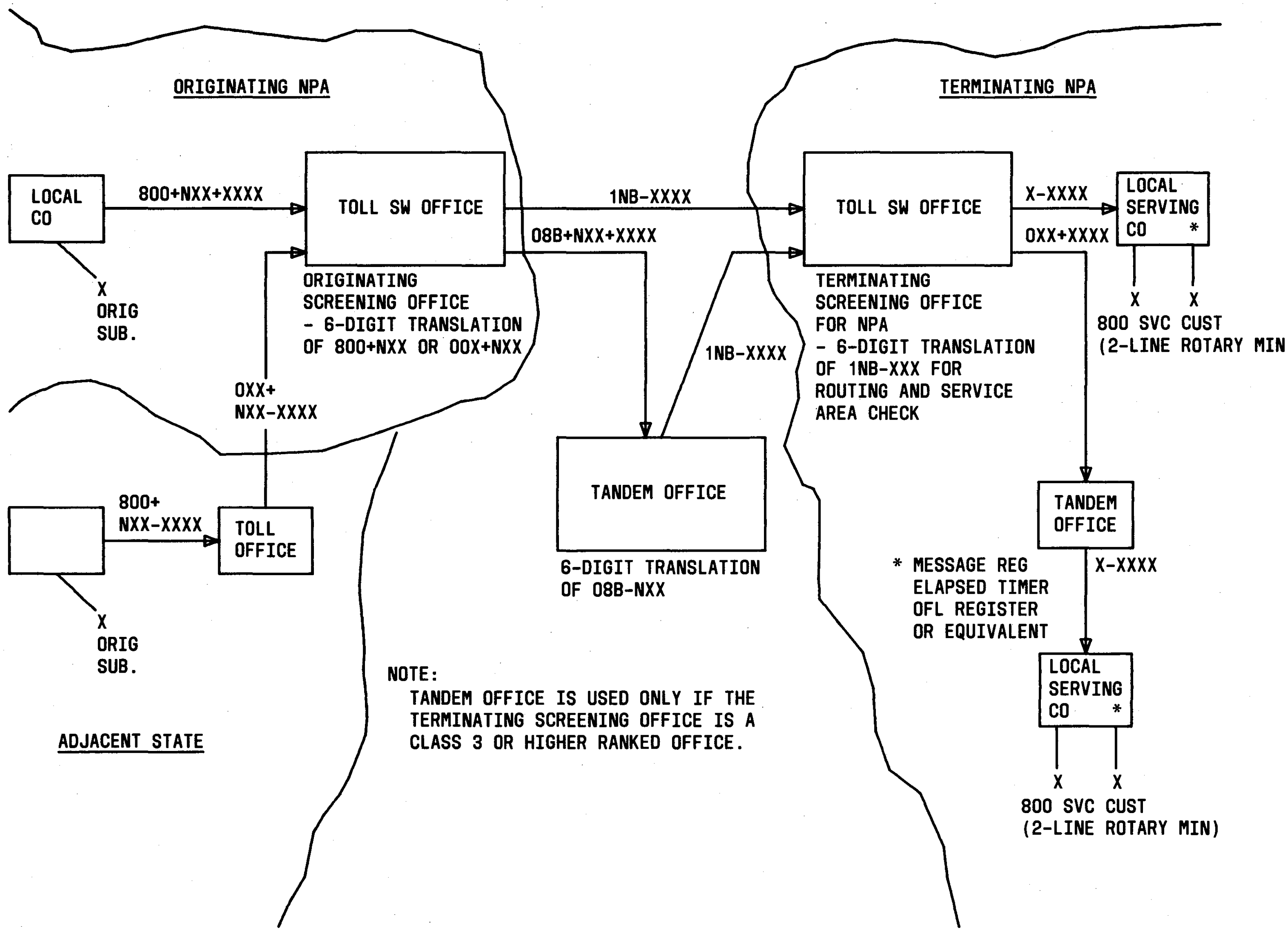


Fig. 2—800 Service Routing—Interstate

(b) ***Tandem routed call:***

(1) If the tandem office is in the same state as the original OSO and handles other originating 800 Service traffic, the 800 Service call may be forwarded as received without code conversion (800 + NXX + XXXX).

(2) If the tandem office is in a different WATS state, the 800 SAC will be code converted to 08B and the 08B + NXX + XXXX sent forward. The 08 identifies the call as 800 Service with the B digit representing the service area indication of the originating state as it relates to the terminating state.

3.11 There are times when an OSO serves more than a single state. In this situation, any adjacent state must convert the originating 800 + calls to a 00X + NXX + XXXX format before they are forwarded to the OSO. The X digit in the 00X code will identify the originating state and permit the OSO to prefix the proper service area indications on all 800 Service traffic from that state.

B. Terminating Screening Office (TSO)

3.12 This office must have the ability to perform 6D translation and can serve as the TSO for a maximum of five 800 Service number series of 10,000 numbers each. It must be able to determine the following:

(a) Whether the incoming call is 800 Service

(b) Whether the call has an allowable service area indicator

(c) The routing of the call to the local serving central office if it is within the service area.

3.13 The TSO receives a 7-digit number (1NB + XXXX) on all terminating interstate 800 Service calls. Six-digit translation is made on the 1NB + XXXX digits. The 1N 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 800 Service number series. The "tens block" also defines the service area assigned to the called subscriber which is matched against the B digit for allowable completion of the call. If the call is within the service area and completion is allowed, the route and outpulsing requirements are obtained from the "tens block" assignment. These details are illustrated in 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.

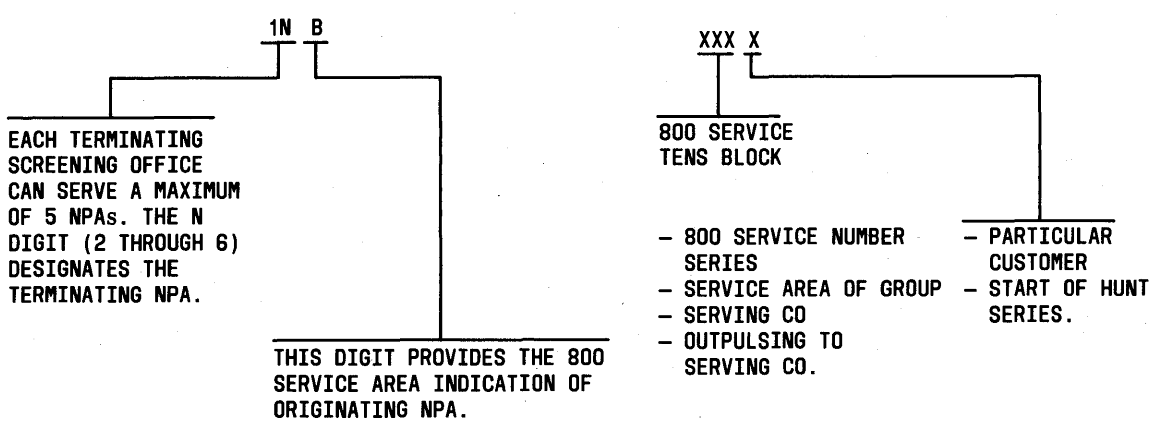


Fig. 3—800 Service Address—Terminating Screening Office

3.14 Routing to the serving central office may be direct or require tandem routing. These requirements are as follows:

(a) ***Direct Routing From TSO:*** The TSO has a direct trunk group to the serving central office. The 1NB is code converted to whatever digit the local office requires to identify the terminating NXX code. This digit and the 4-digit line number are then forwarded to the local serving central office.

(b) ***Tandem Routing From TSO:*** When the TSO does not have a direct trunk group to the serving central office, tandem routing is used. The 1NB is code converted to a 0XX code. The 0XX code and the 4-digit line number are sent to the tandem office. The tandem office will code convert the 0XX code to whatever digit the local office requires to identify the NXX code and sends it and the 4-digit line number to the local serving central office.

(c) Tandem office routing from the TSO to the local serving office may be used only when the addition of the tandem switches does not violate the transmission standards described in Section 3. ***Specifically, routing via a tandem may not be done when the TSO is a class 4 office.*** Similarly, calls may route via only one tandem when the TSO is a class 3 office, via two tandems from a class 2 TSO, and a maximum of three tandem switches when the TSO is a class 1 office.

C. Tandem Screening Office

3.15 As indicated in the paragraphs covering the OSO, some 800 Service calls are routed via a tandem office in another state. These calls are received at the tandem office as 08B + NXX + XXXX where the B is the service area indication of the originating state. The tandem office 6D translates the 08B + NXX and selects a route to the designated TSO in the terminating NPA. The call is then handled as if the tandem office were an OSO with this exception: the service area indication included in the 1NB-XXXX forwarded must reflect the same service area indication it received (ie, the B digit of the 08B code of the incoming call), not the service area indication of the tandem office's own home WATS state.

ROUTING—INTRASTATE

3.16 Intrastate 800 Service routing differs from interstate routing. When an intrastate call arrives at the OSO, it is in the same format as an interstate 800 Service call. Six-digit translation is also required to route the call and the NX2 code following the 800 SAC identifies the call as intrastate.

3.17 There are two ways of assigning NX2 codes for intrastate 800 Service. In one case, each serving central office is provided with its own NX2 code. In the other instance, an NX2 code 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.

3.18 ***Routing With NX2 per Local Serving Central Offices:***

(a) The call arrives at the OSO with the 10-digit number as dialed by the originating party. The 6D translation indicates an intrastate 800 Service call.

(b) The OSO performs 6D 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.)

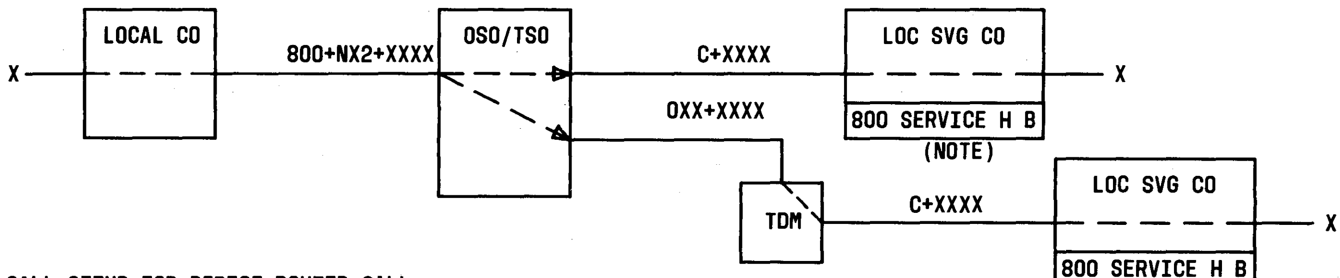
(c) In the event that tandem routing is required, the OSO code converts the 800-NX2 to a 0XX code and forwards it to the tandem office. The tandem office converts the 0XX code to the identifying digit for the serving central office and outpulses this digit and the 4-digit line number. The check is made as described in (b). (See Fig. 4.)

3.19 ***Routing With NX2 for Multiple Local Serving Central Offices:***

(a) The call arrives at the OSO with the 10-digit number as dialed by the originating party. The 6D translation indicates an intrastate 800 Service call.

(b) The 6D translation of the 800-NX2 does not provide enough information to properly route the call since this NX2 code is shared by several

800 - NX2 PER LOCAL SERVING CO
- 800 SERVICE VALIDITY CHECK MADE AT SERVING CO



CALL SETUP FOR DIRECT ROUTED CALL
(1) OSO/TSO SIX-DIGIT TRANSLATES ON 800-NX2.
(2) OSO/TSO SELECTS DIRECT ROUTE TO SERVING CO AND CODE CONVERTS TO 800 SERVICE "CO CODE" AND OUTPULSES TO SERVING CO.
(3) SERVING CO MATCHES 800 SERVICE "CO CODE" AND "HUNDREDS BLOCK" TO ALLOW OR DENY SERVICE.

CALL SETUP FOR TANDEM ROUTED CALL
(1) OSO/TSO SIX-DIGIT TRANSLATES ON 800-NX2.
(2) OSO/TSO SELECTS TANDEM ROUTE AND CODE CONVERTS TO 0XX TYPE CODE REPRESENTING SERVING CO. OUTPULSES TO TANDEM OFFICE.
(3) TANDEM OFFICE CODE CONVERTS 0XX CODE TO 800 SERVICE "CO CODE" AND OUTPULSES TO SERVING CO.
(4) SERVING CO MATCHES 800 SERVICE "CO CODE" AND "HUNDREDS BLOCK" TO ALLOW OR DENY SERVICE.

NOTE:
A SPECIFIC "HUNDREDS BLOCK" NUMBER SERIES IS MARKED 800 SERVICE ONLY AND MUST MATCH 800 SERVICE "CO CODE" FOR VALIDITY CHECK.

Fig. 4—800 Service Routing—Intrastate—NX2 per Local Serving Central Office

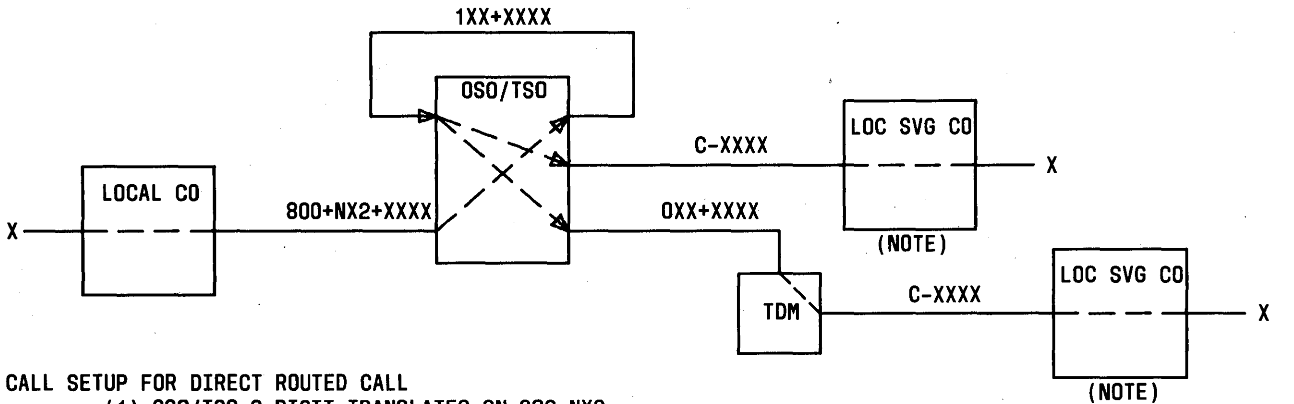
local serving central offices. Since the switching systems designated as OSOs cannot translate more than six digits, the digits needed to route the call cannot be translated. To overcome this obstacle, a group of "loopback" or "loop-around" trunks is used. The 800-NX2 is code converted to a 1XX code and this code and the station digits are outpulsed to reenter the OSO. The OSO then 6D translates the 1XX code 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 code 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.)

(c) 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 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.)

3.20 ***800 Service Routing—Problem Areas:*** 800 Service routing is complicated by the requirements for code conversion and the necessity to reach the TSO of the terminating NPA. These conditions can create problems in route selection at the OSO, tandem switching office, and the TSO screening locations.

3.21 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 traffic becomes complex when the direct, first and second alternates, and the final routes applicable to normal

800 - NX2 FOR MULTIPLE LOCAL SERVING COs
- 800 SERVICE VALIDITY CHECK MADE AT TERMINATING SCREENING OFFICE



CALL SETUP FOR DIRECT ROUTED CALL

(1) OSO/TSO 6-DIGIT TRANSLATES ON 800-NX2.
CODE CONVERTS TO 1XX AND OUTPULSES WITH STATION DIGITS.
(2) OSO/TSO 6-DIGIT TRANSLATES ON 1XX+XXX.
TENS BLOCK CHECK FOR 800 SERVICE AND SERVING CO.
(3) OSO/TSO SELECTS ROUTE TO SERVING CO, CODE CONVERTS 1XX TO
800 SERVICE "CO CODE," AND OUTPULSES TO CO.

CALL SETUP FOR TANDEM ROUTED CALL

(1) OSO/TSO 6-DIGIT TRANSLATES ON 800-NX2. CODE CONVERTS
TO 1XX AND OUTPULSES WITH STATION DIGITS.
(2) OSO/TSO 6-DIGIT TRANSLATES ON 1XX+XXX. MAKES TENS BLOCK
CHECK FOR 800 SERVICE AND SERVING CO.
(3) OSO/TSO SELECTS ROUTE TO TANDEM OFFICE, CODE CONVERTS 1XX TO 0XX TYPE
CODE REPRESENTING THE SERVING CO, AND OUTPULSES TO TANDEM OFFICE.
(4) TANDEM OFFICE SELECTS SERVING CO ROUTE, CODE CONVERTS 0XX TO
800 SERVICE "CO CODE," AND OUTPULSES TO CO.

NOTE:
FOUR DIGITS MAY BE OUTPULSED TO SOME SERVING COs IF
"HUNDREDS BLOCK" MATCH IS NOT POSSIBLE.

Fig. 5—800 Service Routing—Intrastate—NX2 for Multiple Local Serving Central Offices

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. Routing patterns for intrastate traffic must also be included in these evaluations, especially when this traffic is melded into the patterns applicable to the interstate routing requirements.

SERVING CENTRAL OFFICE REQUIREMENTS

3.22 800 Service 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 the terminating area as serving central offices for their convenience in providing the service.

3.23 The basic requirements for 800 Service in the serving central office are as follows:

(a) 800 Service lines are "terminating" only and must be arranged for hunting.

(b) All numbers must be reserved in blocks of ten since this "tens block" provides an indication at the TSO of the service area to which subscribed.

(c) Each service group requires the determination of monthly usage hours and message count for billing and administrative reasons.

(d) Each service group requires overflow registrations which score when calls are offered to the line group and all lines are busy.

(e) AMA, or equivalent, is the preferred method for recording call details.

(f) An alternative mechanical method of recording call details requires the following auxiliary equipment:

(1) An auxiliary circuit arranged to detect "on- and off-hook" supervision at the line circuit

(2) An elapsed time register to score the "off-hook" usage on the line

(3) A message count register to score on completed messages

(4) An overflow register associated with the last line in the group.

(g) The traffic characteristics of this service must also be considered in the serving central office requirements. These characteristics are as follows:

(1) Some 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.

(2) Other 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.

(3) Some businesses that subscribe to this 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.

A. 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:

(a) The busy hour CCS load is excessively high and/or

(b) A high volume of busy hour very short holding time messages is being handled.

3.25 Direct completion from the toll machine to the customer's location may be considered when:

(a) The busy hour CCS load is approximately 1400 to 1600 CCS or more (local office frame load) and/or

(b) Approximately 2000 to 2500 busy hour attempts occur with a very short holding time.

3.26 When direct completion is used, each 800 Service area subscribed to by the customer must be treated as a separate trunk group. When all circuits to a serving area group are busy, the 800 Service calls to that group are "Route Advanced" to a group of Circuit Busy Announcement (CBA) trunks or 60-IPM tone trunks. These announcement trunks can be used in common for all direct completion 800 Service 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 No. 4A crossbar switching system to a 3A Automatic Call Distributor (ACD) 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 paragraph 3.23 are also necessary with this method of operation.

B. Intercept for 800 Service

3.28 If a subscriber dials either a nonworking or working 800 Service number from an unauthorized service area, the call will be routed to a normal vacant code assignment or an intercept operator. A dialed 800 Service number consisting of nine legitimate digits and an incorrect tenth digit will be directed to a vacant, disconnected, or changed number within the "tens block" at the terminating office. These calls should also be routed to the appropriate announcement or intercept operator. With the assignment of the first subscriber to a "tens block" of numbers, any numbers remaining within that "tens block" become unusable except for other customers who have subscribed to the same service area 800 Service.

3.29 Since 800 Service address numbers are in actual local central offices, in some instances, it may be possible for a local or toll calling party using normal telephone codes and dialing procedures (eg, non-800 Service dialing) to be terminated to a working 800 Service terminal or a nonworking terminal in a given "tens block." In these instances, intercept operators must be furnished information with which to respond for these cases.

3.30 When 800 Service access lines which are served from a toll switching system are discontinued or changed, the old number should be reterminated at a local end office where it can be routed to the appropriate intercept.

NOTES ON THE NETWORK
SECTION 10
INTERNATIONAL DIALING

CONTENTS PAGE

Figures

1. GENERAL

1.01 International telephone service accommodates telephone calls placed between nations. These nations may be on the same continent, on adjacent continents, or "overseas." In this section, international telephone service will be discussed as it relates to international dialing.

1.02 In conformance with the worldwide numbering plan, the world is divided into nine zones. (See Fig. 1.) The United States is part of world numbering zone 1 (the integrated North American Dialing Plan) which includes Hawaii, Alaska, Canada, Puerto Rico, the Virgin Islands of the United States, Bermuda, and other Caribbean Islands.* Those nations ***outside*** the United States which are included in the integrated North American Dialing Plan (world numbering zone 1), while international by definition, are dialed in the domestic format.

*Mexico, while part of North America, is not part of world numbering zone 1 nor is it formally part of the integrated North American Dialing Plan. Dialing to Mexico is being standardized in the international dialing format, which is discussed in detail later in this section.

1.03 Because of unique national requirements of geography, population, industry, economics, and existing technological preferences, national telephone networks developed differently. Because of these national differences, international standards were adopted to provide for operational and technical interworking. International dialing plans were developed so that each subscriber is always called by the same number in the international trunk service. International Switching Centers (ISCs) provide the technical interface between the national and international networks. Given the international prefix, foreign country code, and foreign national number, switching systems in the national network direct the call to an appropriate ISC for routing to a foreign country. Conversely, incoming international calls enter the domestic network from the ISC in the domestic format and are completed as domestic calls.

2. INTERNATIONAL RECOMMENDATIONS (STANDARDS)

2.01 The International Telecommunication Union (ITU) is an agency of the United Nations whose purpose is to:

(a) Maintain and extend international cooperation for the improvement and rational use of all types of telecommunication.

(b) Promote the development of technical facilities and their most efficient operation. This development should enable future improvements in the efficiency of telecommunication services, increasing their usefulness to make these services generally available to the public.

(c) Harmonize the actions of nations in the attainment of those common ends.

The ITU works to fulfill these basic purposes through:

- International conferences and meetings
- Publication of information and world exhibitions
- Technical cooperation.

2.02 The international organizations which relate to telecommunications are:

(a) ITU—International Telecommunication Union

(b) CCIR—International Radio Consultative Committee

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

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

2.03 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.

2.04 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.

2.05 The duties of the CCITT are to study technical, operating, and tariff questions and to develop "Recommendations" relating to telegraphy and telephony including data and program services. These Recommendations allow interworking between the different national network designs, making it possible for telephone subscribers in one country to dial directly to subscribers in another country.

2.06 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 ITU in Geneva, Switzerland. The CCIR Recommendations are also published by the ITU in Geneva, Switzerland.

2.07 The CCIR and CCITT books may be purchased from:

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

The United Nations 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 entitled "Telecommunications Journal." Schedules for forthcoming meetings and announcements of other publications are contained in each issue. A complete list of ITU publications can be obtained free of charge from the ITU address in Geneva, Switzerland, listed above.

3. INTERNATIONAL DIRECT DISTANCE DIALING (IDDD)

3.01 IDDD in the United States has been expanded to include calls to 74 countries, which represents over 95 percent of the total United States originated international calling. The term "IDDD" applies to customer-dialed calls placed to foreign points outside the integrated North American Dialing Network (world numbering zone 1). Note that, although calls to Canada (and some Caribbean points) are international in nature, they are handled via the integrated North American Dialing Network and are ***not*** dialed in the international dialing format. Mexico, on the other hand, while geographically part of North America, chose to join the Latin American countries of Central and South America in world numbering zone 5 and is dialable in the international format.

3.02 The North American Dialing Network was designed to use a closed 10-digit national numbering plan. International dialing uses an open numbering plan capable of handling from 7 to 12 digits. To meet the needs of international dialing, significant modifications were required in the various switching systems and/or the Traffic Service Position Systems (TSPSs) of the North American Network. In earlier existing equipment, IDDD service required significant modifications. These modifications were primarily in serving central offices and/or in TSPSs. IDDD capabilities have since been developed for all Bell System Electronic Switching Systems (ESSs) and TSPSs. Electromechanical central offices, eg, step-by-step and the No. 5 crossbar systems, are either directly compatible with the TSPS to provide IDDD or can be modified to provide the service.

3.03 International Originating Toll Center (IOTC) operation enables local assistance operators to complete international calls to IDDD countries for customers who do not have IDDD capability. IOTC operation is mentioned in this section so that a complete overview of the services available to international callers can be treated.

3.04 Calls from those North American locations where IDDD or IOTC service is not available are transferred by the toll operator to an International Operating Center (IOC). At the IOC, 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.

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

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

(b) Accept and handle the increased number of international digits by providing for the expansion of the digit registration capacity in local offices and TSPSs, the ability to perform 2-stage outpulsing, and the modification of Automatic Message Accounting (AMA) recording equipment as may be required.

(c) Route calls from the originating local office to the appropriate ISC.

4. WORLD NUMBERING PLAN

4.01 The world numbering plan provides each subscriber 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 in compliance with the CCITT and, hence, it is not dialable in the international network.

4.02 In addition to the world telephone number, the originating customer must dial an international prefix. The international prefixes for the integrated North American Dialing Network are discussed in paragraph 4.07.

4.03 For numbering and dialing purposes, the world is divided into zones. (See Fig. 1.) Each country within a particular world numbering zone normally has the zone number as the first digit of its country code. The country codes may consist of one, two, or three digits. For example, the USSR has been assigned the 1-digit code 7, Belgium has the 2-digit code 32, and 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 numbering zones 3 and 4.

4.04 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 1-, 2-, or 3-digit code is adequate for requirements as foreseen to the year 2000 AD.

4.05 The North American Dialing Network has an integrated numbering plan. The single digit 1 is used as the country code for 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 1980 are shown in Fig. 2.

4.06 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 some Caribbean points

(6) South Pacific (Australasia)

(7) USSR

(8) North Pacific (Eastern Asia)

(9) Far East and Middle East.

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

United Kingdom	+ 44 plus 7 to 9 digits
Ecuador	+ 593 plus 7 digits
Japan	+ 81 plus 8 to 9 digits
Israel	+ 972 plus 6 to 7 digits
Hong Kong	+ 852 plus 6 to 8 digits

Note: The + sign before the international number indicates that an international prefix must be dialed to access the international network. These international prefixes may vary from country to country. Prefixes are not part of the international number and are not displayed on letterheads, business cards, etc.

4.07 The two international prefixes used within the integrated North American Network are:

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

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

4.08 Dialing international calls requires knowledge of three items of information: (1) the national telephone number of the party being called, (2) the country code of the country being called, and (3) the prefix for accessing the international network in the originating country.

Example: To dial a station-to-station call to the United Kingdom, a United States subscriber would dial the international prefix, 011, then the country code for the United Kingdom, 44, and then the national number for the subscriber in the United Kingdom which can vary from seven to nine digits.

UNITED STATES INTERNATIONAL PREFIX		UNITED KINGDOM COUNTRY CODE		UNITED KINGDOM NATIONAL NUMBER
011	+	44	+	7 to 9 digits

Note: Country code plus the national number cannot exceed 12 digits.

4.09 The international telephone number of a customer in the integrated North American Dialing Network (world numbering zone 1) is shown as country code 1, plus the 10-digit national number (3-digit area code plus seven digits). A foreign subscriber would only have to add the international prefix used in their country to dial a call to the United States.

Example: For a subscriber-dialed call from Geneva, Switzerland, to New York City, the Swiss customer dials the Swiss international prefix, 00, followed by the country code assigned to the integrated North American Dialing Network, 1, plus the 10-digit national number for the New York subscriber. The dialing sequence would be as follows:

SWISS INTERNATIONAL PREFIX		NORTH AMERICAN NETWORK COUNTRY CODE		UNITED STATES NATIONAL NUMBER
00	+	1	+	212 555-4720

5. SWITCHING

5.01 Traffic between the domestic telephone message network and points beyond the boundaries of the integrated North American Dialing Network (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 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 calls are switched. Seven No. 4 ESSs will be performing the ISC role by the end of 1981.

Denver
Jacksonville
New York (two systems)
Sacramento
Pittsburgh
White Plains

5.02 Direct switching to the destination country is the dominant routing procedure. Satellite and submarine cable circuits equipped with CCITT Signaling System No. 5 or 6 are used. Some "via" (transit) switching is performed along routes determined by multilateral agreement among the administrations involved. 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.

5.03 A 2-stage outpulsing arrangement was developed for the TSPS, No. 1/1A ESS offices, and toll cordboards to expand the digit capacity of the national network to handle 12-digit international numbers. In addition to the 2-stage outpulsing, special capabilities are provided in the ISCs to process these digits. The intermediate toll network is not changed.

5.04 The first stage of outpulsing provides a 6-digit routing code which establishes a connection from the TSPS (or No. 1/1A ESS or cordboards) through the national network to the appropriate ISC. At the ISC, special international digit-receiving logic is applied. When the ISC is ready, a "Proceed to Send" signal is transmitted through the built-up toll connection to the TSPS (or No. 1/1A ESS or cordboards).

5.05 Upon receipt of the "Proceed to Send" signal, the originating TSPS (or No. 1/1A ESS or cordboards) sends the second stage of outpulsing (maximum of 12 digits) to the ISC over the built-up connection. At the ISC, the call progresses through international call processing and into the international network.

5.06 IDDD to Mexico uses the standard international dialing format. However, calls to Mexico are not directed to ISCs, but use domestic routing to toll switching systems with direct trunks into Mexico. Over 40 trunk groups presently are homed on four toll centers in Mexico. These toll centers are located at Mexico City, Monterrey, Chihuahua, and Hermosillo. Two additional toll centers serving IDDD calling in Northwest Mexico were added in 1980; they are located at Tijuana and Mexicali. By 1990, it is projected that there will be a total of 16 toll centers in Mexico with terminating groups from the United States. IDDD calling is provided to Mexico without performing 2-stage outpulsing. This requires some unique network arrangements as described in paragraph 7.13 .

6. INTERNATIONAL SIGNALING

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

6.02 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 Time Assignment Speech Interpolation (TASI) (paragraph 8.03) transmission facilities. The specification for this system is found in the latest CCITT publications. System R1 is used internationally to Canada, to various points in the Caribbean, and to Mexico. The Mexican network uses a form of CCITT R2 Signaling (MFC). Signal conversion is required for calling between the United States and Mexico. This conversion is provided in Mexico's toll centers terminating United States trunks.

6.03 A second regional signaling system, known as Signaling System R2 and adapted from a design used in Europe, has also been standardized by the CCITT. It uses 2-way multifrequency (not the same code as System R1) fully compelled interregister signaling and outband (tone or Pulse Code Modulation [PCM]) line or supervisory signaling. It is not compatible with TASI transmission facilities and satellite compatibility is qualified. The specification of System R2 can be found in the latest CCITT publications. System R2 is used as a regional system within Europe, South and Central America, Africa, Australia, and other locations. It is not used in the North American integrated numbering zone.

6.04 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 the latest CCITT publications.

6.05 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 are found in the latest CCITT publications. 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 ISCs. System No. 5 is used today for nearly all intercontinental dial trunks, although applications of System No. 6 are increasing as modern ISCs increase in number. System No. 6 is discussed further in the following paragraph.

6.06 The most advanced international signaling system now in service is CCITT Signaling System No. 6. System No. 6 is similar to Common Channel Interoffice Signaling (CCIS) used domestically. 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 the latest CCITT publications. The specification is also published as a separate pamphlet available from the ITU. Service with System No. 6 was inaugurated in 1978 involving Australia, Japan, and the United States.

6.07 System requirements for demand assignment signaling systems (paragraph 8.04) for demand-assigned multiple access satellite systems were approved by the CCITT in 1972. They may be found in CCITT Recommendation Q.48.

6.08 CCITT Signaling System No. 7 was specified by the CCITT in 1980. It will be covered in the new CCITT publications. This is a common channel system optimized for 64-kb/s digital signaling links and is expected to be used in both national and international applications.

7. METHODS OF OPERATION

7.01 The following is a description of the methods of operation for international calls. These call handling arrangements are part of an overall plan to improve international service by moving call control closer to the caller with the ultimate goal of giving the customer the convenience of dialing as many international calls as possible. The various categories are described in more detail in the following paragraphs.

7.02 International calls may be considered to fall into two general categories depending upon where they are handled (recorded and completed) in the network. The first category refers to those calls handled by the operating telephone companies and is termed International Call Handling (ICH). The second category refers to calls which must be routed by the toll operator to an IOC for handling.

ICH CALLS—IDDD, CDOS, IOTC

7.03 ICH calls fall into two major categories: customer-dialed and operator-handled. Customer-dialed station calls requiring no operator or other special assistance are termed IDDD. International calls dialed by the customer which require operator service, such as person, credit card, collect, request for time and charges, etc, are termed Customer-Dialed Operator-Serviced (CDOS).

7.04 IDDD and CDOS calls are distinguished by the international prefixes 011 for IDDD and 01 for CDOS.

7.05 Operator-handled ICH calls are placed by customers who do not have IDDD capability. These calls, recorded and completed by the operator, are termed IOTC calls.

7.06 A customer who does not have IDDD capability simply dials "0" (operator). The local operator at a TSPS or cordboard will handle the call on an IOTC basis if possible; otherwise, the call will be forwarded to an IOC.

7.07 The traffic-operating procedures used in IOTC service are standardized to follow the procedures used for domestic traffic. The post-dialing delay may be somewhat longer for international calls and the audible signals for ringing, busy, etc, may vary.

7.08 ICH calls (except calls to Mexico) are handled by the 2-stage outpulsing arrangement mentioned in paragraph 5.03 and illustrated in Fig. 3. Particular codes in the outpulsing sequence are used to distinguish between calls involving operators and calls dialed by the customer without operator assistance. This coding arrangement ensures proper and adequate supervision through both the domestic and the international portions of the network.

7.09 The No. 1/1A ESS may provide IDDD directly, performing the recording, translation, and 2-stage outpulsing functions, or the IDDD functions may be performed at the TSPS. For all other class 5 offices offering IDDD, the recording, translating, and 2-stage outpulsing functions are performed at the TSPS.

7.10 The first stage of outpulsing, ie, the 6-digit routing code, which may use either multifrequency signaling or CCIS, establishes a direct connection between the serving entity and the ISC. After the ISC has conditioned the proper logic to set up the international call, it returns a "Proceed-to-Send" supervisory wink (or a "Second Start-Dial" signal on CCIS trunks) and a tone to the originating entity. After the receipt of the "Proceed-to-Send" signal, the originating entity outpulses the second stage, eg, the country code and the national number, over the established connection directly to the ISC.

7.11 At the ISC, the second-stage information is reformatted and the foreign national number and proper supervisory signals are sent over the international circuit.

7.12 The method of operation for all categories of ICH calls is shown in Fig. 3. A call can be traced from the originating subscriber through the network and on to the international circuit. Beginning with the customer-dialed codes, the various code translations and code outpulsings are indicated for each of the ICH categories (ie, IDDD, CDOS, and IOTC calls) as the call progresses through the network.

ICH TO MEXICO

7.13 Customer dialing to Mexico in the international format is subject to all the standard international procedures. These calls are dialed by customers and TSPS operators in the same manner as calls to other international points. However, the network arrangements for handling these calls ***are not*** the same as for other internationally dialed calls and require special network arrangements. These special network arrangements are provided in TSPS Generic 1T8 and translations in No. 1/1A ESSs. A system routing code (180) has been assigned for international dial service to Mexico. (See Fig. 4.) The network procedure is as follows:

(a) A customer dials the international prefix (011) (for an unassisted station call), plus the country code (52) for Mexico, plus the 8-digit Mexican national number desired (011 + 52 + 8 digits).

(b) If the customer is served by a No. 1/1A ESS (properly conditioned), the call will be recorded and translated in the end office. The "011 + 52" will be deleted and the system routing code (180) will be prefixed to the 8-digit Mexican national number. These 11 digits are then sent to the toll network in a single stage of outpulsing.

(c) The toll network translates six digits to route IDDD calls to Mexico. The first three digits (180) identify the call as being directed to a subscriber in Mexico. Since Mexico's numbering plan uses 1-, 2-, and 3-digit routing codes, the next three digits (first three digits of the 8-digit number) must also be translated to direct the call to the proper toll center in Mexico. The complete Mexican national number (eight digits) is forwarded across the border.

7.14 Calls dialed using the international assistance prefix (01) are always directed to TSPS for handling. The necessary recording, translation, and outpulsing are performed in the TSPS. The TSPS is arranged to outpulse 11 digits (180 + 8 digits) for CDOS calls to Mexico.

7.15 Customers served by offices which do not offer IDDD are obliged to dial "0" to place calls to Mexico. (See paragraphs 7.16 and 7.17 for exceptions.) In these cases, the IOTC operator dials the call. Where the customer is served via the TSPS, the operator dials in the international format. The operator depresses the "OVERSEAS" key, then the "KP FWD" (forward) key, followed by country code "52", the 8-digit Mexico national number, and the "ST" (start) key ("OVERSEAS," "KP FWD," 52 + 8 digits, "ST"). The TSPS converts the "OVERSEAS" and the 52 to system routing code 180. The 180 plus the 8-digit national number is then outpulsed by the TSPS to the toll network. Where cordboard operators handle calls to Mexico, the operators outpulse "KP," 180 + 8 digits, "ST."

7.16 Dialing to Mexico City was introduced in 1970 using a pseudo North American dialing arrangement. This pseudo North American dialing will coexist with international dialing to Mexico, as an interim arrangement, until international dialing is fully implemented. Two pseudo Numbering Plan Area (NPA) codes, 90 (5) and 70 (6), are used for Mexico City (zone 5) and Northwest Mexico (zone 6), respectively. To dial Mexico City direct, a customer dials 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 (5) and the 7-digit Mexico City subscriber number, it completes the 10-digit number required in the North American Dialing Network. Calls dialed in this manner appear as directed to NPA code 905, thus, providing a valid and unique North American telephone address.

7.17 Another area of Mexico with a high community of interest with the United States is Northwest Mexico, particularly the Tijuana-Mexicali area. In 1963, NPA code 903 was assigned for North American dialing to this limited part of Northwest Mexico. Northwest Mexico is designated in Mexico's national numbering plan as zone 6; consequently, the digit 6 becomes the first digit of the 8-digit national number. In late 1980, the area served by NPA 903 was renumbered to conform with the Mexican numbering plan. To continue North American dialing into Northwest Mexico and to be consistent with the pseudo NPA scheme developed for Mexico City, NPA code 903 was replaced by pseudo NPA code 70 (6). Standardizing telephone numbering in this part of Northwest Mexico made all of Mexico accessible in the IDDD format. Assigning code 70 (6) not only standardizes the pseudo North American interim plan for Mexico but expands the area served to include all of zone 6 in Mexico.

IOC CALLS

7.18 Certain international calls cannot be handled at this time by ICH methods. Some countries are reached by manual (ringdown) circuits and others can be dialed only by an operator. Even some of the IDDD countries require modifications to standard operating practices for some types of calls. The IOCs are staffed and equipped to handle this non-ICH traffic.

7.19 A customer desiring to place a call which must be handled at an IOC simply dials "0" (operator) to reach the local operator. The local operator dials a 6-digit routing code to reach the appropriate IOC.

7.20 At the IOC, the operator records the call and completes it by connecting to an international circuit terminated directly on the switchboard in the case of a manual circuit or via a tandem trunk to a dial circuit terminated on an ISC. Figure 5 shows examples of IOC-handled calls from Denver, Colorado, to a manual country, Bangladesh, and from Denver, Colorado, to a dial country, French Guiana.

8. INTERNATIONAL TRUNKING FACILITIES

SUBMARINE CABLES

8.01 There are a variety of submarine cable systems in use. These 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 this purpose. Cables with up to 4000 voiceband channels are currently in use.

SATELLITE

8.02 Satellites are used to establish intercontinental and other international circuits. Since these communications satellites are in synchronous orbit approximately 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)

8.03 The TASI system 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

8.04 A demand assignment satellite system called SPADE 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.

9. TRANSMISSION AND MAINTENANCE

9.01 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.

9.02 The circuits in tandem may include trunks on submarine cables and satellites. The limits placed on the range of acceptable transmission transit 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.

9.03 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 the CCITT Orange Books, Recommendation Q.115.) The introduction of the echo cancellers is expected to provide significant improvement in echo performance.

9.04 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. Recommendations concerning transmission maintenance are in the M and O series in the Orange Books, and those concerning trunk maintenance are in the Q series.

9.05 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 Recommendations Q.22 and Q.49.)

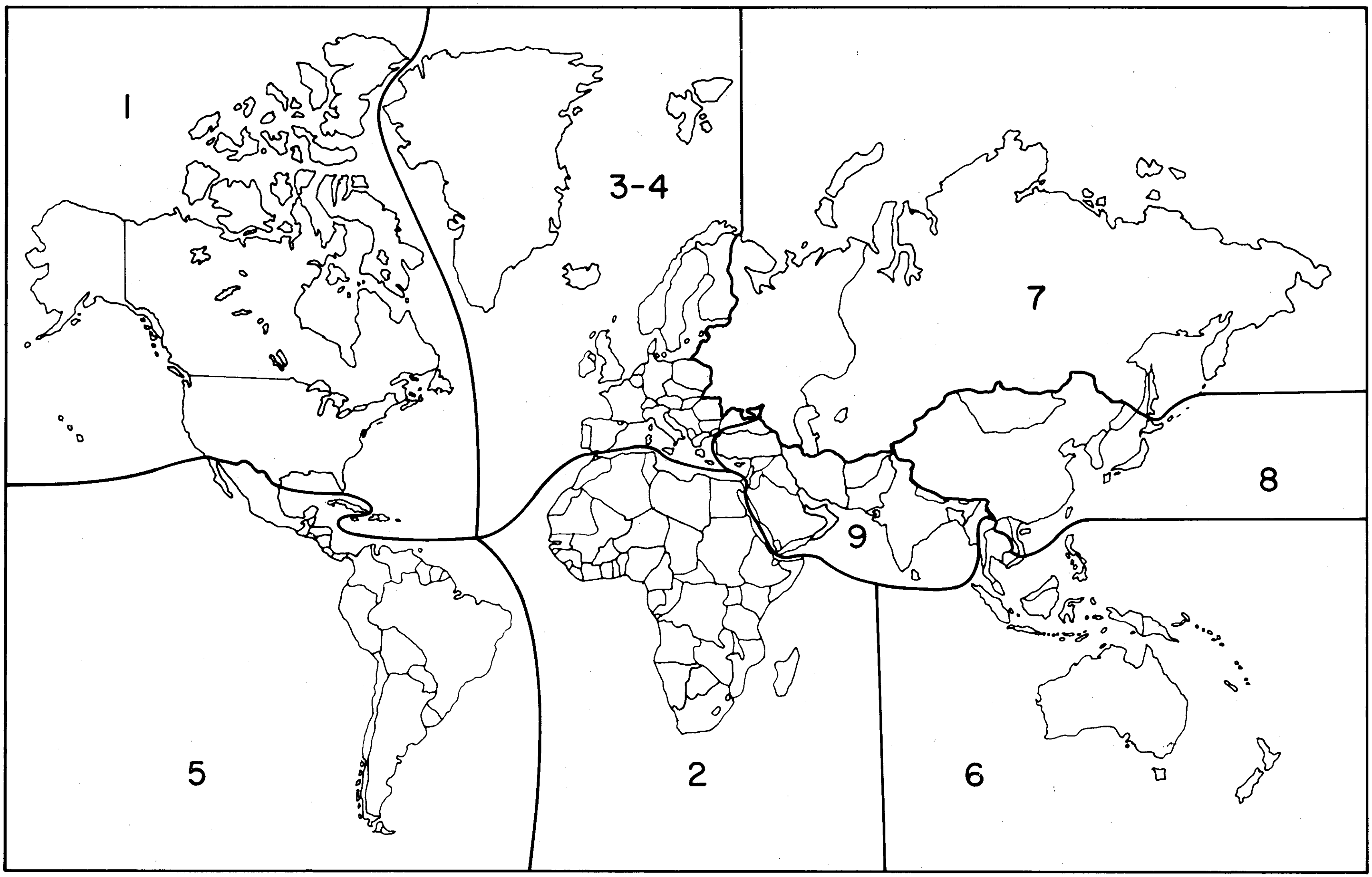


Fig. 1—World Numbering Zones

WORLD NUMBERING ZONE 1

(INTEGRATED NUMBERING AREA)

Canada
Saint Pierre and Miquelon
United States of America including Puerto Rico and the Virgin Islands of the United States
Jamaica
Dominican Republic
Barbados
Antigua
Cayman Islands
British Virgin Islands
Bermuda
Bahamas (Commonwealth of the)
Grenada
Montserrat
St. Kitts
St. Lucia
St. Vincent

WORLD NUMBERING ZONE 2

Egypt (Arab Republic of)	20
Morocco (Kingdom of)	210
Morocco (Kingdom of)	211
Morocco (Kingdom of)	212
Algeria (Algerian Democratic and Popular Republic)	213
Algeria (Algerian Democratic and Popular Republic)	214
Algeria (Algerian Democratic and Popular Republic)	215
Tunisia	216
Tunisia	217
Libyan Arab Republic	218
Libyan Arab Republic	219
Gambia	220
Senegal (Republic of)	221
Mauritania (Islamic Republic of)	222
Mali (Republic of)	223
Guinea (Republic of)	224
Ivory Coast (Republic of the)	225
Upper Volta (Republic of)	226
Niger (Republic of the)	227
Togolese Republic	228
Benin (People's Republic of)	229
Mauritius	230
Liberia (Republic of)	231
Sierra Leone	232
Ghana	233
Nigeria (Federal Republic of)	234
Chad (Republic of the)	235
Central African Empire	236
Cameroon (United Republic of)	237
Cape Verde (Republic of)	238
Sao Tome and Principe (Democratic Republic of)	239
Equatorial Guinea (Republic of)	240
Gabon Republic	241
Congo (People's Republic of the)	242

Fig. 2—List of Country Codes

WORLD NUMBERING ZONE 2 (Contd)

Zaire (Republic of)	243
Angola (People's Republic of)	244
Guinea-Bissau (Republic of)	245
Seychelles	248
Sudan (Democratic Republic of the)	249
Rwanda (Republic of)	250
Ethiopia	251
Somali Democratic Republic	252
Afars and Issas	253
Kenya (Republic of)	254
Tanzania (United Republic of)	255
Uganda	256
Burundi (Republic of)	257
Mozambique (People's Republic of)	258
Zanzibar (Tanzania)	259
Zambia (Republic of)	260
Madagascar (Democratic Republic of)	261
Reunion (French Department of)	262
Rhodesia (Zimbabwe)	263
Namibia	264
Malawi	265
Lesotho (Kingdom of)	266
Botswana (Republic of)	267
Swaziland (Kingdom of)	268
Comoros (State of the)	269
South Africa (Republic of)	27

Spare Codes: 246, 247, 28X, 29X

WORLD NUMBERING ZONES 3 AND 4

Greece	30
Netherlands (Kingdom of the)	31
Belgium	32
France	33
Monaco	33
Spain	34
Hungarian People's Republic	36
German Democratic Republic	37
Yugoslavia (Socialist Federal Republic of)	38
Italy	39
Roumania (Socialist Republic of)	40
Switzerland (Confederation of)	41
Czechoslovak Socialist Republic	42
Austria	43
United Kingdom of Great Britain and Northern Ireland	44

Fig. 2—List of Country Codes (Contd)

WORLD NUMBERING ZONES 3 AND 4 (Contd)

Denmark	45
Sweden	46
Norway	47
Poland (People's Republic of)	48
Germany (Federal Republic of)	49
Gibraltar	350
Portugal	351
Luxembourg	352
Ireland	353
Iceland	354
Albania (Socialist People's Republic of)	355
Malta (Republic of)	356
Cyprus (Republic of)	357
Finland	358
Bulgaria (People's Republic of)	359

WORLD NUMBERING ZONE 5

Belize	501
Guatemala	502
El Salvador (Republic of)	503
Honduras (Republic of)	504
Nicaragua	505
Costa Rica	506
Panama (Republic of)	507
Haiti (Republic of)	509
Peru	51
Mexico	52
Cuba	53
Argentine Republic	54
Brazil (Federative Republic of)	55
Chile	56
Colombia (Republic of)	57
Venezuela (Republic of)	58
Guadeloupe (French Department of)	590
Bolivia (Republic of)	591
Guyana	592
Ecuador	593
French Guiana (French Department of)	594
Paraguay (Republic of)	595
Martinique (French Department of)	596
Surinam (Republic of)	597
Uruguay (Oriental Republic of)	598
Netherlands Antilles	599

Spare codes: 500, 508

Fig. 2—List of Country Codes (Contd)

WORLD NUMBERING ZONE 6

Malaysia	60
Australia	61
Indonesia (Republic of)	62
Philippines (Republic of the)	63
New Zealand	64
Singapore (Republic of)	65
Thailand	66
Guam	671
Portuguese Timor	672
Brunei	673
Nauru (Republic of)	674
Papua New Guinea	675
Tonga (Kingdom of)	676
Solomon Islands	677
New Hebrides	678
Fiji	679
Wallis and Futuna	681
Cook Islands	682
Niue Island	683
American Samoa	684
Western Samoa	685
Gilbert Islands (Kiribati Network)	686
New Caledonia and Dependencies	687
Tuvalu Islands	688
French Polynesia	689

Spare codes: 670, 680, 69X

WORLD NUMBERING ZONE 7

Union of Soviet Socialist Republics	7

WORLD NUMBERING ZONE 8

Japan	81
Korea (Republic of)	82
Viet-Nam (Socialist Republic of)	84
Hong Kong	852
Macao	853
Khmer Republic	855
Laos People's Democratic Republic	856
China (People's Republic of)	86
(Note 1)	87
Bangladesh (People's Republic of)	880

Spare codes: 80X, 83X, 851, 854, 857, 858, 859, 881
882, 883, 884, 885, 886, 887, 888, 889, 89X

Fig. 2—List of Country Codes (Contd)

WORLD NUMBERING ZONE 9

Turkey	90
India (Republic of)	91
Pakistan	92
Afghanistan (Republic of)	93
Sri Lanka (Ceylon) (Republic of)	94
Burma (Socialist Republic of the Union of)	95
Maldives (Republic of)	960
Lebanon	961
Jordan (Hashimite Kingdom of)	962
Syrian Arab Republic	963
Iraq (Republic of)	964
Kuwait (State of)	965
Saudi Arabia (Kingdom of)	966
Yemen Arab Republic	967
Oman (Sultanate of)	968
Yemen (People's Democratic Republic of)	969
United Arab Emirates (Note 3)	971
Israel (State of)	972
Bahrain (State of)	973
Qatar (State of)	974
Mongolian People's Republic	976
Nepal	977
Iran	98

Spare codes: 970, 975, 978, 979, 99X

Notes:

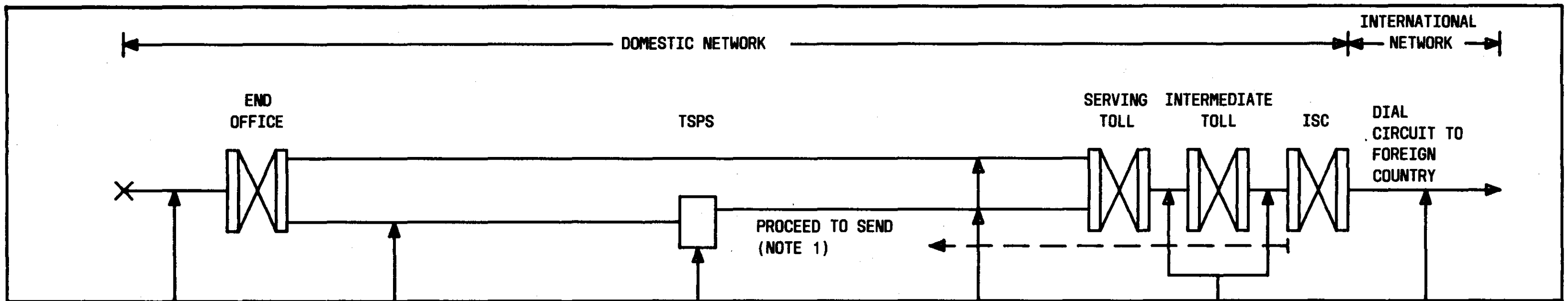
1. Country code 87 is reserved for maritime mobile service:

   871 Marisat (Atlantic)
   872 Marisat (Pacific)
   873 Marisat (Indian Ocean)

2. The designations 83X, 89X, etc, refer to the ten number sets 830 through 839, 890 through 899, etc.

3. United Arab Emirates: Ajman, Fujairah, Ras El Khaimah, Sharjah, Umm âl Quwain, Dubai, Abu Dhabi.

Fig. 2—List of Country Codes (Contd)



ICH CATEGORY	CUSTOMER-DIALED CODE	CODE OUTPULSED FROM END OFFICE TO TSPS	OPERATOR-DIALED CODES	CODE OUTPULSED FROM END OFFICE OR TSPS	CODE OUTPULSED THROUGH NETWORK	CODE OUTPULSED ON INTERNATIONAL CIRCUIT
IDDD	011 + CC + NN	STEP-BY-STEP (DIAL PULSE) 11 + CC + NN OTHER CLASS 5 OFFICES (MF) KP + 1 + CC + NN + ST (OR ST2P)		1ST STAGE KP + 011 + PCC + ST 2ND STAGE (DIRECT TO ISC) KP + CC + NN + ST	1ST STAGE KP + 011 + PCC + ST (MF OR CCIS)	KP + 0 + NN + ST (NOTE 2)
CDOS	01 + CC + NN	STEP-BY-STEP (DIAL PULSE) 1 + CC + NN OTHER CLASS 5 OFFICES (MF) KP + 1 + CC + NN + STP (OR ST3P)		1ST STAGE KP + 011 + PCC + ST 2ND STAGE (DIRECT TO ISC) KP + PCC + NN + ST	1ST STAGE KP + 011 + PCC + ST (MF OR CCIS)	KP + 2 + NN + ST (NOTE 3)
IOTC	0-	STEP-BY-STEP (DIAL PULSE) NO DIGITS OTHER CLASS 5 OFFICES (MF) KP + STP (OR ST3P)	TSPS OPERATOR OVS + CC + NN + ST CORDBOARD OPERATOR 1ST: KP + 011 + PCC + ST AFTER RECEIPT OF 480-HZ TONE 2ND: KP + PCC + NN + ST	1ST STAGE KP + 011 + PCC + ST 2ND STAGE (DIRECT TO ISC) KP + PCC + NN + ST	1ST STAGE KP + 011 + PCC + ST (MF OR CCIS)	KP + 2 + NN + ST (NOTE 3)

LEGEND:
CC - COUNTRY CODE (ONE, TWO, OR THREE DIGITS)
PCC - PAIRED (OR PSEUDO) COUNTRY CODE (THREE DIGITS)
NN - NATIONAL NUMBER

NOTES:
1. "PROCEED TO SEND" SIGNALS FROM ISC:
   - 480-HZ AUDIBLE TONE (CORDBOARD OPERATION)
   - SUPERVISORY WINK (MF SIGNALING)
   - "SECOND START DIAL" (CCIS SIGNALING)
2. DISCRIMINATING DIGIT "0" - RECOGNIZES SUBSCRIBER-DIALED CALLS.
3. LANGUAGE DIGIT "2" - RECOGNIZES OPERATOR-HANDLED CALLS (DIGIT "2" SIGNALS "ENGLISH" LANGUAGE ASSISTANCE WHEN REQUIRED).

Fig. 3—ICH 2-Stage Outpulsing

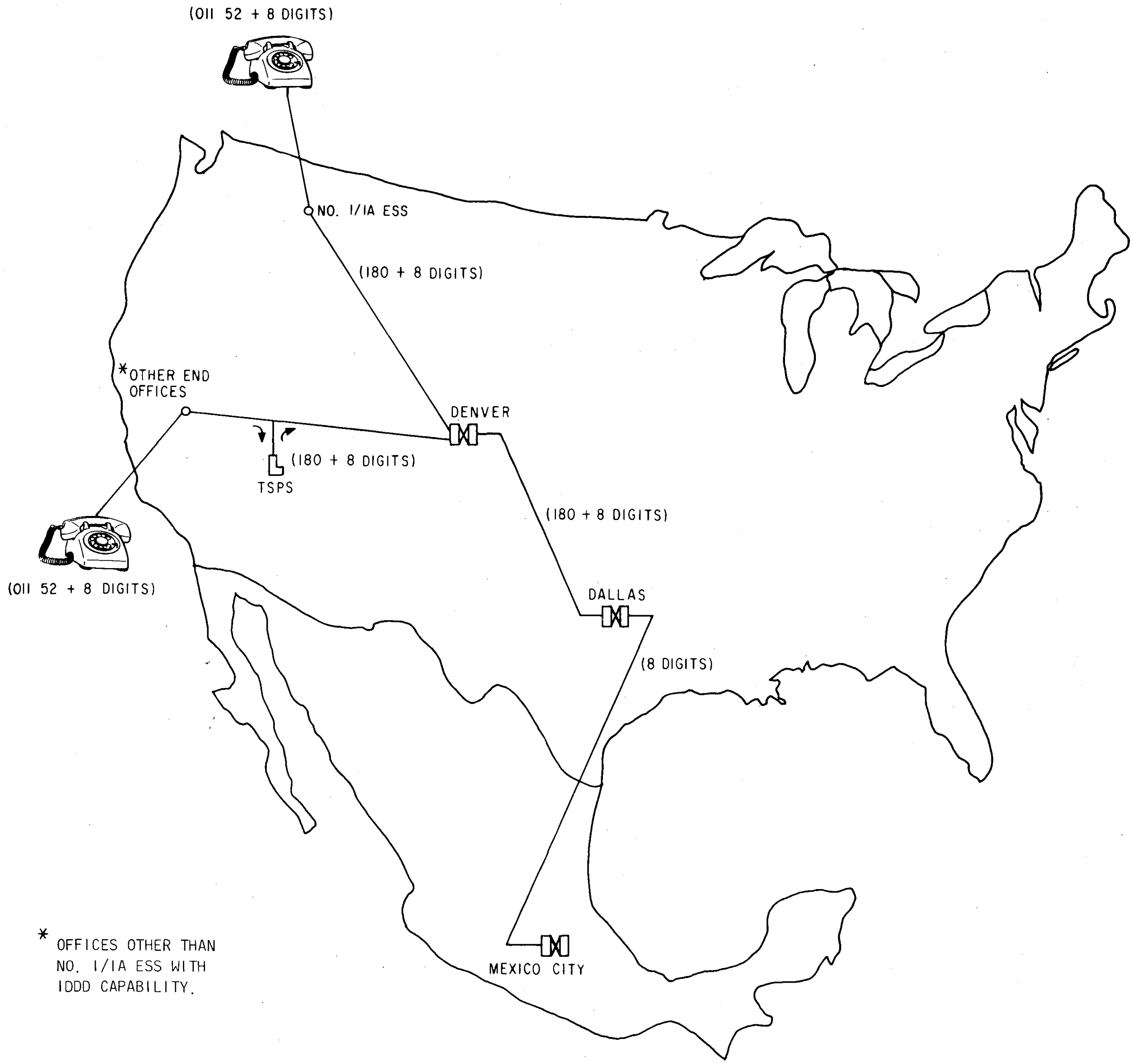
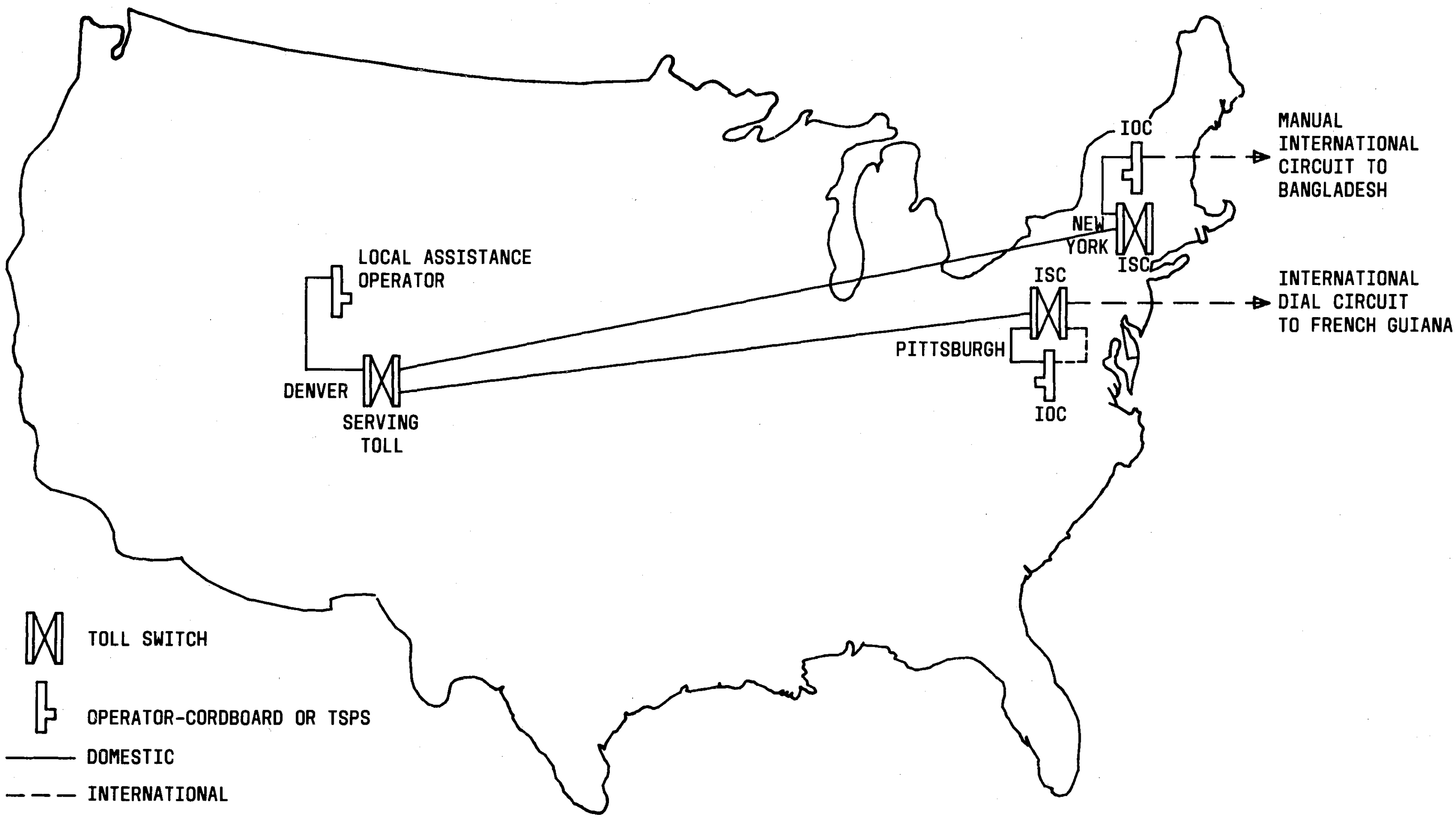


Fig. 4—IDDD to Mexico



CALL TO	CUSTOMER DIALS	OPERATOR DIALS	SERVING TOLL OUTPULSES	IOC OPERATOR	ISC OUTPULSES
BANGLADESH	0	KP + 160 + XXX + ST	KP + 160 + XXX + ST	RINGS FORWARD	
FRENCH GUIANA	0	KP + 160 + XXX + ST	KP + 160 + XXX + ST	DIALS KP + PCC + NN + ST	KP + 2 + NN + ST

LEGEND:

PCC – PSEUDO COUNTRY CODE
NN – NATIONAL NUMBER
XXX – COUNTRY CODE

Fig. 5—IOC Routed Call

NOTES ON THE NETWORK
SECTION 11
NETWORK MANAGEMENT

CONTENTS — PAGE

Figures

1. GENERAL

1.01 The network functions as a single, integrated entity to which customers have shared access for voice telephone calls, data calls, and other uses, such as facsimile transmission. The network is currently being enhanced by the rapid introduction of Stored Program Controll (SPC) switching systems interconnected via the Common Channel Interoffice Signaling (CCIS) system. In effect, the CCIS network is a separate high-speed packet-switched data network which allows SPC switching systems in the network to communicate with one another. The interconnection of SPC switching systems by a reliable, high-speed, high-capacity signaling system permits more efficient use and control of the network.

1.02 Network management is real-time surveillance and control to optimize use of the call-carrying capacity in a network under stress due to traffic overload or failure. Current emphasis is being placed on improved automatic network management controls that are built into modern SPC switching systems and signaling systems. Advances are also being made in manual network management controls and real-time network surveillance capabilities. These advances are being accomplished primarily by using computer-based systems which support the operation of centralized Network Management Centers (NMCs). Network managers in NMCs are available to intervene in problems for which automatic solutions would be excessively expensive and in problems requiring human judgment. The current approach to network management is to provide an economical balance between automatic and manual network management capabilities, with emphasis on continued improvements in automatic controls.

1.03 The objective of network management is to enable as many calls as possible to be successfully completed. This objective is met by maximizing the use of all available equipment and facilities in any situation which may occur by:

(a) Inhibiting switching congestion and preventing its spread

(b) Utilizing all available circuits (eg, by utilizing idle capacity due to time zone differences)

(c) Keeping all available circuits filled with traffic which has a high probability of resulting in effective calls

(d) Giving priority to calls requiring a minimum number of circuits to form a connection when all available circuits are in use (eg, where direct circuits are available by inhibiting traffic from using routings involving two or more circuits in tandem).

2. ORGANIZATION

NETWORK MANAGEMENT RESPONSIBILITIES

2.01 Network management is responsible for the surveillance and control of traffic on the telephone network. Through a combination of manual and automated techniques, network managers optimize the call-carrying capacity of the network and minimize the effects of traffic overloads and machine or facility failures. This work is crucial in today's modern network of common control and stored program controlled processor switching, extensive alternate routing, and centralization of network switching into larger, more efficient machines. When operating under design limitations, the network is highly efficient and economical. In periods of overloads or major equipment failures, however, network performance can degrade rapidly and the number of carried calls can fall well below design capacities. This is due to excessive alternate routing and regenerative switching delays that are compounded by customer and machine reattempts. Switching delays, if left uncontrolled, spread quickly throughout the network. Network management helps to maintain network integrity during overloads and major failures; it is also instrumental in realizing optimized call-carrying capacity throughout the network when it is needed. This is accomplished through the use of near real-time, preprocessed surveillance data, automatic controls responding dynamically to switching office or trunk congestion, and manual controls for the intervention into network problems requiring human judgment.

NETWORK MANAGEMENT CENTER

2.02 At the base level of the network management hierarchy is the NMC. The NMC is supported by the Engineering and Administration Data Acquisition System/Network Management (EADAS/NM).

EADAS/NM

2.03 The EADAS/NM supports the activities of the centralized NMC. This system collects data in near real time from both toll and local offices in a large geographical area, such as an entire metropolitan area, a state, or several states (Fig. 1). This allows such an area, called a "cluster," to be managed as a whole and breaks away from the concept of managing individual switching offices. From one EADAS/NM-supported NMC, network managers can monitor and control up to several hundred switching offices.

2.04 The EADAS/NM employs a minicomputer and peripherals to provide centralized surveillance and control of switching machines and trunk groups. To accomplish this, the EADAS/NM:

(a) Gathers network data and performs calculations every 5 minutes. The results of these calculations are matched against preset thresholds in the data base. Results which equal or surpass these thresholds cause the computer to activate indicators on the display board and present a hard copy exception printout.

(b) Receives an update of discretes (off-on status conditions) each 30 seconds and causes indicator displays to be updated accordingly.

Fig. 1—EADAS/NM Systems

(c) Has a display system organized so that the onset of an indicator on the wall panel will direct the manager to a Cathode-Ray Tube (CRT) display page for problem investigation and control activation. The CRT pages are arranged so that the network manager can search in pyramidical fashion from a gross indication of a network problem to a detailed description of the problem.

(d) Can activate manual controls in many switching offices simultaneously through interactive CRT control pages. Control commands are communicated back to the switching office by the EADAS/NM system over the same interfaces on which data are collected from these offices.

2.05 Most switching offices are connected to the EADAS/NM system (Fig. 2) through an intermediate computer-based Traffic Data Collection System (TDCS). Some toll offices, such as the No. 4A Toll Crossbar Electronic Translator System (ETS) and the No. 4 Electronic Switching System (ESS), have their own TDCSs and interface with the EADAS/NM via direct data links.

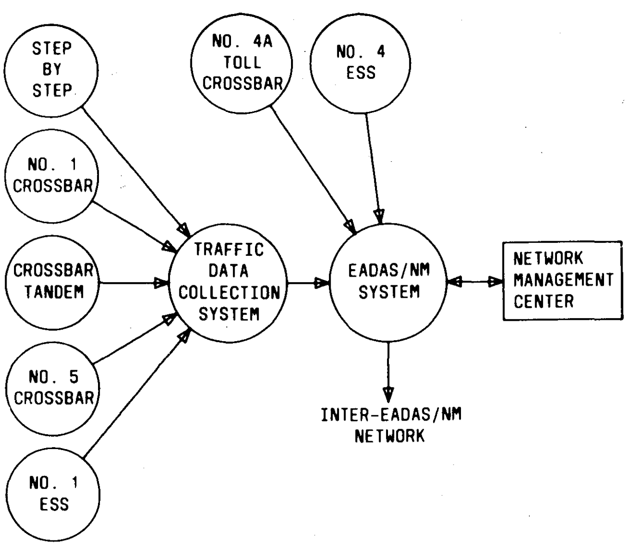


Fig. 2—EADAS/NM Interfaces

2.06 NMCs in the United States are organized in a 3-level hierarchy. The first or basic level is the EADAS/NM-supported NMCs.

2.07 The next level in this hierarchy is occupied by the Regional Operations Centers (ROCs). Each ROC is supported by an EADAS/NM computer system and provides similar tools to network managers as are available in the NMCs. Whereas an NMC has the direct network management responsibility for control and surveillance of the toll and local network within its cluster, the ROC has the responsibility for supervision and coordination of activities between the NMCs in its region. Another key function of the ROC is network management surveillance of the CCIS network. There are ten switching regions in the United States; therefore, there are ten ROCs.

2.08 The top level of this hierarchy is occupied by a single center called the Network Operations Center (NOC). This center is also supported by its own computer system and is responsible for coordinating national network management problems between the ten ROCs in the United States and two regional NMCs in Canada. The NOC also has the main responsibility for international network management and is the primary point of contact with foreign telecommunications administrations regarding international network management matters.

2.09 As shown in Fig. 3, data are transmitted between the EADAS/NM and the NOC via an inter-EADAS/NM data network. The hub of this network is a high-capacity data switcher called the Data Transfer Point (DTP). Each EADAS/NM has a dedicated data link to the DTP. This inter-EADAS/NM data network permits the exchange of network management data between NMCs and ROCs. It also furnishes the NOC with data for all major toll switchers in the network and all International Switching Centers (gateway offices).

EADAS/NM SWITCHING MACHINE INTERFACES

2.10 The traffic data collected for other than No. 4A crossbar and No. 4 ESS offices are forwarded to the EADAS/NM via a TDCS. Various types of TDCSs may be used as the data collection system. In the following discussion, the term "EADAS" will be used to represent all compatible TDCSs.

2.11 ***No. 4 ESS:*** The No. 4 ESS offices interface directly with the EADAS/NM. A selected set of data from the display and control system is transmitted to the EADAS/NM center. The data are gathered as a part of the existing

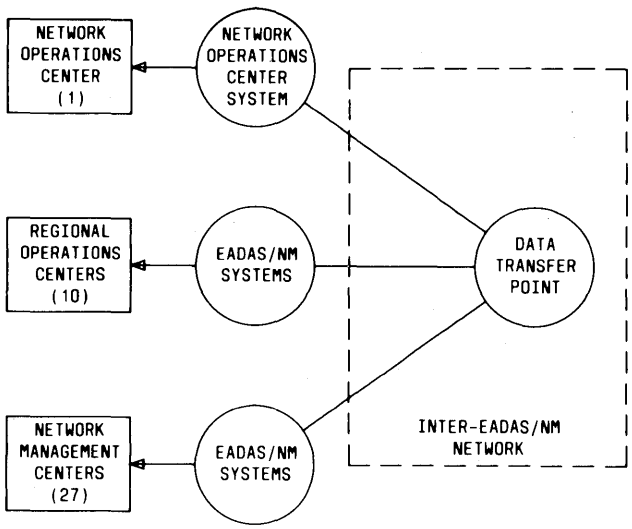


Fig. 3—Network Management Data Transfer Arrangement

30-second and 5-minute schedules. Data consist of the following:

- 30-second on/off status discretes equivalent to those appearing on the exception panel
- 5-minute "hard-to-reach" exception messages
- 5-minute trunk subgroup data
- 5-minute machine performance data
- Control status data
- Trunk subgroup register data
- CCIS data.

2.12 In performance of the network management function, the network manager at the EADAS/NM center activates or modifies controls in each office in its cluster via direct entry from the NMC. Principal controls available for activation/deactivation by the No. 4 ESS CRT in the NMC are as follows:

- Code Block
- Cancel To
- Cancel From
- Skip
- Trunk Subgroup Access Restriction
- Manual Reroutes.

2.13 ***No. 4A Crossbar Equipped With Electronic Translator System:*** The No. 4A/ETS offices interface directly with the EADAS/NM using three separate data links. The No. 4A/ETS must be equipped with a peripheral bus computer to enable the EADAS/NM to obtain 5-minute register data.

2.14 Interface arrangements for discretes and reverse controls for Directional Reservation Equipment (DRE), Sender Attachment Delay Recorder (SADR), and Dynamic Overload Control (DOC) are available. The interface for these controls and discretes is via E2A telemetry. The interface for the No. 4A ETS is via a TTY port.

2.15 ***4A Crossbar Equipped With Card Translator (4A/CT):*** Register data from the 4A/CT are transmitted to the EADAS on a standard basis, either through an Electronic Traffic Data Converter (ETDC) or through the existing traffic data recorders, Peg Count (PC) and Traffic Usage Recorder (TUR) converters, or outside vendor terminals. Standard E2A telemetry interfaces for discretes and controls associated with the DOC consoles, SADR units, route transfer controls, and DRE units are available.

2.16 ***Crossbar Tandem:*** Register data from crossbar tandems are provided to the EADAS through an ETDC, PC converter, and TUR converter, or outside vendor terminals. Standard interface arrangements for DOC equipment, DRE units, SADR units, and the route transfer keys of the traffic supervisory cabinet are available. Depending on the volume of discretes and reverse controls, a crossbar tandem may be accessed for these features by E2A telemetry or by appropriate standard appliques to the ETDCs. The addition of a ***command module*** in offices without traffic supervisory cabinets provides limited controls via the ETDCs. Crossbar tandems equipped with traffic supervisory cabinets must utilize E2A telemetry when discretes and reverse controls are required.

2.17 ***No. 5 Crossbar:*** Register data, discretes, and reverse controls are handled via an ETDC, PC converter, TUR converter, or outside vendor terminals. Standard interfaces are available for DRE, line load control, route transfer keys, and sender group busy circuits.

2.18 ***No. 1/1A ESS:*** The standard interface between the EADAS and the No. 1/1A ESS provides network administration and engineering data, network management data, status data, and reverse controls. This information is transmitted over one 1200-baud channel between the No. 1/1A ESS and the EADAS.

2.19 ***Other Switching Systems:*** Network data for No. 1 crossbar and step-by-step switching systems are available through an ETDC, PC converter, TUR converter, or outside vendor terminals. Reverse controls and discretes are not available.

2.20 ***Local Control:*** In general, the EADAS/NM does not preclude local control or local discrete data. Control and discrete data should be retained at the remote offices as a backup in case of failure in either the telemetry or the EADAS/NM systems. An override switch, which determines local backup or EADAS/NM control, is located at the switching system. All local control options can be monitored by the EADAS/NM through the discrete data.

3. NETWORK MANAGEMENT ACTIONS AND CONTROLS

3.01 There are two broad categories of network management action:

(a) ***Protective Action:*** Involves removing traffic from the network which has a low probability of completion during overload conditions. Such traffic should be removed as close as possible to its origin, thus, making more of the network available to traffic which has a higher probability of success.

(b) ***Expansive Action:*** Involves rerouting traffic from routes experiencing congestion to other parts of the network which are lightly loaded with traffic because of time zone differences, seasonal differences, or noncoincident daily busy hours.

Implementation of either of these actions can be accomplished via manual or automatic controls.

MANUAL CONTROLS

3.02 The following is a list of manual network management controls stated in general terms. The availability of any specific control, its nomenclature, or the method of operation can vary with the different switching systems and technologies used in the network. Where specific control capability does not exist, consideration should be given to providing such capability when engineering new switching machines or when upgrading existing systems. In many instances, these network controls can be activated with variable percentages of traffic affected (eg, 25, 50, 75, or 100 percent), so as to "fine tune" the control to match the magnitude of the problem.

(a) ***Cancellation of Alternate Routing:*** There are two variations of this control. "Cancel From" prevents overflow traffic from a selected high-usage circuit group from advancing to its next alternate route. "Cancel To" prevents alternate routed traffic from all sources from accessing a specific route. Some control arrangements permit "Cancel From" and "Cancel To" to be applied either to alternate routed or alternate and direct routed traffic.

(b) ***Skip Route:*** This control allows traffic to bypass a specific circuit group and advance instead to the next route in its normal routing pattern.

(c) ***Code Block:*** This control limits routing of a specific destination code. In some cases, a code block control can be specified to include the called station number.

(d) ***Call Gapping:*** This control, like code blocking, limits routing to a specific code. It is markedly more effective in controlling mass calling situations than the code block control. Call gapping consists of an adjustable timer which blocks all calls to a specified code for a set interval of time. Sixteen different time intervals are available. After the expiration of the time interval, one call is allowed access to the network after which the call blocking procedure is recycled for another time interval.

(e) ***Circuit Directionalization:*** This control changes 2-way circuits to 1-way operation.

(f) ***Circuit Turndown:*** This control removes 1- or 2-way circuits from service.

(g) ***Operator Controls:*** These are a variety of controls which modify the call-handling procedures of operators. They include reducing the number of attempts on calls to a particular destination (or on all calls), special instructions on emergency call handling during overload or failure situations, different routing instructions on certain destination codes, and additional routes to be used when blocked on normal routes.

(h) ***Recorded Announcements:*** These are announcements which give special instructions to operators and subscribers during overloads, failures, and/or unusual conditions such as deferring their calling to a later time, etc.

(i) ***Reroutes:*** These are a variety of controls that serve to reroute traffic from congested routes to other circuit groups not normally included in the route advance chain which have idle capacity at that time. These can be accomplished by changing direct or alternate routes in switching machines or by making new routing available to operators. Reroutes can be used on a planned basis such as on a recurring peak calling day or in response to an unexpected overload or failure.

(j) ***Line Load Control:*** This control limits the number of customers that can obtain a dial tone to originate calls in an end office.

AUTOMATIC CONTROLS—ELECTROMECHANICAL SWITCHING SYSTEMS

A. Dynamic Overload Controls

3.03 Network management controls can also be categorized in terms of controls which are initiated automatically. 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.

3.04 The types of internal controls activated by DOCs in electromechanical common control switching systems are as follows:

(a) ***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.

(b) ***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.

3.05 The DOC system also provides a communications link to connected offices to automatically restrict traffic routed to a switching system. These features are external controls as opposed to the internal controls described in paragraph 3.04. The switching system receiving these controls can be other crossbar tandems, No. 4 crossbar, No. 5 crossbar, No. 1 crossbar, panel, or No. 1/1A ESS. The control signal is of the simple on/off type and contains no coded information; the response at 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, data link, or ground return.

3.06 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 immediately to normal whenever the load level drops below the threshold.

3.07 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 systems since their senders/transmitters are not held up (or timed out) while waiting for service from the congested system. The programmed responses within the subtending system depend on routing and the network design but generally include the following:

(a) ***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 usually 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.

(b) ***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 1- or 2-way.

(c) ***Skip Route:*** In response to a DOC signal, a subtending office may deny alternate 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.

B. Directional Reservation Equipment

3.08 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.

AUTOMATIC CONTROLS—NO. 4 ESSs

3.09 The automatic control systems available with the No. 4 ESS consist of:

(a) Selective Dynamic Overload Control (SDOC)

(b) Selective Trunk Reservation (STR)

(c) Automatic Out-of-Chain (AOOC) Routing

(d) Dynamic Overload Control (DOC).

SDOC and STR are considered protective controls in that they control traffic to hard-to-reach (HTR) points more severely than other traffic. An HTR code is a 3- or 6-digit destination code to which calls have a very small chance of completing. If the probability of completing through the distant network is very low and the outgoing trunk groups, connected switching systems, or associated CCIS facilities are overloaded, then the waste usage of these overloaded network resources for traffic to HTR points can be prevented.

3.10 SDOC responds to switching congestion by dynamically controlling the amount and type of traffic offered to an overloaded or failed switching system. SDOC response actions are taken based on control request messages from the overloaded switching system, typically transmitted via the CCIS network. STR, on the other hand, does not require the transmission of a control message; it responds to trunk congestion in the outgoing trunking field and is triggered on a particular trunk group when less than a certain number of circuits is idle in that group.

3.11 SDOC and STR are 2-level control systems, where the first level indicates less congestion than the second level. The first-level response is typically limited to control of traffic destined for HTR points, whereas the second level applies controls to both HTR and other traffic, typically alternate-routed traffic.

3.12 HTR traffic is automatically detected by the No. 4 ESS based on an analysis of destination code completion statistics. This analysis is performed on a 3- and 6-digit basis every 5 minutes. The No. 4 ESS counts the number of Ineffective Machine Attempts (IMA), ie, attempts which fail within the No. 4 ESS. It also counts the number of Ineffective Network Attempts (INA) which represent the number of calls failing in the distant network. The INA count is based on the number of calls that abandon after outpulsing without obtaining answer supervision from the called customer line.

3.13 Automatic controls such as SDOC and STR, described previously, are designed to be automatically invoked by a switching system within a matter of seconds in response to a switching system or network overload. Thus, these controls provide rapid protection for the network and, by their code-selective nature, attempt to restrict primarily traffic which has a low probability of successful completion. When automatic controls trigger, network managers monitor their operation and adjust their parameters to deal with the particular event at hand, whether it be a general overload, a mass call-in, a natural disaster, or a major network component failure. Among these parameters are call completion fractions designating a code as HTR, and control response options which designate the amount of traffic to be controlled or trunks to be reserved at each triggering level. Since the optimum control response depends on the severity, geographical distribution, and type of overload, maximizing the calls carried by the network requires the coordination of automatic control responses with manual controls employed in combination.

3.14 DOC signals can also be sent out by a No. 4 ESS to non-CCIS offices homing directly on it. These signals are transmitted over the same type of facilities described for the electromechanical switching systems. In the event of a No. 4 ESS failure, an MC-3 signal will be sent out by the affected No. 4 ESS which will cancel and reroute all calls normally destined for that switching system around the failure. (See paragraphs 5.03 and 5.04.)

3.15 In contrast to protective controls which restrict access to overloaded network resources, expansive controls take advantage of idle capacity on out-of-chain routes, ie, on routes which are not within the design of the hierarchical routing structure. The No. 4 ESS provides an automatic expansive control, called AOOC routing. AOOC routing expands the route selection beyond the hierarchical routing constraints by offering calls overflowing the normal final-choice in-chain routes to up to seven out-of-chain routes. AOOC routing is the first step towards improved network utilization by taking advantage of network capacity that is often available through traffic noncoincidence. AOOC routing is made possible by the capabilities of the CCIS network which permit AOOC routed calls to be classmarked, counted, and to have their routing restricted to out-of-chain routes with idle capacity.

AUTOMATIC CONTROLS—CCIS

3.16 The SPC network not only creates new opportunities but also new network management challenges inasmuch as the CCIS network adds a new, separate data network which can overload or fail. Failures are rare because of the high degree of redundancy built into the CCIS network. Nevertheless, new protective automatic controls had to be provided which sense overloads and failures in the CCIS network and cause SPC switching systems to respond with control actions that can affect the flow of traffic in the telecommunications network. For instance, a focused overload can overload CCIS data links and associated terminal buffers. To avoid the loss of CCIS messages, SPC switching systems apply automatic protective controls in response to CCIS data link overloads and STP processor congestion. The controls temporarily restrict the amount of new messages that are offered to trunk groups which signal via the overloaded CCIS data links. CCIS link overloads are usually caused by unsuccessful reattempts to HTR points and can, therefore, be controlled most effectively by code-selective controls similar to SDOC and STR.

3.17 Figure 4 shows the various types of controls, both manual and automatic, and indicates which controls are applicable to which switching systems.

4. LOCAL NETWORK MANAGEMENT

4.01 With the widespread deployment throughout metropolitan areas of switching systems such as the No. 1/1A ESS, local network management and implementation are rapidly expanding. The network management capabilities inherent in the No. 1/1A ESS coupled with those of the EADAS/NM and the NMC can make a substantial contribution

CONTROL \ SWITCHING MACHINE	SXS	XBT	4A CT	5XB	4A ETS	1/1A ESS	4A ETS CCIS	4 ESS	5XB ETS
1 Reroutes		•	•	•	•	•	•	•	•
2 Immediate Reroute						•	•	•	•
3 Traffic Overload Reroute Control					•		•	•	
4 Selective Cancellation Key		•	•	•	√		√	√	
5 Regular Cancellation Key		•	•	•	√		√	√	
6 Cancel From					•	•	•	•	•
7 Cancel To					•	•	•	•	•
8 Finalized Cancel To							•	√	
9 Skip Routes					•	•	•	•	•
10 Code Blocks		•	•		•	•	•	•	•
11 Directionalization	•	•	•	•	•	•	•	•	•
12 Trunk Make Busy	•	•	•	•	•	•	•	•	•
13 Directional Reservation Equip.	•	•	•	•	•	•	•	•	•
14 Protection Reservation Equip.						•	√	√	
15 Short Sender Timing		•	•	•	•	√	•	√	•
16 Line Load Control	•			•		•			•
17 Recorded Announcement	•	•	•	•	•	•	•	•	•
18 Limit Operator Attempts	•	•	•	•	•	•	•	•	•
19 Dynamic Overload Control (Receive)	•	•	•	•	•	•	•	•	•
(Send)		•	•		•	•	•	•	
20 Selective Dynamic OVLD Control							•	•	
21 Circuit Busy Announcement TKS		•	•		•				
22 Hard to Reach List							•	•	

LEGEND
• Available
√ Accomplished By Other Controls

Fig. 4—Network Management Controls

to increasing completions and, thereby, improving revenues.

4.02 The network management capabilities of the No. 1/1A ESS include:

(a) Preprogrammed trunk group controls where up to 63 preprogrammed trunk group controls can be activated manually or automatically via DOC. These controls consist of the cancel-to, cancel-from, or skip options in various percentages.

(b) Code blocking to control mass calling situations.

(c) DOC to effect traffic to the switch during overloads.

(d) Reroute controls which allow traffic destined for one trunk group to be routed to another trunk group.

(e) Tandem switching capabilities which allow a properly provided switch to function in a tandem mode.

5. NETWORK MANAGEMENT PLANNING

5.01 Advance planning for network overload is important to efficient and responsive network management operation. Plans can be developed for known or recurring events, such as Christmas, with detailed expansive and protective control strategies. Advance planning can also be done for unpredictable events such as facility or switching system failures or the heavy calling due to some unusual event such as earthquakes, floods, hurricanes, etc. While events such as these cannot be predicted, the effects of them can be; therefore, plans should be prepared in advance to handle the additional traffic, to handle all or some of the traffic on alternate routes, or to restrict traffic which will have little or no chance of completion.

PREPLANNING

5.02 Emergency preplans should be developed for each major toll/tandem switching system. These preplans should incorporate guidelines on any emergency procedures which should be taken, including guidelines on the establishment of local emergency announcements, the use of special operator service traffic or cordboards to provide operator service, traffic service position system actions, and available facility patching. These steps will help reduce customer reattempts. Procedures for timely restoration to normal operating conditions should also be included in the preplans.

SERVICE CONTINUITY

5.03 The ability of the network to function effectively in the presence of a system failure depends on the structure of the network and on its performance when subjected to the resulting network overloads. The effect of a major switch or facility failure in the toll network can generally be controlled through the use of existing network management techniques.

5.04 In the event of a toll/tandem failure, the primary objective is to ensure adequate performance in the end offices by controlling congestion. Network management actions such as DOC and "Cancel To" controls will alleviate problems due to sender/transmitter blocking. Improvements in the general overload control, called the improved overload control feature, better the No. 1/1A ESS performance with respect to both real-time overloads and dial tone delay due to customer digit receiver queuing.

5.05 Network designs which provide trunking or switching diversity will help to reduce the fraction of traffic destined for the failed switch. In areas with only a single toll/tandem switch, end office toll trunking provides trunking diversity which can help alleviate end office congestion in the event of a failure. In areas which can economically support multiple tandems, the selective routing tandem configuration can be a cost-effective choice which is preferable with respect to performance in the event of a failure. The implementation of expansive network management controls can further reduce the fraction of traffic to the failed switch by taking advantage of spare capacity on available alternate routes. In addition, the network management controls can be used to minimize the toll isolation by rerouting traffic to other toll switches to maximize completions.

NOTES ON THE NETWORK

SECTION 12

SYNCHRONIZATION OF THE DIGITAL NETWORK

CONTENTS PAGE

Figures

Tables

1. GENERAL

1.01 The introduction of digital switching systems which are directly interconnected by digital transmission facilities as an integral part of a telecommunications network requires the use of some means of synchronizing clock rates. The term synchronization, as used here, refers to an arrangement for operating digital switching systems at a common (or synchronized) clock rate. Improperly synchronized clock rates would result in the loss of some portions of the bit streams being transmitted. The resulting service impairment would generally be more serious for data customers than for voice customers.

1.02 The Switched Digital Network (SDN) is comprised of digitally interconnected digital switching systems which require synchronization in order to control "slips," a service impairment of major concern in this network. This section provides background information as well as methods and procedures to plan, engineer, implement, operate, and maintain a synchronized network to meet established performance objectives.

2. SYNCHRONIZATION BACKGROUND

THE NEED FOR SYNCHRONIZATION

2.01 Since the early 1960s, the application of digital technology in the design of transmission facilities between analog switching systems has been expanding. The T1 Carrier system, which encodes 24 voice channels into a 1.544 Mbit/second digital bit stream, is an example of such a transmission facility. As long as channel banks are used to decode such digital bit streams into separate voice-frequency channels prior to passing through a switching system, the precise clock rate of an individual digital bit stream is, within certain relatively coarse limits, unimportant. When, however, such a digital bit stream passes through a digital switching system, it is necessary to synchronize the clock rate of the digital bit stream with the clock rate of the digital switching system.

2.02 Figure 1 illustrates the exchange of digital bit streams between various elements of a telecommunications network consisting of digital facilities and various combinations of digital and analog switching systems. (See Fig. 1.)

2.03 Figure 1(A) illustrates the use of a digital facility, such as T1 Carrier, which is equipped with a pair of channel banks interconnecting two analog type switching systems. In this situation, the transmitting portion of each channel bank independently determines the clock rates F_0 and F_1 of the digital bit streams being transmitted in either direction. The receiving portion of each channel bank decodes its incoming digital bit stream at the rate received, F_0 or F_1. In this instance, there is no need for F_0 to precisely equal F_1.

2.04 Figure 1(B) illustrates the use of a digital facility which is equipped with one channel bank interconnecting a digital switching system with an analog switching system. In this situation, the digital switching system transmits a digital bit stream at a rate F_0 which is determined by its internal clock. The digital switching system also needs to receive each incoming digital bit stream at this F_0 rate; otherwise, the system's receiving buffer will eventually overflow or underflow.

2.05 It is necessary to control the overflows and underflows of a digital switching system's receiving buffers so as to allow the overflow (deletion) or underflow (repetition) of exactly one frame. ***The deletion or repetition of a single frame, which in T1 Carrier is 125 μs in duration, is termed a "slip" or a "controlled slip."***

2.06 A slip represents a distortion of information. For an individual digital bit stream, however, a slip is a less serious impairment than a misframe. During recovery from a misframe, a number of frames are generally lost while the framing pulse is being relocated; but a slip involves the distortion of only a single frame. ***However, it should be observed that eventually a slip can become a more serious impairment than a misframe. This is because a digital switching system with an improperly synchronized clock will eventually suffer slips on every received digital bit stream, while misframes only affect individual digital bit streams.***

2.07 Returning to Fig. 1(B), slips on the digital bit stream arriving at the digital switching system's receiving buffer can be prevented by forcing the transmitting portion of the remote channel bank to run at the same clock rate as the receiving portion of this channel bank. Such an

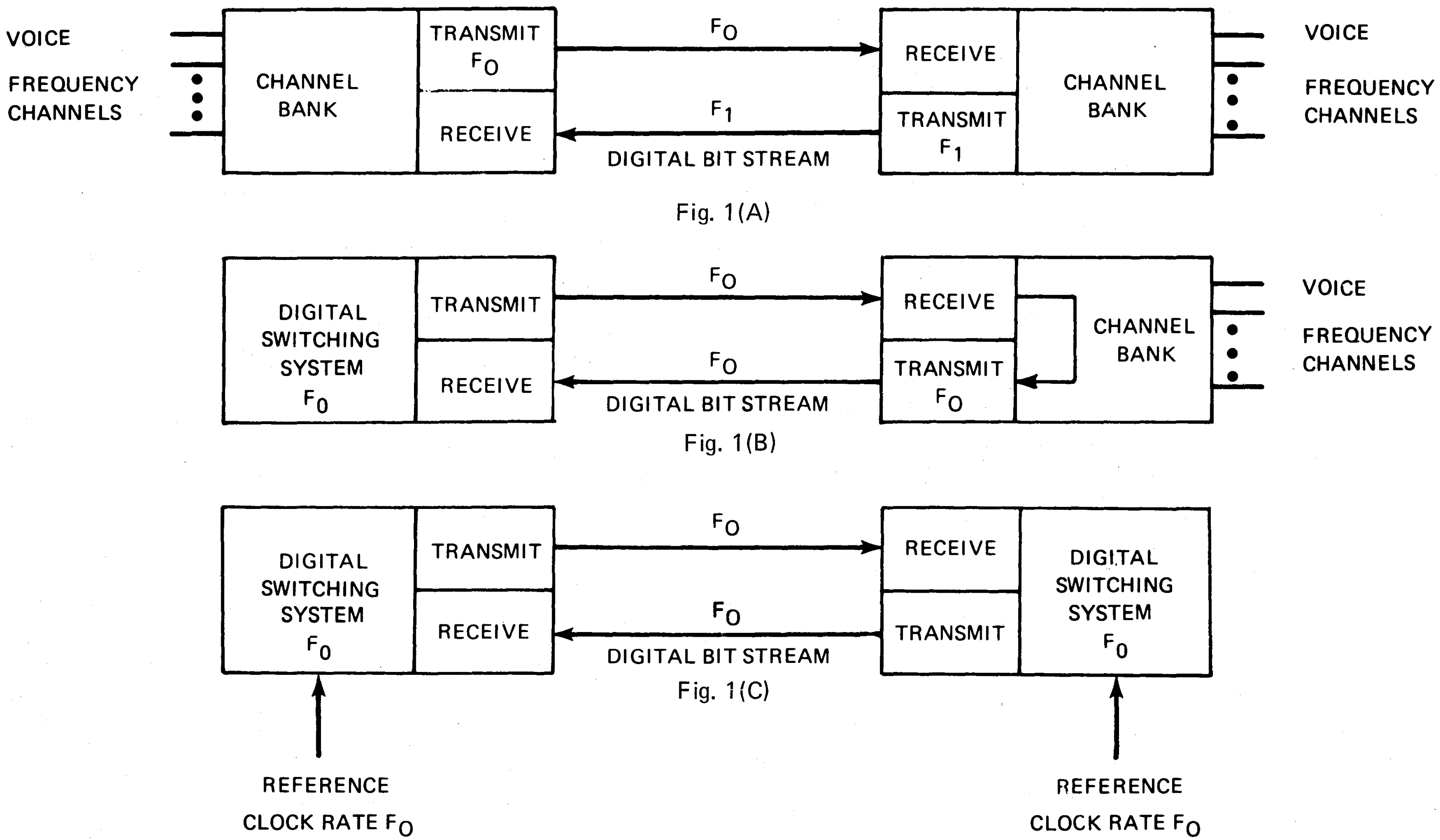


Fig. 1—Need for Synchronization

arrangement is referred to as channel bank loop timing. While the rudimentary idea of synchronization is introduced here, this situation does not require a synchronized network.

2.08 Figure 1(C) illustrates the use of a digital transmission facility interconnecting two digital switching systems. In this situation, each switching system is transmitting at a rate which is determined by its own internal clock. Unless the digital bit stream which is received at each switching system arrives at the same clock rate as its internal clock rate, slips will occur. To prevent these slips, it is necessary to force both switching systems to use some common, synchronized reference clock rate, F_0. Both will then be part of a synchronized network.

2.09 The transmission facilities used in a telecommunications network include wire, coaxial cable, and radio. Each of these facility types experiences variations in transmission delay due to thermal change and other effects. Excessive variations in the transmission delay on a facility connecting two digital switching systems that use the same clock rate can also cause slips. Because variations in the transmission delay of a given facility are bounded, however, this problem is treated by appropriate buffering arrangements.

HIERARCHICAL SYNCHRONIZATION

2.10 The hierarchical synchronization method has been selected for synchronizing the Switched DigitalNetwork based upon consideration of satisfactory customer service, ease of maintenance, administration, and cost. This method is elaborated upon in paragraphs 2.11 through 2.16.

2.11 The established end-to-end performance objective for synchronizing the Switched Digital Network is one slip or less in 5 hours over an end-to-end connection. This performance objective was developed to satisfy customer service needs. As previously stated, telecommunications customers can suffer impaired service if this performance objective is not met.

2.12 In the hierarchical synchronization method indicated in Fig. 2, a frequency reference is transmitted from one node to another node. A network for this method of synchronization is hierarchical in nature with nodal clocks supplying a synchronization reference to certain other nodes, each of which can, in turn, supply reference to still other nodes. This interconnection of nodes with frequency references gives rise to a hierarchical synchronization network. The design and layout of synchronization references are discussed in Part 4 of this section.

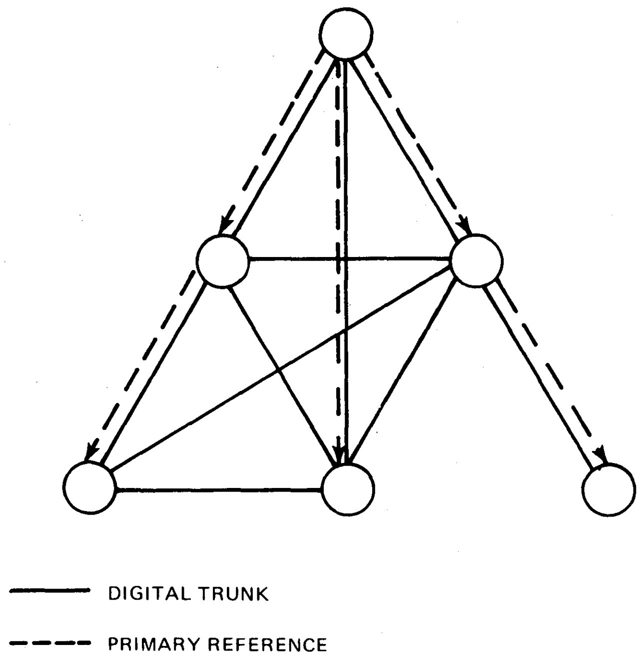


Fig. 2—Hierarchical Synchronization

2.13 One attractive feature of hierarchical synchronization is that existing digital transmission facilities between digital switching systems can be used for synchronization. For example, either the basic 1.544 Mbit/second line rate or the 8000 frame per second frame rate of a T1 Carrier system can be used for this purpose; at the same time, it will not diminish the traffic carrying capacity of that carrier system. ***Hence, no separate transmission facilities need to be dedicated for synchronization.***

2.14 Reliable operation is an important consideration for all parts of a telecommunications network. For this reason, a synchronization network must consist of primary and secondary (ie, "backup") synchronization facilities. In addition, each stratum 2 and 3 digital switching system must be equipped with an internal clock which can bridge short disruptions of the synchronization references. This internal clock is normally controlled so as to follow the synchronization reference. When the synchronization reference is removed, the clock frequency will drift at a rate determined by its stability. For example, the No. 4 Electronic Switching System (ESS) has a clock with a free-running drift rate of less than one part in 10^{10} per day, and so after a loss of reference for 10 days, this clock would still have an accuracy of at least one part in 10^{9}.

2.15 The synchronization network for the SDN is illustrated in Fig. 3. The highest level clock in this synchronization network is the Bell System Reference Frequency (BSRF) standard which is described in paragraphs 2.17 and 2.18. This frequency is transmitted to selected digital toll switching systems (such as the No. 4 ESS) by existing broadband analog transmission facilities. These or similar switching systems, which are synchronized directly or indirectly to the BSRF standard, form the second stratum of the synchronization hierarchy. Clocks in these selected switching systems then supply frequency reference to other digital switching systems over existing digital transmission facilities.

2.16 Care must be exercised in the choice of the primary and secondary transmission facilities and routings when designing this synchronization network. Two important considerations in the administration and engineering of these synchronization facilities are:

(a) Synchronization reference is never exchanged between nodes in such a manner that a loop is formed. If this is done, the synchronization network could experience a frequency instability.

(b) Synchronization facilities should be chosen so as to maximize the reliability and survivability of the synchronization network. The length and diversity of these facilities are some of the items which can affect reliable operation.

BELL SYSTEM REFERENCE FREQUENCY

2.17 The highest level clock or frequency reference in the synchronization hierarchy is the BSRF standard. This frequency is transmitted by certain existing broadband analog transmission facilities (eg, the L5 coaxial cable system) to selected digital switching systems which form the second stratum of the synchronization hierarchy. Clocks in these selected locations can then supply frequency reference to other digital switching systems over existing digital transmission facilities.

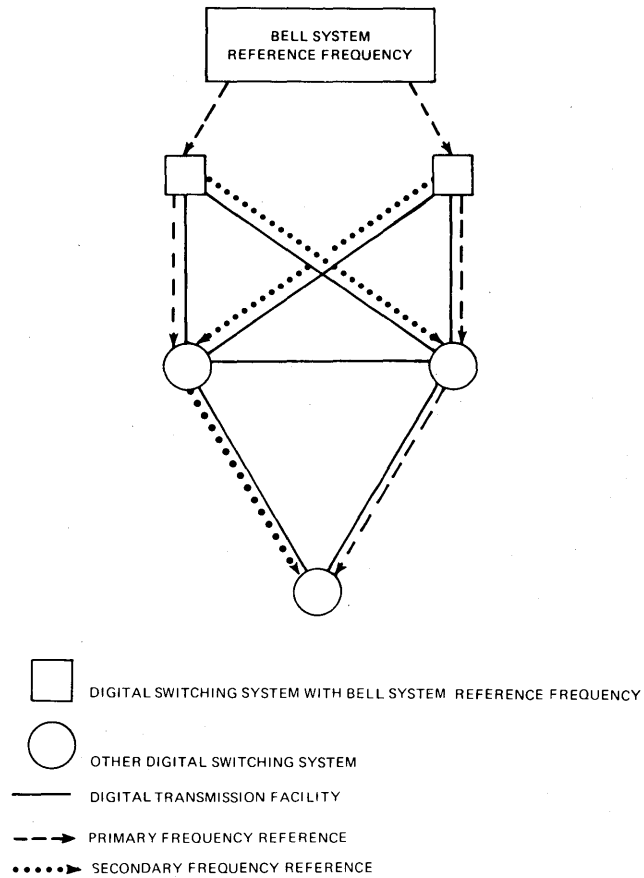
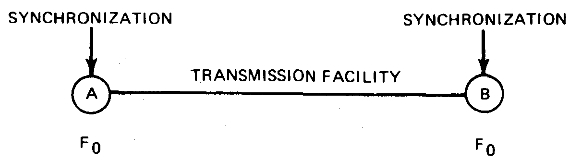


Fig. 3—Synchronization Network for the SDN

2.18 The BSRF standard is derived from equipment located in an underground AT&T Long Lines office located in Hillsboro, Missouri. This equipment includes three cesium-beam frequency standards, each of which is accurate to within one part in 10^{11}. Three of these standards are used because this allows their outputs to be jointly compared in order to promptly identify a malfunction of any one of the standards. These cesium-beam frequency standards have output frequencies of 20.48 MHz and 2.048 MHz.

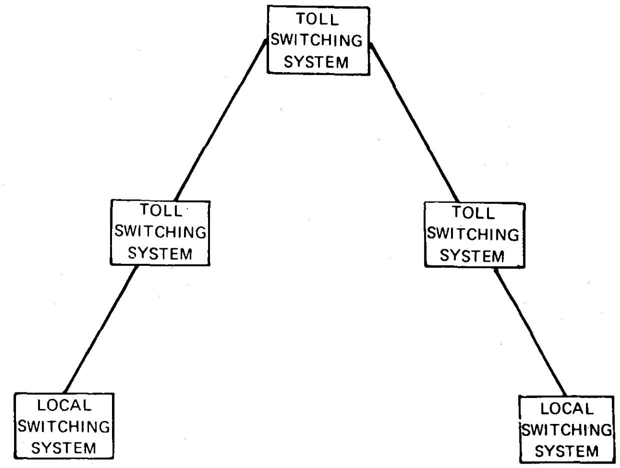
SERVICE OBJECTIVES AND ALLOCATION OF IMPAIRMENT

2.19 Control of the slip rate between two digital switching systems is considered with reference to Fig. 4. The total slip rate is the sum of the slip rate due to the difference between the clock rates and the slip rate due to environmental effects on the connecting transmission facility. Even when the nominal clock slip rate between two digital switching systems is zero, slips can occur due to the influence of a temperature change on the time delay of the connecting transmission facility.



- THE NOMINAL CLOCK SLIP RATE BETWEEN DIGITAL SWITCHING SYSTEMS Ⓐ AND Ⓑ IS ZERO
- ENVIRONMENTAL EFFECTS ON THE TRANSMISSION FACILITY CAN CAUSE SLIPS BETWEEN DIGITAL SWITCHING SYSTEMS Ⓐ AND Ⓑ
- TOTAL SLIP RATE IS SUM OF CLOCK AND TRANSMISSION FACILITY SLIP RATES

Fig. 4—Control of Slip Rate



	SLIP RATE ALLOCATION
TRANS FACILITIES	1 SLIP IN 10 HOURS
TOLL SWITCHING SYSTEM	~0 SLIPS IN 5 HOURS
LOCAL SWITCHING SYSTEM (TROUBLE FREE OPERATION)	~0 SLIPS IN 10 HOURS
LOCAL SWITCHING SYSTEM (ONE FAILURE)	1 SLIP IN 10 HOURS
END-TO-END	1 SLIP IN 5 HOURS

THIS ALLOCATION ALLOWS MARGIN FOR SYNCHRONIZATION LINKS TO FAIL WITHOUT VIOLATING END-TO-END OBJECTIVE

Fig. 5—Slip Rate Allocation

2.20 Consider the allocation of the end-to-end slip rate objective, which is one slip in 5 hours, to various elements of the SDN. A reference connection of two toll connecting and two intertoll trunks is shown in Fig. 5. The very stable clock in the No. 4 ESS can operate at a slip rate of far less than one slip in 5 hours during all trouble-free and most trouble conditions. Therefore, essentially a rate of zero slips in 5 hours is allocated to a digital toll switching system. One-half of the end-to-end slip rate objective, that is one slip in 10 hours, is allocated to digital transmission facilities.

2.21 The remaining half of the end-to-end slip rate objective can be allocated to the two local digital switching systems in the reference connection. Hierarchical synchronization permits local digital switching system equipment to operate with an essentially zero slip rate during trouble-free conditions. The most likely trouble condition is expected to be the failure of the digital transmission facility which carries a local digital switching system primary synchronization reference. Since the digital transmission facilities which carry primary and secondary synchronization references to the two local digital switching systems in the indicated connection will not usually fail simultaneously, the remaining portion of the end-to-end slip rate objective (ie, one slip in 10 hours) can be reserved for a reference failure at either local digital switching system. This approach allows some margin for digital synchronization facilities to fail without violating the end-to-end slip rate objective.

2.22 In order to be compatible with the No. 4 ESS, the slip rate impairment related to a local digital switching system under various operating conditions is summarized in Fig. 6. During trouble-free conditions, its nominal clock slip rate should be zero. During operation with a reference trouble, its nominal clock slip rate should not exceed one slip in 10 hours, which is assured by a frequency deviation from the No. 4 ESS of no more than 3.5 parts in 10^9. This performance should be achievable with quick switching to a secondary synchronization reference. During the most extreme trouble conditions, the nominal clock slip rate should always be less than 255 slips per day, which is assured by a frequency deviation from the No. 4 ESS of less than 3.7 parts in 10^7 in order to avoid turning down trunks which connect to a No. 4 ESS.

SLIP RATE IMPAIRMENT RELATED TO A LOCAL DIGITAL SWITCHING SYSTEM UNDER VARIOUS OPERATING CONDITIONS

1. OPERATION DURING TROUBLE-FREE CONDITIONS:

- NOMINAL CLOCK SLIP RATE = ZERO

2. OPERATION DURING PRIMARY REFERENCE TROUBLE CONDITIONS:

- NOMINAL SLIP RATE <1 SLIP IN 10 HOURS FOR ANY TRUNK CONNECTED TO NO. 4 ESS
- THIS REQUIRES THAT THE LOCAL DIGITAL SWITCHING SYSTEM MAINTAINS A FREQUENCY DEVIATION FROM THE NO. 4 ESS OF LESS THAN .0035 PARTS PER MILLION
- WITH QUICK SWITCHING TO SECONDARY REFERENCE, LESS THAN .0035 PARTS PER MILLION IS ACHIEVABLE

3. OPERATION DURING LIMITING TROUBLE CONDITIONS:

- NOMINAL SLIP RATE CAN EXCEED 1 SLIP IN 10 HOURS
- NOMINAL SLIP RATE <255 SLIPS PER DAY FOR ANY TRUNK CONNECTED TO NO. 4 ESS. THIS OCCURS WHEN THE LOCAL DIGITAL SWITCHING SYSTEM MAINTAINS A FREQUENCY DEVIATION FROM THE NO. 4 ESS OF <.37 PARTS PER MILLION

Fig. 6—Slip Rate Impairment

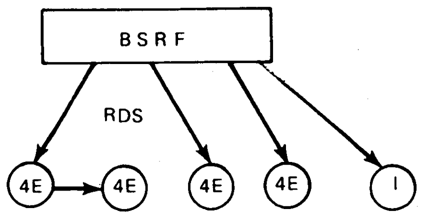
2.23 In conclusion, operation of the synchronization network is a new area in which extensive experience is lacking. It is essential to rapidly isolate troubles in the synchronization network. ***Therefore, low slip rates under most operating conditions will enhance the visibility of such troubles by providing a high contrast background against which these troubles can be more readily seen.***

3. ADMINISTRATION PLAN

REFERENCE DISTRIBUTION SYSTEM

3.01 The highly stable BSRF standard will serve as the highest reference source for the synchronization network and will be provided via a hierarchical distribution structure. Many No. 4 ESSs can and will derive synchronization conveniently on a direct basis from the BSRF standard as illustrated in Fig. 7. When this is not economically convenient, other No. 4 ESSs will receive equivalent synchronization reference over digital facilities. Because of the very stable No. 4 ESS clocks, these No. 4 ESSs may be regarded as a digital extension of the BSRF standard. These digital extensions and the BSRF standard will be referred to as the Reference Distribution System (RDS). The RDS will be made available to provide synchronization to many interconnected nodes. Obviously, other digital switching systems with clocks of comparable quality to the No. 4 ESS may be considered for inclusion in the RDS.

3.02 A backup RDS synchronization structure will also be established with the objective of making single failures within the RDS transparent to subtending digital switching systems. For example, if a No. 4 ESS lost synchronization to the BSRF standard, synchronization could be provided from one of the remaining BSRF standard connected switching systems. However, even if a backup is not available, a No. 4 ESS can "free run" for as long as 17 days and still meet slip rate objectives. Therefore, short outages within the RDS will have little or no effect on dependent switching systems.



- PROVISION OF BSRF TO No. 4 ESS AND SIMILAR SYSTEMS
- OTHER SWITCHES MAY DERIVE SYNCHRONIZATION FROM "BSRF EQUIVALENT" No. 4 ESS AND SIMILAR SYSTEMS
- PROVISION FOR SECONDARY SYNCHRONIZATION WITHIN RDS SUCH THAT ALL NODES REMAIN SYNCHRONIZED UNDER AS MANY FAILURE CONDITIONS AS POSSIBLE
  OBJECTIVE: FAILURES WITHIN RDS WILL BE TRANSPARENT TO SUBTENDING SYSTEMS
- RDS ADMINISTERED BY AT&T LONG LINES
- SWITCHING SYSTEM AND FACILITY MAINTENANCE HANDLED BY EXISTING WORK GROUPS

(4E) – No. 4 ESS
(I) – INDEPENDENT Co. DIGITAL SWITCHING SYSTEM

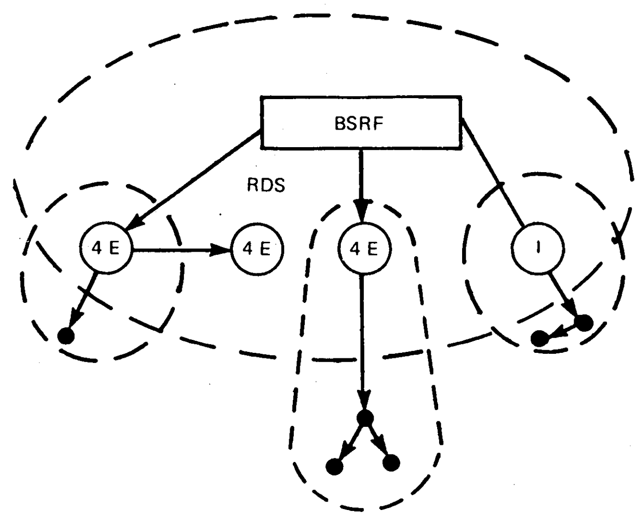
Fig. 7—Reference Distribution System

3.03 The RDS will be administered by AT&T Long Lines as described in paragraphs 3.07 through 3.12. Synchronization outside the RDS will be administrated on a local basis as described in paragraphs 3.04 through 3.07.

SYNCHRONIZATION NETWORK SECTOR

3.04 Figure 8 displays a typical synchronization network structure. For ease in administration, synchronization network sectors will be established. Sector nodes (switching systems) which have synchronization responsibility should have a reasonably stable clock as defined in other portions of this section.

A synchronization network sector is the largest subnetwork of the SDN which can be treated as an independent entity for the purpose of synchronization network planning. The synchronization network sectors, under certain circumstances, may overlap with the RDS, with other sectors, and with different Bell or Independent Operating Telephone Company administrative areas. There may be separate primary and secondary synchronization network sectors as well. (Refer to Fig. 8 and 9 for examples.)



– SECTOR BOUNDARIES WILL FOLLOW OPERATING TELEPHONE COMPANY AND/OR HIERARCHICAL BOUNDARIES
– RDS AND NETWORK SECTORS MAY OVERLAP

(I) – INDEPENDENT COMPANY DIGITAL SWITCHING SYSTEM
(4E) – No. 4 ESS
● OTHER DIGITAL SWITCHING SYSTEM

Fig. 8—Synchronization Network Sectors

3.05 Each sector will be locally administered by the participating Bell System or Independent Telephone Companies. To establish this structure, AT&T has established a "synchronization coordinator" in each Bell System Operating Company and AT&T Long Lines. The responsibilities of the synchronization coordinator and the network engineering methods used are described in paragraph 3.13 and Part 4, respectively.

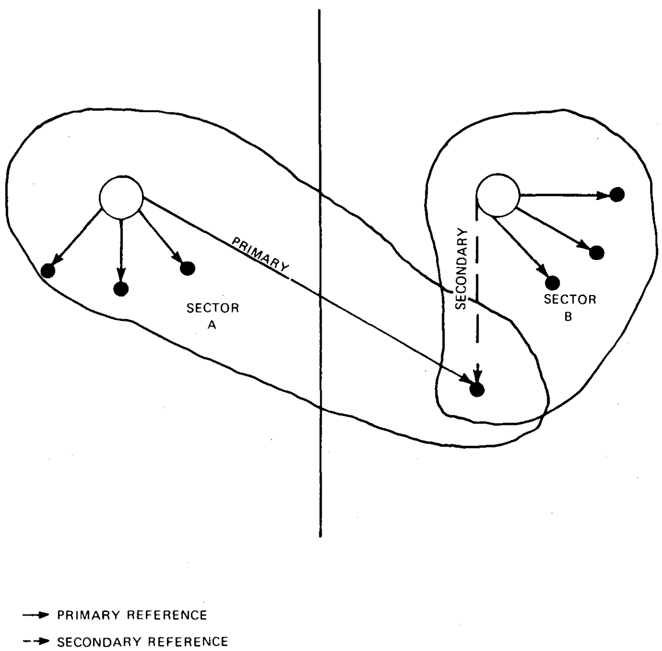


Fig. 9—Primary and Secondary Synchronization Network Sectors

PROVIDING BSRF STANDARD AND RDS DIRECTLY TO INDEPENDENT TELEPHONE COMPANIES

3.06 Initially, the RDS will consist of only the BSRF standard and some No. 4 ESSs. However, as the synchronization network evolves, other digital switching systems may also be included. In general, other digital switching systems will probably derive synchronization reference either directly or indirectly via an RDS node. In cases where two or more non-No. 4 ESS digital switching systems are digitally interconnected and neither has a digital interconnection to an RDS node, it may be desirable for one of these systems to derive synchronization reference directly from the BSRF standard. For example, two such systems may be digitally interconnected and constitute a synchronization network sector. This sector may be digitally connected to another sector which has a BSRF standard reference connection. In that event, a BSRF standard connection may be required to the sector which has none. These cases should be discussed individually with AT&T Long Lines.

AT&T LONG LINES ADMINISTRATION OF RDS

3.07 The RDS is defined as an upper level, stable synchronization source for the synchronization network. It consists of the Bell System Reference Frequency Network (BSRFN) and the digital switching systems receiving their synchronization directly from the BSRF standard or indirectly via an RDS digital extension. The RDS consists of stratum 1 and stratum 2 as defined in Part 4 of this section. The cost of providing the BSRF standard prohibits the connection of all digital switching systems directly to it.

3.08 Initially, RDS connections will be provided to at least one No. 4 ESS in each synchronization network sector which interconnects digitally with another synchronization network sector. Additional connections to the RDS within a synchronization network sector will be evaluated on an individual basis. Sectors with no intersector digital connection do not necessarily require synchronization from the RDS.

3.09 The stability of the BSRF standard and the RDS minimizes the dangers of synchronization network sectors losing synchronization between each other. To further reduce this possibility, secondary synchronization references will be provided within the RDS (to the extent practical) to assure that all nodes remain synchronized under as many failure conditions as possible.

3.10 The BSRF standard is fully alarmed as are the connected No. 4 ESS nodes. Trouble clearance, restoration, and maintenance of the RDS will be performed by the existing switching system and facility maintenance work groups as defined in Part 6.

3.11 AT&T Long Lines is responsible for the RDS. In addition, AT&T Long Lines is responsible for the BSRFN and its connection to digital switching systems. AT&T Long Lines headquarters will coordinate with its seven regions all connections to the BSRFN and extensions of that network via the RDS to locations where it is not presently available.

3.12 AT&T Long Lines regional representatives will work with Bell or Independent Operating Company synchronization coordinators on the provision of the RDS to synchronization network sectors within their geographical area. The connection of switching systems directly to the BSRFN will be coordinated by the Planning Engineer—BSRFN and representatives of the Engineering Manager—Transmission in each of the AT&T Long Lines regions.

SYNCHRONIZATION COORDINATOR

3.13 The functions and responsibilities of the synchronization coordinator for each Bell System Operating Company and AT&T Long Lines are as follows:

(a) Maintenance of the operating company synchronization network sector map and the AT&T Long Lines RDS map. The synchronization coordinator should maintain on a forward looking basis (3 to 5 years) a map of primary and secondary synchronization facility connections between all digital switching systems within the operating company boundaries. This includes connections within multiple synchronization network sectors and between sectors within various operating company boundaries. On occasion, this may also include connections to switches or sectors between operating company areas as well as the AT&T Long Lines RDS. The synchronization map must be updated on an ongoing basis and be kept as current as possible. The AT&T Long Lines coordinator should, of course, maintain a similar map for the RDS.

(b) Coordinate the following activities on a project management basis:

(1) Synchronization equipment engineering and ordering

(2) Engineering of the synchronization facilities

(3) Installation

(4) Testing

(5) Cutover

(6) Operations activities (eg, maintenance, failure reporting, and administration)

(7) Maintenance of synchronization plan documentation

(8) Bell-Independent interactions (through Bell-Independent relations group).

(c) Ensure that the synchronization network is administered, designed, and operated in accordance with the guidelines in this section.

(d) Maintain a contact list and liaison with other synchronization coordinators.

BELL-INDEPENDENT COORDINATION

3.14 As the synchronization network evolves, numerous interactions will occur between Bell and Independent Telephone Companies as interconnecting synchronization facility links are established. Based on past experience with similar projects, it has been concluded that the coordination with Independent Telephone Companies to plan, design, install, test, and administer the synchronization network can be most effectively handled through normal Bell-Independent relations.

4. SYNCHRONIZATION NETWORK ENGINEERING

4.01 This part presents a methodology for engineering the hierarchical synchronization strategy of the SDN. This methodology is intended to assist in rank ordering network synchronization clocks and selecting the most reliable choice of facilities as interconnecting links to minimize the probability of violating the SDN slip objectives. These guidelines and procedures are intended for use by Bell or Independent Operating Company representatives responsible for administering and engineering the synchronization network.

4.02 The synchronization network is made up of a hierarchy of switching system clock supplies which ultimately derive synchronization reference from a single clock supply through a network tree which utilizes selected digital facilities as synchronization links that also provide customer service. It should be noted that no closed loops are allowed in the SDN synchronization network. As a general rule, clocks may derive synchronization reference from other clocks that are higher or equally positioned in the synchronization hierarchy but never from another clock that is lower in the hierarchy.

4.03 For convenience of administration, the SDN is partitioned into synchronization network sectors. Each synchronization network sector is treated as an independent network for synchronization planning except when sectors are also digitally interconnected.

CLOCK STRATA

4.04 In order to engineer the synchronization network for the SDN, the operating company must identify and rank order the various clocks in accordance with their "quality" levels and select the best possible digital transmission systems to serve as primary and secondary synchronization facilities. Although numerous parameters influence overall clock quality (eg, stability, accuracy, and reliability), for purposes of this discussion, two clocks are said to be equivalent whenever their accuracy falls within certain bands. AT&T general departments and Bell Laboratories are continuing to evaluate clock quality parameters and their impact on meeting slip objectives. For the existing network, clocks have been grouped into four major bands (or strata) beginning with the BSRF standard in stratum 1 as the highest quality clock and ending with standard D-type banks in stratum 4 as the lowest quality clock. Based on currently available data, clocks have been ranked in the order shown in Table A.

4.05 The BSRF standard is the only clock in stratum 1; stratum 2 consists of No. 4 ESS clocks and any clock of equivalent quality. Likewise, stratum 3 consists of other digital central office clocks and any other clock of equivalent quality, etc. Stratum 4 consists of D-type banks and other loop terminal applications.

FACILITY SELECTION

4.06 Identifying digital transmission facilities with the best overall "availability" is the major objective in selecting primary or secondary synchronization links. Availability is defined in terms of long outages on the order of tens of minutes or tens of hours, ie, hard failures. The major contributor to availability is the hostile outside plant environment. Outages may be caused by hard failures of electronics, craft activity, or man-made or natural disruptions. Transmission performance of the network such as reframes and line errors may suggest a marginal system, perhaps with a hard fault likely in the near future or a facility exposed to craft activity. Poor transmission performance is used as a criterion to reject a link as a candidate or to reassign one already chosen.

4.07 The synchronization of No. 4 ESSs in stratum 2 from the BSRF standard in stratum 1 is derived from a 20.48 or 2.048 MHz analog signal from the BSRF standard located in Hillsboro, Missouri. Secondary synchronization facilities between No. 4 ESS nodes in stratum 2, however, are derived from digital facilities.

4.08 Characteristics which primarily determine the availability of a digital transmission facility are rank ordered as follows:

(1) History record

(2) Activity

(3) Facility length

(4) System type (ie, whether the facility supports T1, T1C, T1D, T2, T4M, 3A-RDS, etc)

(5) Protection switching

(6) Physical type (ie, whether the facility is physically installed as an underground, buried, or aerial paired cable, a coaxial cable, a radio link with air as the transmission medium, or a satellite link)

(7) Number of and type of regenerative repeaters

(8) Number of multiplexers and other intermediate office equipments, if any

(9) Dedicated or nondedicated cables (eg, cable which includes T1 Carrier and voice-frequency facilities)

(10) Cable cross section.

4.09 Satellites should not be used as transmission media for synchronization references at the present time. The role of digital radio and optical fiberguides as synchronization facilities and their final places in the rank ordering are currently under study.

4.10 The generic facility rank ordering is based on limited technical and operational information. It is recommended, therefore, that facility selections be based on actual local field experience where available. Inf^rmation regarding specific facility history profiles may be obtained from various sources, eg, T-Carrier Restoration Control Center,

TABLE A

CLOCK STRATA

STRATUM (NOTE 1)	TYPE OF THE CLOCK	SLIP RATE CRITERION			CLOCK ACCURACY		
		TROUBLE-FREE OPERATION	PRIMARY REFERENCE FAILURE	ALL REFERENCE FAILURE	TROUBLE-FREE OPERATION	PRIMARY REFERENCE FAILURE	ALL REFERENCE FAILURE
1	BSRF	—	—	—	1 part in 10^{11}	NA	NA
2	No. 4 ESS or equivalent	0	0	0	PLL (Note 2)	1.7 parts (Note 4) in 10^9 after 17 days	1.7 parts in 10^9 after 17 days
3	DCO (Note 5) or equivalent	0	1 slip every 10 hours	255 slips (Note 3) per day	PLL	3.5 parts in 10^9 relative to No. 4 ESS	3.7 parts in 10^7
4	Loop-timed terminals (D-Bank)	0	—	—	PLL	32 parts in 10^6	32 parts in 10^6

Notes:

1. The clocks are presented in order of superiority with the Bell System Reference Frequency (BSRF) standard placed at the top. The positions of other switching entities, such as the digital PBX or a remote switching unit in the loop plant, in the rank ordering are yet to be determined.
2. Determined by the characteristics of the Phase-Locked Loop (PLL) and the master (if any).
3. Approximately 10 slips per hour.
4. Normal No. 4 ESS free-running drift rate is equal to 1 part in 10^{10} per day.
5. Digital Central Office (ie, other digital switching system).

Switching Control Center, facility engineers, route engineers, etc.

4.11 To augment this information, the facilities are rank ordered in Table B. For both system type and physical type, the most reliable facility is placed on the top, with reliability progressively decreasing from top to bottom.

TABLE B

FACILITIES RANK ORDERED BY RELIABILITY

SYSTEM TYPE (NOTE)	PHYSICAL TYPE (NOTE)
SAME PHYSICAL TYPE	SAME SYSTEM TYPE
T4M with protection switching	Underground
T2 with protection switching	Trenched or buried
T1/OS with protection switching	Aerial
TIC, TID, or T1 with low power integrated repeaters	
TIC, TID, or T1 with repeaters of other types	
Radio	
All other parameters being the same, the following characteristics are preferred: (a) Low craft activities (b) Shorter length (c) Dedicated digital facility links (d) Nonaerial.	

Note: All facilities are assumed to be of the same length and are located in the same geographical neighborhood.

ENGINEERING RULES

4.12 The following engineering rules must be satisfied to meet the synchronization objectives of the SDN.

Rule 1: If a node (ie, a clock) of the SDN is directly connected to the BSRF standard, the node must derive its synchronization reference from the BSRF standard.

In the present SDN, only the No. 4 ESS or equivalent can derive its synchronization reference from the BSRF standard.

Rule 2: A node can only receive the synchronization reference signal from another node, distinct from itself, which contains a clock of superior or at least equivalent quality. In general, the node under consideration will receive direct synchronization from a node containing the highest quality clock.

Clearly, if all nodes in a given stratum are placed in the same horizontal level, and the strata are placed in the same vertical order, with stratum 1 (the BSRF standard) at the top, then the flow of synchronization reference is mainly downwards with perhaps a few horizontal excursions, but never upwards.

Rule 3: The facility with the greatest availability must be selected for primary and secondary synchronization facilities.

Rule 4: Where possible, all primary and secondary synchronization facilities should be diverse.

Rule 5: Synchronization facilities within the same cable should be minimized.

Rule 6: The total number of cascade node connections starting from the BSRF standard should be minimized.

Rule 7: The number of nodes receiving synchronization reference from any given node should be minimized.

4.13 When engineering a synchronization network sector, the operating company should be cognizant of future changes which may affect the synchronization plan. Facility additions and rearrangements or the installation of new digital switching systems (nodes), for example, may inadvertently violate the synchronization rules, thus, increasing the probability of violating slip objectives. To avoid major changes in the synchronizatior network plan, proposed facility and/or switching node additions or deletions should be considered when selecting synchronization facilities and in deriving hierarchical relationships between switching system clocks.

4.14 In general, it is recommended that the synchronization coordinator periodically compare the evolution of synchronization network sectors with the original synchronization plan and coordinate the reengineering of the network (on paper) when the following conditions prevail:

(a) A stratum 2 digital switching system is added.

(b) Two or more stratum 3 digital switching systems are added or the total number of new digital switching systems in strata other than stratum 2 exceeds five.

(c) The number of new facilities exceeds 10 percent of the original configuration.

4.15 If the reengineered network reveals that more than 5 percent of the nodes in stratum 3 (excluding new nodes) require new primary synchronization facilities or if more than 10 percent of such nodes require new secondary facilities, the new synchronization plan should be implemented. If not, new nodes should be added in accordance with the engineering rules.

5. IMPLEMENTATION CONSIDERATIONS

INSTALLATION

A. Testing

5.01 All elements associated with the synchronization of a pair of digital switching systems (eg, network clocks, synchronization units, digital facilities, etc) should be installed individually and have demonstrated that they are in a stable operating mode prior to the start of digital synchronization cutover testing.

B. Cutover

5.02 After the successful completion of the testing requirements have been demonstrated and concurred to by the organizations responsible for the operation and maintenance of both switching systems, the systems may then cut over to a digital synchronization mode of operation at a date mutually agreed upon. The date for cutover to digital synchronization between two switching systems should always precede the date at which circuits which are digitally connected between those systems are made available for service. This condition can only be waived with the specific consent of the appropriate level of management in each operating company with the operating responsibility for those locations. Furthermore, all such instances of waiver of the digital synchronization test requirement prior to service must be reported to the responsible synchronization coordinator.

IMPLEMENTATION—COORDINATION RESPONSIBILITIES

5.03 The implementation of digital synchronization will usually be stimulated by the installation of a new digital switching system or the addition of synchronization capability to an existing one. Within the Bell System, the implementation of all new switching system installations, generic retrofits, and major growth additions is controlled via a series of Project Coordination Committee structures as recommended by AT&T. These committees include representatives from all Bell Operating Companies and disciplines within those companies which are responsible for the planning, engineering, ordering, installation, operation, administration, and maintenance of that switching system. Standard practices exist which define the committee structure and responsibilities.

5.04 The synchronization coordinator should interface with these Project Coordination Committees to ensure the successful implementation of digital synchronization. This will ensure that all organizations associated with that project are aware of the following:

(a) The need for digital synchronization

(b) The actual layout of the synchronization hierarchy and the position of that switching system within that hierarchy

(c) The identification of all other elements required for digital synchronization in that hierarchy (ie, facilities, other switching systems, BSRF standards, etc)

(d) The responsibilities of each organization regarding the implementation of digital synchronization.

5.05 The utilization of the established committee structures will also provide the mechanism to:

(a) Track the status of each of the required elements

(b) Provide notification to upper management if any part of the hierarchy jeopardizes the implementation of digital synchronization

(c) Establish contingency plans if irreconcilable events preclude the implementation of digital synchronization.

5.06 The interaction between the synchronization coordinator and the Project Coordination Committees discussed above will accommodate the graceful implementation of the synchronization plan. This is accomplished by providing the necessary project management control structure to ensure the timely and satisfactory discharge of responsibilities of ***all*** involved organizations.

6. OPERATIONAL CONSIDERATIONS

6.01 This part is written in view of the requirements, capabilities, and responsibilities of network operations switching system maintenance and administration groups in maintaining and administering synchronization in the portion of the SDN encompassed by a particular switching system. In that context, there is no overall maintenance or network operations administration coordinator (in the sense of the switching system) for a synchronization network sector.

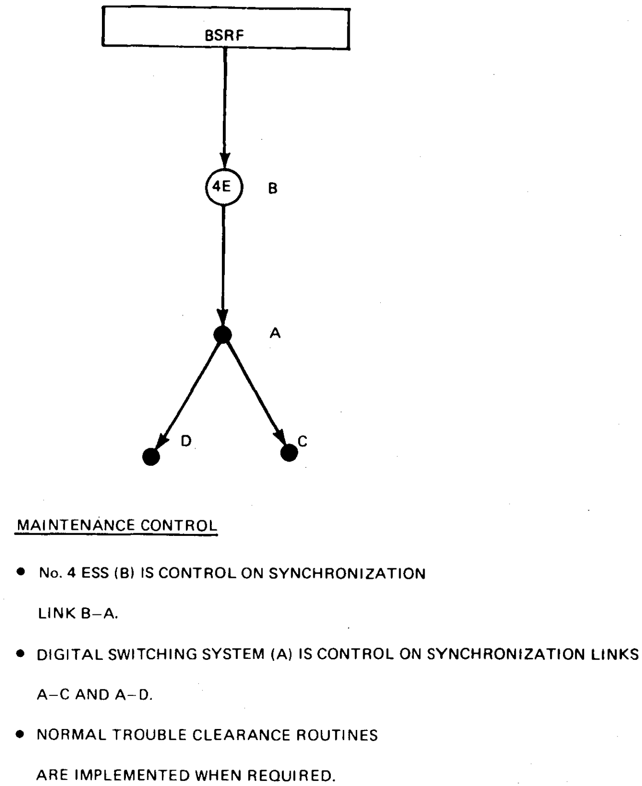


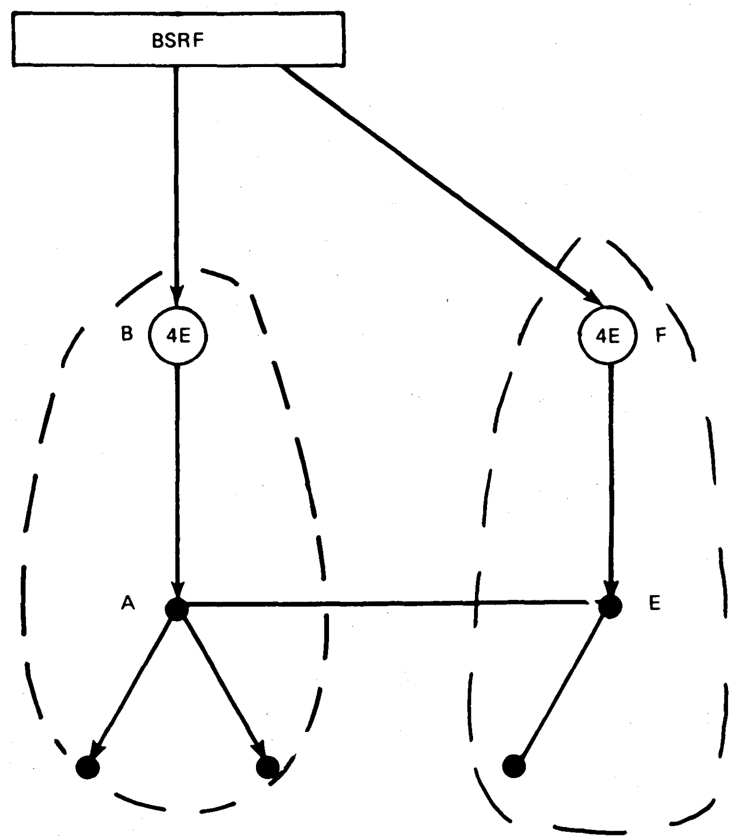
Fig. 10—Maintenance Control

MONITORING

6.02 Each switching system should have the capability to monitor all synchronization facilities and equipment connected to it. Surveillance is limited to connected synchronization facilities and equipment. Therefore, each switching system should have the capability to detect synchronization problems. ***The maintenance control office for synchronization will be that office of a 2-office chain which transmits reference along each synchronization facility in the synchronization hierarchy of the sector (Fig. 10).***

6.03 In the case of a No. 4 ESS, maintenance and monitoring capabilities exist as defined earlier in this section. However, every affected office is responsible for continuous monitoring of synchronization facilities and equipment connected within the office and for reporting problems to the appropriate control office. The control office will coordinate the sectionalization, removal from service, synchronization, restoral, repair, and return to service of the defective synchronization facility and equipment in accordance with ***normal trouble clearance procedures (both Bell and Independent Telephone Company offices included).*** At the present time, manual craft activity is required to remove a trunk from service. In the case of the nonhierarchical connection by digital facilities of two digital switching systems (Fig. 11), extensive coordination may be required between control offices and upward through the synchronization chains in order to resolve a synchronization problem. Even so, normal trouble clearance procedure applies. Satisfactory maintenance of the synchronization network is contingent on stringent surveillance of all digital facilities.

6.04 The operational administrative effort involved on a switching system basis will include the recording of facilities designated as primary and secondary synchronization facilities; assignment of these facilities and equipment to appropriate alarming, monitoring, and report sources; and the compilation of error reports. No other administrative effort is contemplated at this time.



NONHIERARCHICAL CONNECTION BETWEEN SECTORS

- DIGITAL SWITCHING SYSTEM (A) AND (E) ARE CONNECTED BY A DIGITAL FACILITY.
- NO. 4ESS (B) AND (F) AS WELL AS DIGITAL SWITCHING SYSTEM (A) AND (E) WOULD BE INVOLVED IN TROUBLE CLEARANCE.
- NORMAL TROUBLE CLEARANCE ROUTINES ARE IMPLEMENTED WHEN REQUIRED.

→ INDICATES SYNCHRONIZATION PATH.

Fig. 11—Nonhierarchical Connection Between Sectors

NOTES ON THE NETWORK

SECTION 13

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CONTENTS PAGE

1. GENERAL

1.01 A considerable number of articles dealing with network dialing have been written by Bell System personnel and published either in Bell System publications or trade journals. This bibliography lists a number of these articles which, although treating principally Bell System problems in network 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 network dialing.

1.02 In addition, many other valuable papers have been written by persons outside the Bell System relating generally to network dialing as well as to particular problems that network 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.

1.04 Requests for Bell System Technical References (PUBs) listed in this bibliography and related pricing information should be submitted in writing to:

American Telephone and Telegraph Company
Information Distribution Center, Room C190
Attention: Technical References
Post Office Box 3513
New Brunswick, New Jersey 08903

All orders should be either prepaid or accompanied by a purchase order number. Billing and shipping addresses should be included also. Billing will be rendered by Western Electric; therefore, all checks should be made payable to same.

1.05 Requests for Technical Advisories listed in this bibliography or for meeting notes of the USITA Equipment Compatibility Committee or the USITA Subcommittee on Network Planning can be obtained by contacting:

United States Independent Telephone Association
(USITA)
Office of the Technical Director
1801 K Street, NW
Washington, DC 20006

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