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.

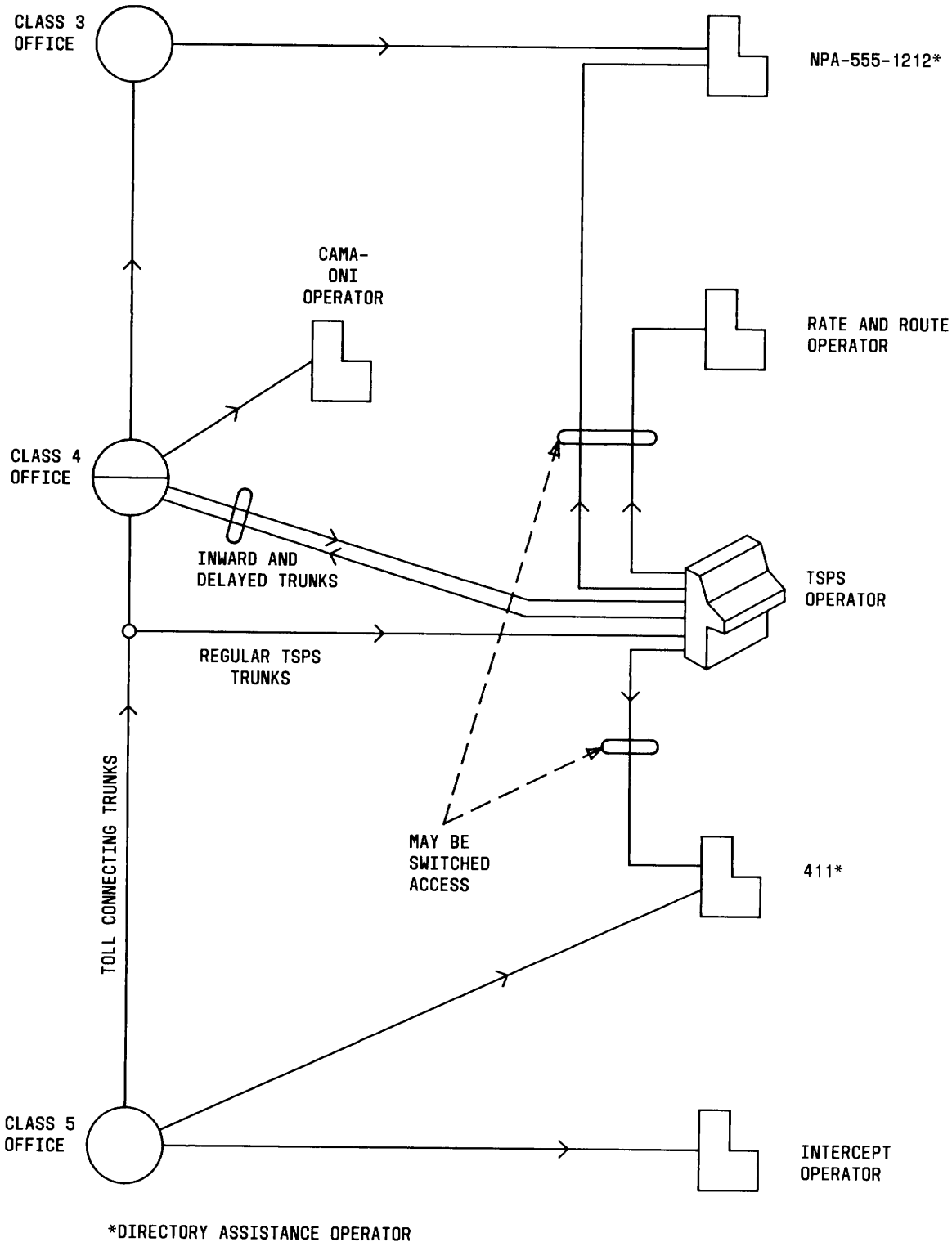

Fig. 1—Typical Topology of Operator Systems

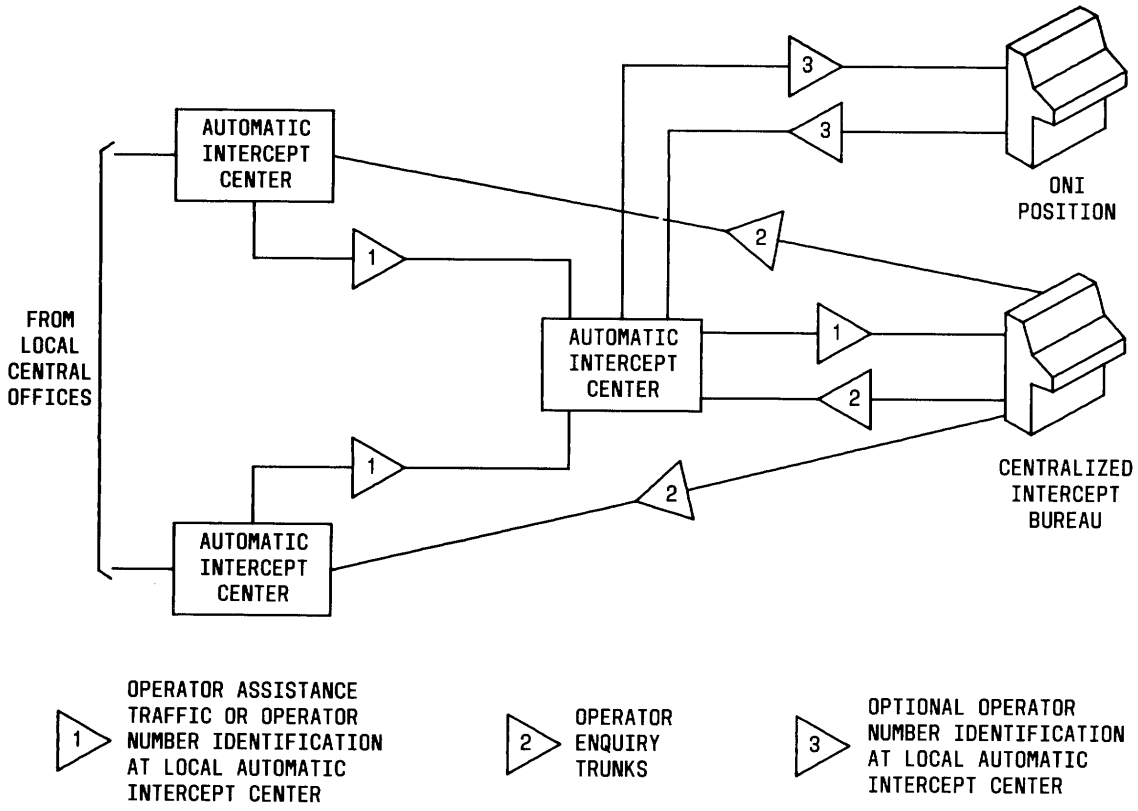

Fig. 2—Automatic Intercept System

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.

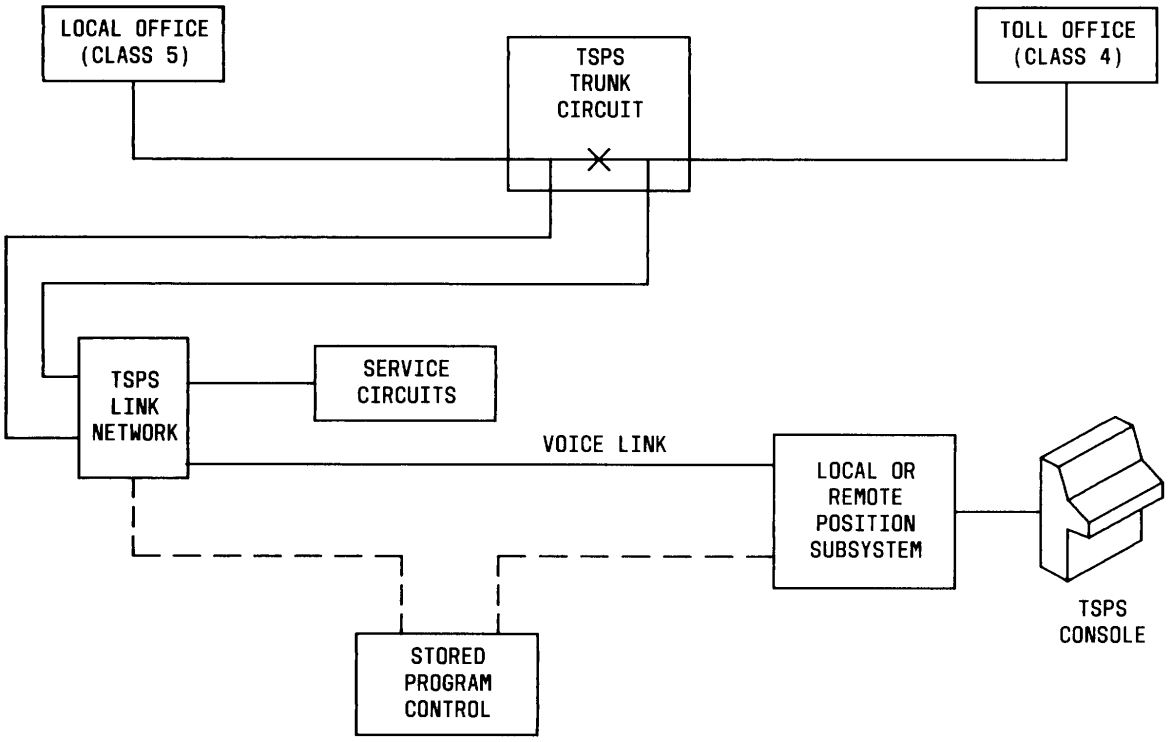

Fig. 3—Traffic Service Position System

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.

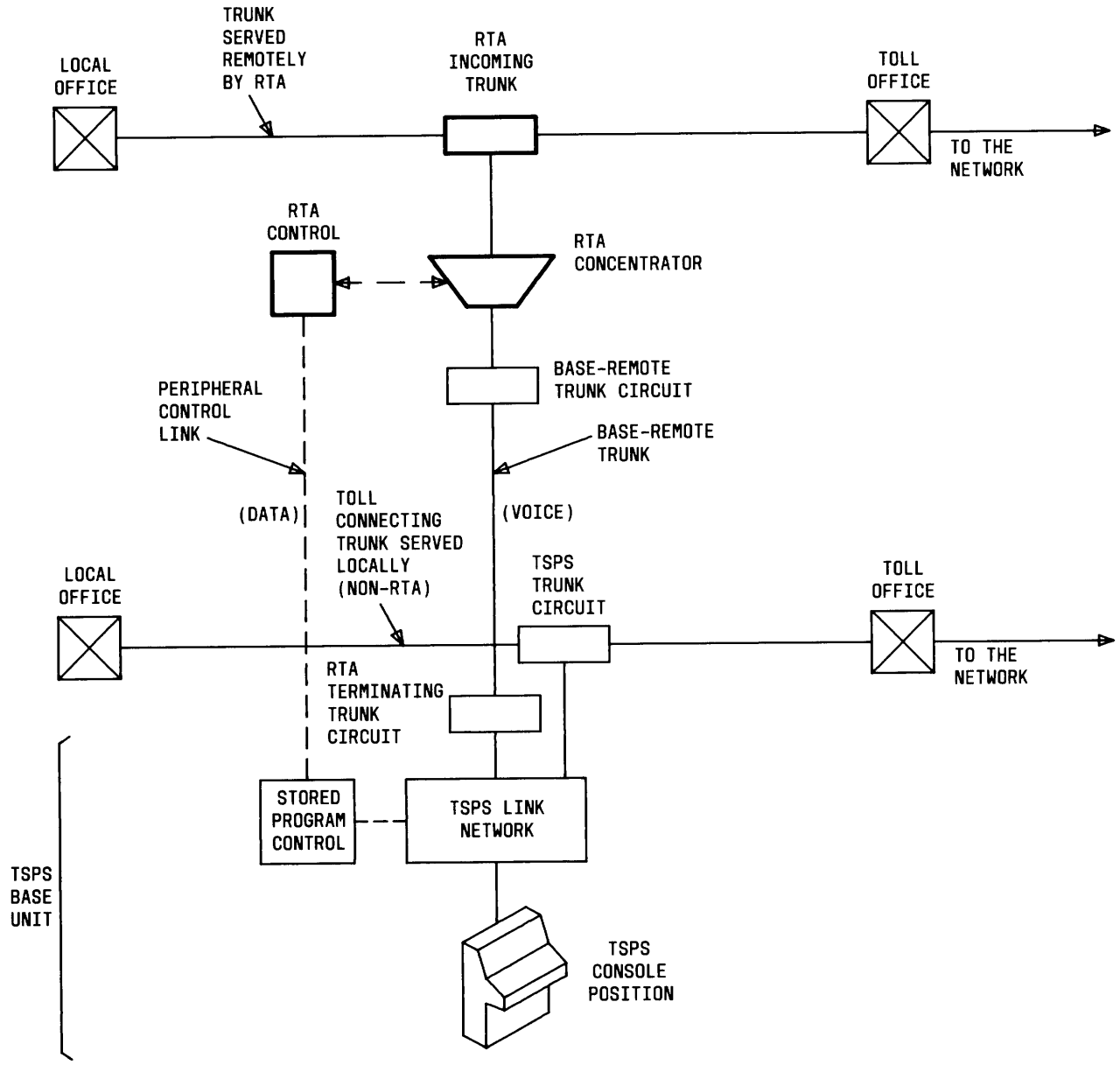

Fig. 4—Remote Trunk Arrangement

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 32×64 matrix and 1984 available classmarks. The No. 1/1A ESS has an 8×16 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.