CUSTOMER LOOP SIGNALS AND SIGNALING SYSTEMS

CONTENTS PAGE

CONTENTS PAGE

1. GENERAL

1.01 In providing facilities and equipment for telephone service, it is necessary to consider, not only the technical requirements for the transmission of speech as well as the volume and routing of traffic, but also the limits set by signaling considerations. This practice describes the signals and signaling systems normally encountered in the design and operation of customer loop telephone plant. Special emphasis has been placed on signaling nomenclature and on the operating principles of the various signaling systems.

1.02 This section is being reissued to update the technical data herein. Since this reissue constitutes a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 Signaling may be required in both directions of transmission, sometimes sequentially and sometimes simultaneously. For some purposes, precise signal element timing is necessary, or definite limits must be met for pulse length, pulse magnitude or pulse form. Signals may be transmitted either within the channel and frequency range used for voice, or by other means. Signaling, as used in telephone systems, embraces both the signals and also the physical means by which certain types of messages are transmitted. A signal may consist of one timed pulse or pulse groups, either simple or complex. In a typical telephone connection, signals are needed in both the calling and called customer loops and in trunks between the switching centers through which the call may be routed.

The electrical signaling power is usually supplied in one of the following forms:

(1) direct current (dc)

(2) alternating current (ac)

(3) multiple frequency tones (MF).

1.04 There are five classes of signals used on customer loops:

(a) ***Information signals*** are audible tones or announcements that inform the customer or operator about the progress of the call.

(b) ***Supervisory signals*** are the means by which a customer initiates a request for service, holds or releases a connection or recalls an operator or the equivalent. The supervisory signal is also used to initiate and terminate charges for the call.

(c) ***Control signals*** are used for auxiliary functions associated with equipment connections to the customer loop. Typical examples are: coin collect, coin return, toll diversion, and ground-start.

(d) ***Address signals*** provide information to the switching system concerning the desired destination of the call (usually the called number).

(e) ***Alerting signals*** are supplied by the switching system to alert the customer to an incoming call or receiver inadvertently left off-hook.

More detailed information on the five classes of signals is contained in Table A. This includes the direction of each signal, the indication given to the customer, and the on-hook or off-hook classification of the signal is shown where applicable by a check mark in the column.

2. DEFINITION OF SIGNALS FROM THE CUSTOMER TO THE SERVING OFFICE

A. Information Signals

Recorder Warning Tone

2.01 Recorder warning tone is a beep tone connected to the line to inform the distant party that the conversation is being recorded.

B. Supervisory Signals

Seizure and Connect

2.02 A request for service initiated at the calling end is called a seizure signal. The transition of the loop from an idle (on-hook) state to a busy (off-hook) state is considered a connect signal.

Flash or Recall

2.03 The flash or recall signal is a momentary on-hook which alerts an attendant or operator (at a PBX or service position) by activating an audio or visual device. The attendant answers and serves the customer. Flashing is also used by customers to exercise the use of custom calling features (see paragraphs 6.02 and 6.03).

Answer

2.04 Answer is a sustained off-hook signal transmitted from the called customer. This signal indicates to the serving office that the call was answered.

Calling Party Disconnect

2.05 Calling party disconnect is an on-hook (open loop) signal from the calling station which notifies the serving office that the established connection is no longer needed and should be released.

Called Party Disconnect

2.06 Called party disconnect is an on-hook (open loop) signal from the called station. It is recognized by the serving office that the connection at the called end is no longer needed.

TABLE A

NAME OF SIGNAL	ON-HOOK	OFF-HOOK	DIRECTION: CALLING END	DIRECTION: SERVING OFFICE END	DIRECTION: CALLED END	USE OR MEANING	INDICATION TO CUSTOMER
A. INFORMATION Dial Tone		√	←	—		Equipment ready for dialing.	Steady Tone
Audible Ringing		√	←	—		Called station is being rung or awaiting operator answer.	Ringing Tone
Line Busy		√	←	—		Called line is busy.	60-IPM Tone
Reorder		√	←	—		All paths busy, all trunks busy, blockage in equipment, or incomplete registration of digits.	120-IPM Tone
Recorded Announcements		√	←	—		Indicates to customer reason the call cannot be completed.	
Reverting Tone		√	←	—		Calling party is off-hook and has to hang up while line is rung.	60-IPM Tone
Recorder Warning Tone		√	←	←	—	Indicates telephone conversation is being recorded.	1400-Hz tone of 0.5 second duration applied every 15 seconds.
B. SUPERVISORY Connect (Seizure)		√	→	—		Requests service and holds connection.	
Recall (Customer Flashing)	√	√	→	←	—	Manually recalls operator to connection.	
Hold	√	√				By depressing hold key or switchhook connects line to a holding bridge.	
Answer		√		←	—	Called party has answered. Charged timing begins and depends on this signal.	Audible ringing has stopped to calling customer.
Ring Trip		√				Answer signal has been received and ringing has stopped.	Ringing has stopped to called customer.
Disconnect	√		→	←	—	No service is desired. Message is completed. Release connection.	

TABLE A (Contd)

NAME OF SIGNAL	ON-HOOK	OFF-HOOK	DIRECTION: CALLING END	DIRECTION: SERVING OFFICE END	DIRECTION: CALLED END	USE OR MEANING	INDICATION TO CUSTOMER
C. CONTROL Coin Collect			←	—		To collect coins deposited in coin box.	
Coin Return			←	—		To return coins deposited in coin box.	
Toll Diversion			←	—		To indicate that a PBX station cannot make a toll call.	Recording, busy tone, or attendant.
Ground-Start			→	→		Minimizes dual seizure on a two-way PBX trunk. Also provides seizure signal for older coin type telephone equipment.	
Party Identification		√	→	—		Indicates that the Tip party is calling.	
D. ADDRESS Dial Pulsing	√	√	→	—		Indicates called number.	
TOUCH-TONE			→	—		Indicates called number.	
Verbal Digits			→	—		Indicates called number.	
E. ALERTING Ringing			—	→		Alerts called customer to an incoming call.	Bell rings or other alerting signal.
Receiver Off-Hook		√	←	—		Alerts the customer to an off-hook receiver.	1400 + 2060 + 2450 +2600 Hz at 300 IPM.

C. Control Signals

Ground-Start

2.07 Ground-start is the application of ground, by the private branch exchange (PBX) or coin station, to the ring (R) conductor of a loop to seize the serving office line circuit and prepare the distant circuit to receive loop signals. This signal is used on older types of coin stations (without dial tone first) and on private branch exchange-central office trunks. A detailed description of ground-start is provided in paragraphs 4.23 through 4.36.

Party Identification

2.08 On a 2-party line, the party identification signal indicates to the serving office (for charging purposes) which party is calling.

D. Address Signals

2.09 An address signal is a group of pulses or tones which can vary from 1 to 3, 7, 8, 10, or 11 digits. For example, by dialing the digit 0, the calling party will be connected with an operator; dialing a 3-digit service code will connect the calling party with emergency (911) or information (411) personnel; generally, 7-digit dialing will establish a local exchange call; 7- or 8-digit dialing will establish a toll call connection within the local area code; 10- or 11-digit dialing is required to establish a toll call outside the local area code. For international direct distance dialing (IDDD) calls, more than 11 digits may be required.

E. Alerting Signals

2.10 Alerting signals are not passed from the customer to the serving office. The supervisory connect (off-hook) signal is used as a customer request for service to the serving office.

3. DEFINITION OF SIGNALS FROM THE SERVING OFFICE TO THE CUSTOMER

A. Information Signals

Dial Tone

3.01 Dial tone indicates that the serving office is ready to receive address information.

Audible Ringing

3.02 Audible ringing is a tone heard at the calling end, indicating that the connections have been made and ringing current has been applied toward the called customer.

Line Busy Tone

3.03 Line busy tone informs the calling customer that the called line is busy and that no connection can be made.

Reorder Tone

3.04 Reorder tone indicates to the calling customer that the call did not go through due to traffic congestion or equipment malfunction.

Recorded Announcements

3.05 When all trunks are busy or machine blockage occurs or no such number exists, and no connections can therefore be made, recorded announcements are received by the customer. These announcements explain to the calling customer the nature of the problem.

Revertive Calling Tone

3.06 When the called party is on the same party line as the calling party, the revertive calling tone informs the calling party to hang up before the line is rung.

B. Supervisory Signals

3.07 Supervisory signals are not transmitted from the serving office to the called customer. The status of the line is determined by the status of the customer's line supervision device which is internal to the switching machine. Alerting signals are used to provide the status of a line to the customer. In the special case of calling into a private branch exchange (PBX), the serving office transmits seizure and disconnect signals to the PBX.

Ring Trip

3.08 Ring trip is the process of removing the 20-Hz ringing signal from the loop. The ringing is tripped when the customer answers the station set.

C. Control Signals

Coin Collect

3.09 The coin collect signal causes the coin telephone to collect the coins held in suspension.

Coin Return

3.10 The coin return signal causes the coin telephone to return the coins held in suspension to the customer.

Toll Diversion

3.11 The toll diversion signal is sent from the serving office to a private branch exchange (PBX). This allows selected PBX stations to make toll calls and denies others. An example of its application is in hotels or motels, where customers are billed locally for any toll calls made but are permitted to make local calls free or at a fixed charge per call.

Ground-Start (CO to PBX)

3.12 Ground-start is the application of ground, by the central office, to the tip (T) conductor of a loop to seize the PBX circuit. When a ringing detector is supplied as part of the PBX circuit, the ground is used only as a seizure signal, and prepares the distant circuits to receive loop signals. A detailed description of ground-start is provided in paragraphs 4.23 through 4.27.

D. Address Signals

3.13 Address signals are not normally transmitted from the serving office to the customer. The only case where address signals are transmitted over the customer loop is to PBXs arranged for direct inward dialing. Also, the application of ringing signals and the appropriate dc potential (in selective 4-party ringing) is considered an alerting signal. A detailed explanation of ringing and ringer connections is provided in paragraph 4.37.

E. Alerting Signals

Ringing

3.14 The ringing signal is transmitted from the called serving office which alerts the called customer to an incoming call.

Receiver Off-Hook (ROH)

3.15 When the station set has been in the off-hook state approximately 20 to 60 seconds, and address information has not been supplied by the customer, ROH tone is applied to the loop. This tone is a high amplitude "beep" or "howl", heard through the station set to attract the attention of the customer.

4. METHODS OF PROVIDING CUSTOMER LOOP SIGNALS

A. Information Signals

4.01 Figure 1 illustrates how the serving office supplies battery and signals to the customer loop. The serving office connects different signaling circuits to provide dial tone, audible ringing, line busy, etc. The serving office transmits these signals toward the calling or called customer as shown in Table A. The current limiting device Z in Fig. 1 is for protection against any short circuit between the tip and ring which could overload the office wiring.

Dial Tone

4.02 Dial tone is heard when the calling customer goes off-hook and consists of 350 Hz plus 440 Hz superimposed on -48 volt dc loop battery. Dial tone is removed from the loop when the serving office receives the first digit of the address signal. An example of how dial tone is applied to a customer line is shown on SD-1A172 and described in CD-1A172 for the No. 1 Electronic Switching System (ESS).

Audible Ringing

4.03 Audible ringing is usually provided by the final local switching equipment at the called end of the connection and is usually heard about the same time the called customer receives ringing current. In most cases, audible ringing consists of 440 Hz plus 480 Hz superimposed on -48 volt loop battery. This signal is removed from the loop when the called customer goes off-hook. An example of how the ringing signal is removed from the customer loop is shown on SD-1A168 and described in CD-1A168 for the No. 1 ESS.

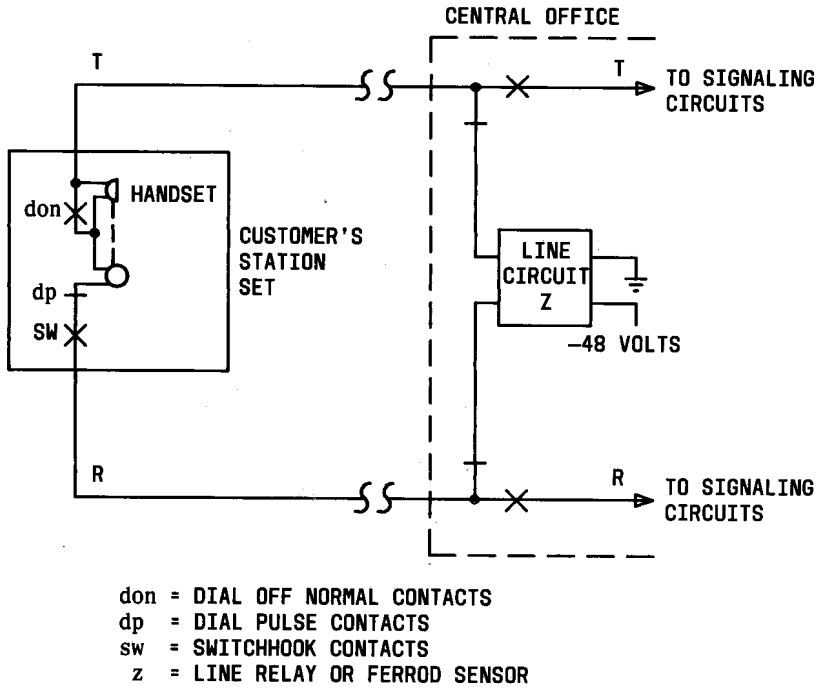


Fig. 1—Customer Loop Configuration

Line Busy

4.04 Line busy is usually provided by the final local switching equipment at the called end of the connection and is applied when the called line is busy. It consists of a low tone (480 Hz plus 620 Hz) at 60 interruptions per minute (IPM) superimposed on -48 volt dc loop battery. Line busy is removed when the calling customer goes on-hook.

Reorder

4.05 Reorder is a low tone at 120 IPM and is provided by the switching office that is unable to complete the call when no connections are available to the called customer. This signal is removed when the calling customer goes on-hook.

Recorded Announcements

4.06 Recorded announcements are provided by magnetic tape (machine announcements) or Automatic Intercept System (AIS). AIS determines the status of the intercepted number, links together prerecorded phrases and numbers to form an assembled announcement, and presents this announcement to the customer. Some examples of these announcements are shown in Table B. Further reference to AIS is in Section 984-120-100.

Revertive Calling Tone

4.07 Revertive calling tone is the same as line busy (low tone at 60 IPM). The calling party hears it when calling another party on the same line. When the tone is heard, the calling party should hang up and the serving office will place the call. The serving office selects the proper ringing code for the called party and applies revertive ringing code tone to the other side of the line. If the calling party and called party are on the same side of the line, the calling party station and called party station set will ring with the proper ringing code. If the calling party and called party are not on the same side of the line, the revertive ringing code tone will ring the calling party station set and the proper ringing code will ring the called party station set. In both cases, when ringing stops, the calling party knows the called party has answered. The revertive ringing signal code is different from the called party code to avoid confusion.

TABLE B

RECORDED ANNOUNCEMENTS

I'm sorry, (pause) all circuits are busy now. Will you try your call again later, please? This is a recording.

I'm sorry, your call did not go through. Will you please hang up and try again? This is a recording.

I'm sorry, we are unable to complete your call as dialed. Please check the number and dial again or ask your operator for assistance. This is a recording.

I'm sorry, unexpected damage to telephone equipment has delayed your call. Emergency calls may be placed with your operator. This is a recording.

I'm sorry, the number you have reached is not in service at this time. If you need assistance, please stay on the line and an operator will answer. This is a recording.

I'm sorry, the number you have reached is not in service at this time. If you need assistance, please hang up and dial your operator. This is a recording.

AIS RECORDING

The number you have reached, 555-3564, has been changed; the new number is 555-3563. Please hang up and dial again.

Recorder Warning Tone

4.08 Recorder warning tone is 1400 Hz and is applied to the loop every 15 seconds for a 0.5 second interval. This tone source is located within the electric recording equipment or telephone company equipment and cannot be controlled by the party applying the recorder to the line unless the recording is stopped.

B. Supervisory Signals

4.09 Both off-hook and on-hook signals, when they are not used to convey numerical information, are often referred to as supervisory signals or simply as "supervision." These terms were derived from the position of the receiver of an old fashion telephone set in relation to the mounting (hook) provided for it.

4.10 Usually, if the loop is not in use, it is signaling on-hook toward the serving office. If the station is on-hook, the loop (tip, T, and ring, R) between the station and the serving office is open (idle) and no current is flowing through the loop (Fig. 1). For an off-hook condition (busy), there is a dc shunt (the telephone set) across the line and current is flowing from the serving office common battery (-48 volts).

Seizure and Connect

4.11 The seizure signal is initiated when the station set receiver is in the off-hook position. Battery current flows (connect signal) and activates a line sensing device in the serving office. Activation of the line sensing device causes connection of switching equipment and applies dial tone to the loop.

Flash or Recall

4.12 Flashing is achieved by the customer momentarily depressing (no longer than 1.2 seconds) and releasing the switchhook. This is an off-hook to on-hook to off-hook signal.

Answer and Ring Trip

4.13 The answer signal informs the called serving office that the called customer has answered the incoming call. In order for this signal to be recognized as an answered call, the signal must be present for a minimum of 0.2 through 5 seconds depending on the specific type of serving office (step-by-step, crossbar, or electronic).

4.14 The 20-Hz ringing is tripped within 250 milliseconds (ms) but not less than 12 ms, when the serving office receives the answer signal from the called customer. The direct current path through the station set operates the tripping device regardless of whether the answer signal occurs during the ringing or silent interval. The tripping device in the serving office removes the audible and 20-Hz ringing from the loops. When the ringing is tripped, the talking paths are connected.

Calling Party Disconnect

4.15 The calling party disconnect signal is initiated when the calling customer places the handset on the switchhook (on-hook) for more than 1.5 seconds. This signal initiates the sequence of events that causes the serving office to return the connected switching equipment to the idle state.

Called Party Disconnect

4.16 The called party disconnect signal is initiated when the called customer places the handset on the switchhook (on-hook) for more than 1.5 seconds. This signal initiates the sequence of events that causes the serving office to perform one or more functions prior to releasing the connection to the called customer line.

C. Control Signals

Coin Collect

4.17 To collect a coin into the coinbox, the coin trunk circuit or auxiliary coin circuit in the local serving office removes battery and ground from the coin station exchange loop and applies a positive potential (typically +100 through +130 volts dc) to the tip conductor with the ring open.

Coin Return

4.18 To return a coin from the coin station, the coin trunk circuit or auxiliary coin circuit in the local serving office removes battery and ground from the coin station exchange loop and applies a negative potential (typically -100 through -130 volts dc) to the tip conductor with the ring open.

Note: The coin collect and coin return potentials are transposed in some areas.

Toll Diversion

4.19 Toll diversion can be accomplished two ways, depending on the type of PBX and serving office equipment available. One method is serving office battery reversal and the other is PBX digit translation.

Serving Office Battery Reversal PBX Toll Diverting Method

4.20 This method requires the serving office to send a momentary battery reversal signal to the PBX if the digits dialed indicate a toll call. If the call is a toll call, the serving office sends the battery reversal signal (-48 volts on the tip and ground on the ring) and the PBX either permits or diverts the call governed by the class of service of the calling PBX station. If the call is diverted, the connections to the serving office are disconnected. The customer is connected to a PBX recording, tone trunk, or attendant.

PBX Digit Translation Toll Diverting Method

4.21 This method uses a single-digit or 3-digit translation or both depending on the type of PBX equipment. When a toll restricted PBX station initiates a call to the serving office by addressing an access code, a connection is established from the PBX station to the PBX-CO circuit. The PBX-CO circuit seizes a trunk and passes the addressed digits. A PBX controller also collects and stores the first digit or first three digits and compares these digits with logic in the code check unit. If the code checks, the call goes through and if it does not, the call is diverted and busy tone is returned to the PBX station.

4.22 Newer PBX and centrex systems restrict the toll diverted stations within the switching system by means of dialed digit translation.

Note: Most carrier systems and range extension equipment are incapable of relaying the toll diverting signal from the serving office to the PBX.

Basic Description of the Operation of Dial PBX Ground-Start Central Office Trunk Circuits

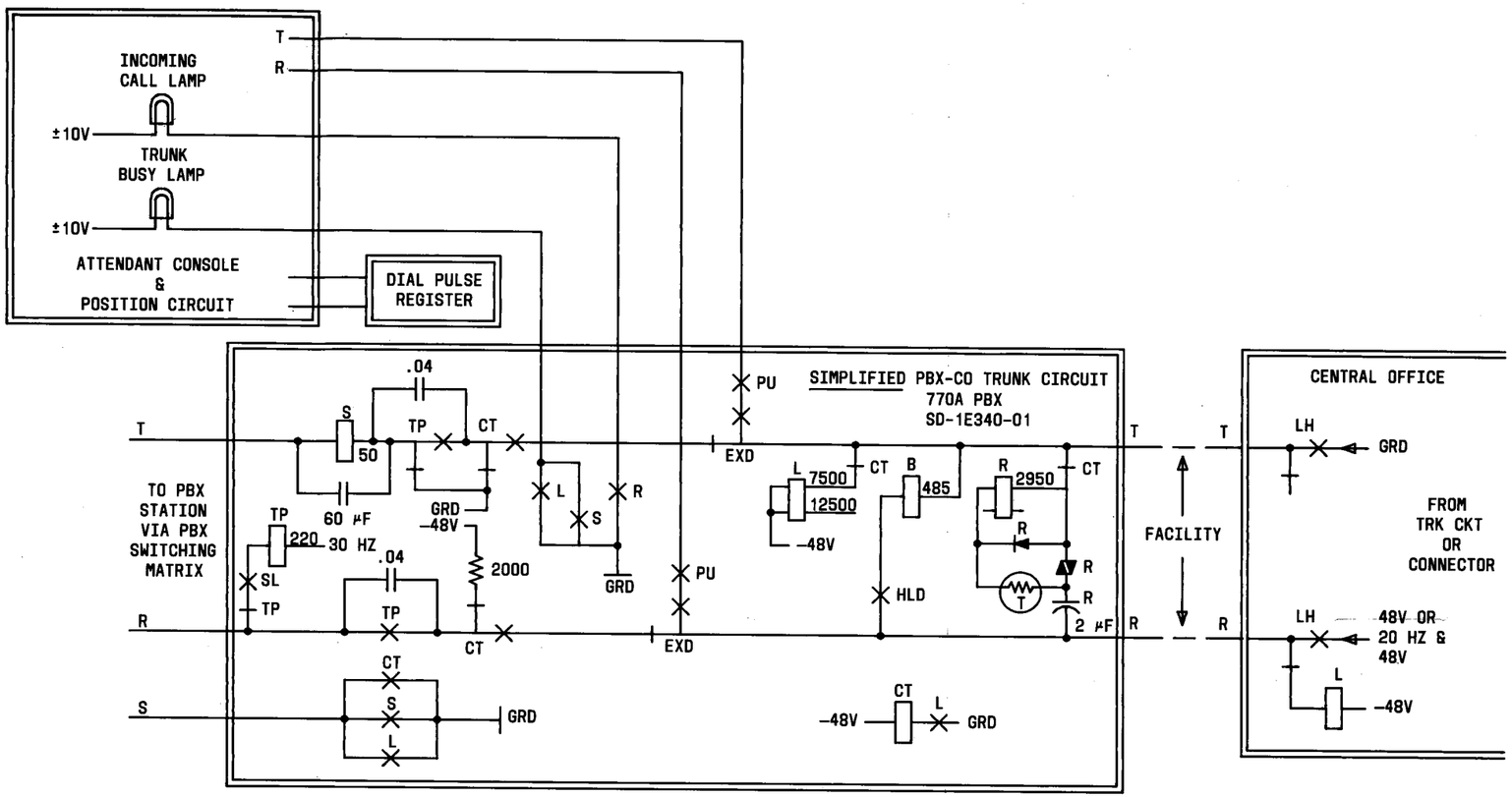
General Information

4.23 The following descriptions and figures of the basic operation of dial PBX-central office trunk circuits are ***simplified*** to more clearly explain the basic principles and functions of the ground-start portion of their operation on both ***an incoming call*** to the PBX as described in paragraph 4.24, and ***an outgoing call*** to the central office as described in paragraph 4.31. The explanation of these basic signals and the response to them is ***accurate in principle*** but leaves out most of the interactive logic necessary to provide the auxiliary services and peripheral functions performed by actual modern circuits. The 770A dial PBX central office trunk circuit SD-1E340-01 for example, requires 29 relays to perform these logic functions. This complexity is beyond the scope of this basic explanation.

Basic Description of a Call From the Central Office to a PBX Station Via the PBX Attendant

4.24 Refer to Fig. 2 to follow the circuit operation of the ground-start PBX-CO trunk circuit for a call from the central office to a dial PBX station including the actions necessary by the PBX attendant.

4.25 With all circuits in the idle state, the tip conductor is open at the central office and the ring conductor is connected to 48-volt battery in series with the winding of a line relay or a ferrod sensor L at the central office. The tip and ring conductors of the PBX-CO trunk circuit facing the central office are isolated from the PBX station tip and ring and from the PBX attendant tip and ring by the open make contacts on relays cut through CT, and pick up PU respectively, which are not closed until later stages of the call. When the central office seizes this trunk circuit for a call to the PBX, it applies ground to the tip conductor toward the PBX, removes the line relay (L) from the ring conductor toward the PBX and applies either (a) 20-Hz ringing superimposed on -48 volts dc to the ring conductor, or (b) -48 volts dc only to the ring conductor, dependent on the status of the usual 2-second ring, 4-second silent period of the ringing cycle at the central office. If the trunk is seized during the ringing period of



LEGEND:

X	INDICATES CONTACT CLOSED WHEN RELAY OPERATES
-	INDICATES CONTACT CLOSED WHEN RELAY IS RELEASED
CT	CUT THROUGH RELAY
TP	RINGING TRIP RELAY
S	SUPERVISORY RELAY
R	RINGING DETECTOR RELAY
EXD	EXCLUDE DESTINATION RELAY
PU	PICKUP RELAY
B	HOLDING BRIDGE RELAY
HLD	HOLD RELAY
LH	LINE HOLD MAGNET
L	LINE RELAY (IN CENTRAL OFFICE)
L	GROUND DETECTING RELAY (IN PBX TRUNK)

Fig. 2—Ground-Start Circuit for an Incoming Call to a Dial PBX

the ringing cycle, the following actions take place in the PBX trunk circuit: The ringing detector relay R operates in response to the half wave rectified 20-Hz ringing energy in series with the 2 μf R capacitor, and the ground detecting relay L operates in response to the ground on the tip from the central office. However, if the trunk is seized during the silent period of the central office ringing cycle, the ground detecting relay L operates in response to the ground on the tip conductor from the central office and the ringing detector relay R does not operate until the beginning of the next ringing cycle.

4.26 The operation of the ground detector relay L in either of the two cases above makes this trunk circuit appear busy to the PBX switch and to the PBX attendant and in ***some*** PBXs alerts the PBX attendant. In most dial PBXs, including the 770A, the PBX attendant is not alerted until the ringing detector relay R is operated. The attendant answers the incoming call by depressing a pickup key at the console which operates pickup relay PU, cut through relay CT, excludes destination relay EXD, and other relays not shown which connect the attendant to the tip and ring conductors from the central office, the loop closure tripping the central office ringing and resulting in the closure of a voice path from the calling party to the PBX attendant.

4.27 The PBX attendant determines from the calling party which PBX station is desired and then depresses a start key at the attendant position causing the following actions to occur:

(a) Operates the hold relay HLD, placing a holding bridge toward the central office (the winding of the B relay)

(b) Disconnects the attendant from the central office tip and ring conductors

(c) Attaches a PBX dial pulse register directly to the attendant position circuit.

4.28 The PBX attendant hears dial tone when the PBX dial pulse register is attached and dials the number of the desired PBX station into the register. The PBX attendant functions have now been completed, and the attendant may release from the connection to answer another call, or the attendant may remain on the connection to announce the call to the PBX station upon answer. In either case the PBX common equipment now takes over and causes the following actions to occur ***if the called PBX station line is not busy:***

(a) A connection is established through the PBX switching matrix from the PBX-CO trunk circuit to the called PBX station.

(b) Ringing is applied to the PBX station by the PBX-central office trunk circuit (through the winding of the ringing trip relay TP).

(c) Ringing tones are returned to the calling party at the central office end of the connection by the PBX central office trunk circuit.

(d) Ringing is removed (tripped) from the called PBX station by the operation of the PBX-CO trunk circuit TP relay upon answer by the PBX station, and ringing tones are removed from the calling party.

(e) The voice path is closed from the central office calling party to the called PBX station due to operation of TP relay.

4.29 Conversation between the calling party and the called PBX station now occurs. Battery and ground are supplied from the central office to the PBX station in series with the supervisory relay S in the PBX-CO trunk circuit, holding it operated, which holds the connection through the PBX.

4.30 When the PBX station disconnects or when the central office connection is released, removing the tip ground, there is no current flowing through the supervisory relay S in series with the PBX station loop and the S relay therefore releases, initiating the release of the connection through the PBX. It should be noted that if the PBX station disconnects, but the central office remains connected, the PBX central office trunk circuit releases (because there is no loop current to hold the S relay), releasing the connection through the PBX switching matrix. The ground detecting relay L in the PBX-CO trunk circuit is applied to the tip conductor, and if the central office is still furnishing ground on the tip conductor, the ground detecting relay L operates, making the trunk appear busy to the PBX and to the PBX attendant. When the central office releases, removing the tip ground, the L relay releases in

the PBX-CO trunk circuit, permitting the PBX-CO trunk circuit to restore to the idle state.

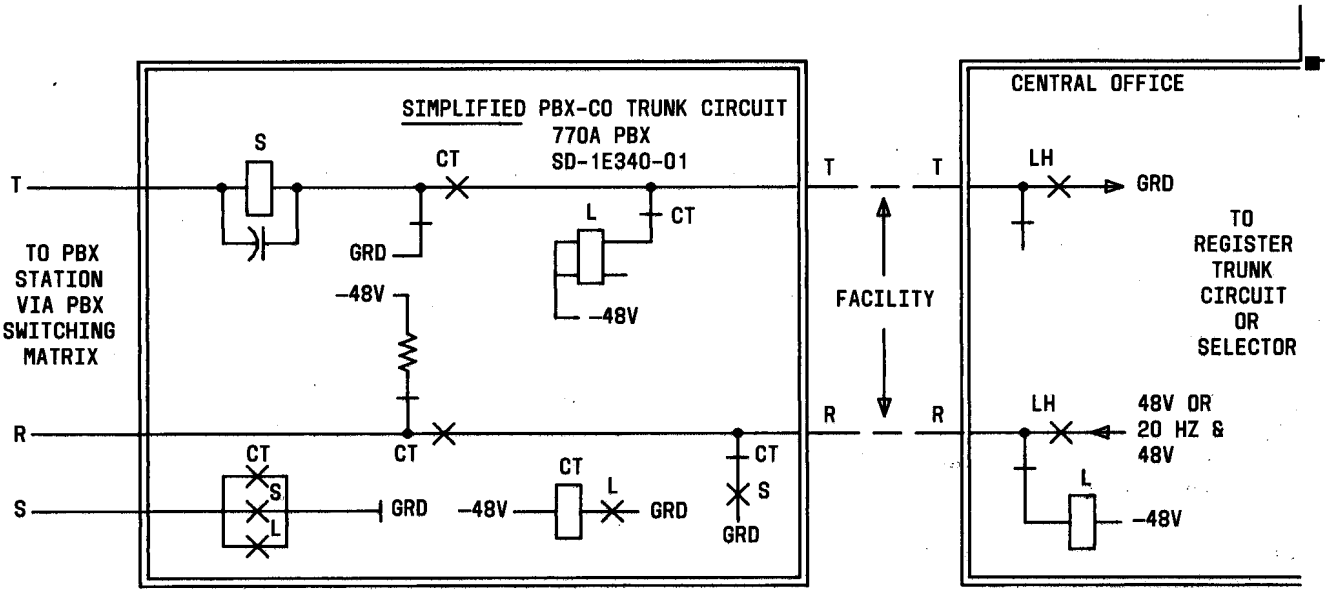
Basic Description of a Call From a Dial PBX Station to a Local Class 5 Central Office Destination not Involving Toll Charges

4.31 Refer to Fig. 3 to follow the circuit operation of the ground-start PBX-CO trunk circuit for a call from a dial PBX station to a central office destination ***not involving toll charges.***

4.32 With all circuits in the idle state, the tip conductor is open at the central office, and the ring conductor is connected to negative 48-volt battery in series with the winding of a line relay or ferrod sensor (L) at the central office. The tip and ring conductors of the PBX-CO trunk circuit facing the central office are isolated from the PBX attendant by the open make contacts of the pick-up relay PU (Fig. 2), and from the PBX station by the open make contacts of the cut through relay CT.

4.33 A dial PBX station goes off-hook, causing the PBX common control equipment to attach a dial pulse register to that station line. The PBX station, upon hearing dial tone, dials the digit 9 into the register which summons the marker, which causes a connection to be established from the station to the PBX-CO trunk circuit. The register and marker are released, and the PBX station receives battery and ground from the PBX-CO trunk circuit in series with the supervisory relay S in the PBX-CO trunk circuit, causing the operation of the S relay. The operated S relay performs three major functions: (1) places a ground on the sleeve lead toward the switching matrix to hold the established connection, (2) lights a busy lamp at the PBX attendants console, and (3) places a ground on the ring conductor toward the central office to initiate seizure.

4.34 The central office responds to the seizure and connects a central office dial pulse register to the line. The central office dial pulse register applies a ground to the tip conductor toward the PBX and a 48-volt battery potential to the ring conductor toward the PBX and applies dial



LEGEND:

X	INDICATES CONTACT CLOSED WHEN RELAY OPERATES
-	INDICATES CONTACT CLOSED WHEN RELAY IS RELEASED
CT	CUT THROUGH RELAY
S	SUPERVISORY RELAY
LH	LINE HOLD MAGNET
L	LINE RELAY (CENTRAL OFFICE)
L	GROUND DETECTING RELAY (PBX TRUNK)

Fig. 3—Ground-Start Circuit for an Outgoing Call From a Dial PBX

tone. The L relay in the PBX-CO trunk circuit operates from a local 48-volt supply to the tip ground at the central office. The operation of the L relay causes the operation of the cut-through relay CT. The operation of the cut-through relay CT connects the station tip and ring conductors through to the central office tip and ring conductors, removes the local battery and ground which was supplied to the station prior to the operation of relay CT, and removes the ground applied to the ring conductor toward the central office.

4.35 The station now is receiving battery and ground as well as dial tone from the central office dial pulse register. The S relay remains held by current supplied by the central office through the PBX station loop. Both the S relay and the slow release CT relay are now holding the path through the PBX switching network.

4.36 The PBX station dials the desired number into the central office dial pulse register, and the call is established to the desired destination in the usual way. Conversation occurs, and no further circuit action takes place until either the PBX station or the central office goes on-hook. When either party goes on-hook, loop current is removed toward the PBX releasing the supervisory relay S, causing the release of slow release relay CT, releasing the path through the PBX switching matrix. Upon the release of all relays in the PBX-CO trunk circuit, the ground detector relay L is applied to the tip conductor toward the central office. If the central office has not yet released its connection to this trunk, the tip ground from the CO will cause the operation of the PBX-CO trunk circuit L relay making this trunk busy to the PBX until the central office restores to normal removing the tip ground.

Party Identification

4.37 The station sets of the tip parties on a multiparty line must provide a dc circuit to ground for party identification purposes when the handset is off-hook (Fig. 4). The impedance of this circuit to ground must be high enough so as not to impair dialing and transmission but the dc resistance must be low enough to be recognizable by the serving office party identification circuit. The dc resistance of the ringer coil (identification coil) from tip to ground may be 1000, 1900, 2650, or 3650 ohms depending on the identification capabilities of the serving office equipment.

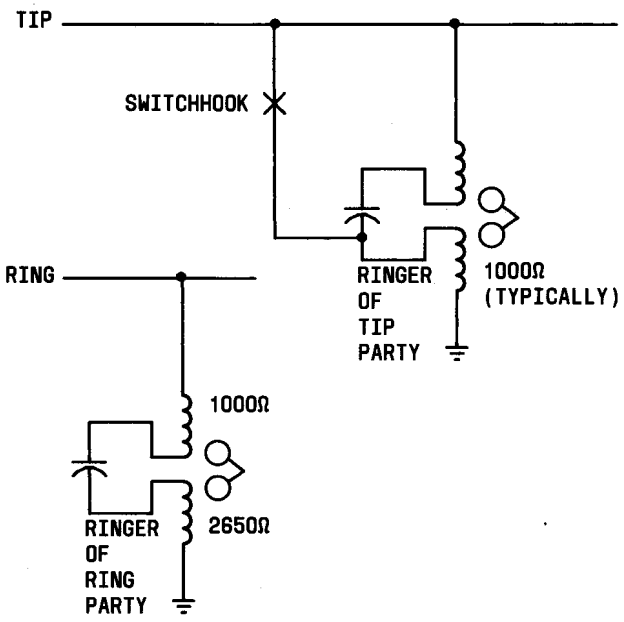


Fig. 4—Party Identification (Typical Arrangements)

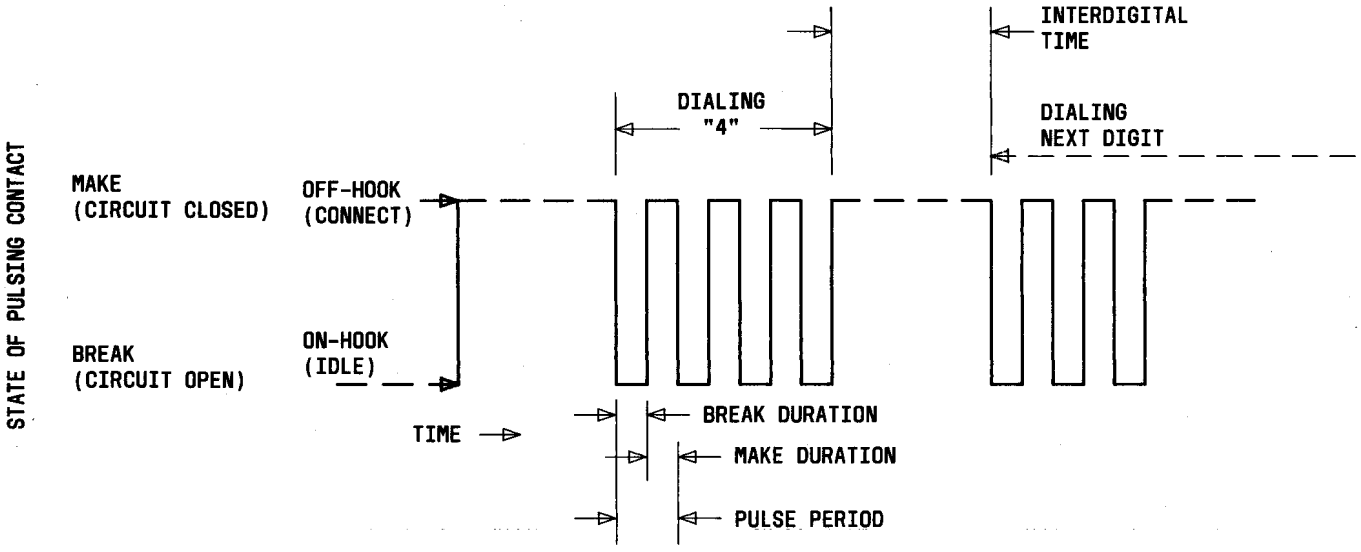
D. Address Signals

4.38 Until 1978, the verbal addressing method was still used in some parts of the Bell System. When the calling customer went off-hook, the operator would come on the line and ask for the desired number.

4.39 Address signals are normally applied to the loop by using a rotary dial or TOUCH-TONE ® station set, which applies dial or TOUCH-TONE pulses to the loop. The total series of pulses is considered an address or called number information.

Dial Pulsing

4.40 When the customer goes off-hook at the station set, the switchhook contacts close and current flows through the loop. A digit is dialed when the rotary dial is pulled off-normal (clockwise direction). When the dial is released, contacts in the station set open and close the loop corresponding to the dialed digit. The dial contacts close at the end of the series of pulses. So if the digit four is dialed, the loop is opened and closed four times at a rate of 10 pulses per second (Fig. 5). Not only is the speed of the dialed digit important but also the percent break (% BK). Dial pulses are normally between 58 through 64% BK.



PULSING PERIOD = BREAK DURATION + MAKE DURATION (MILLISECONDS)
PERCENT BREAK = 100 X BREAK DURATION ÷ PULSING PERIOD

DIAL PULSING DEFINITIONS

Fig. 5—Dial Pulse Signaling

TOUCH-TONE Pulsing

4.41 The TOUCH-TONE pad (Fig. 6) consists of a rectangular array of pushbuttons, a mechanical arrangement to cause closure or tone generation, and an oscillator circuit to generate these tones. After going off-hook, the customer can address the desired number by sequentially depressing the TOUCH-TONE buttons corresponding to the digits of the called number. Depression of a button causes a 2-frequency tone to be generated in the station set and transmitted through the loop to the serving office. Since TOUCH-TONE is much faster than rotary dialing, the speed at which the digits are addressed depends mainly on the customer. With TOUCH-TONE, the maximum speed is usually ten digits per second. This corresponds to a minimum tone on time of 50 msec and a tone off time of 45 msec for a complete cycle time of approximately 100 msec. More reference to TOUCH-TONE calling can be found in Section 951-920-100.

4.42 The TOUCH-TONE method of signaling uses two groups of frequencies:

Low group (Hz): 697, 770, 852, 941

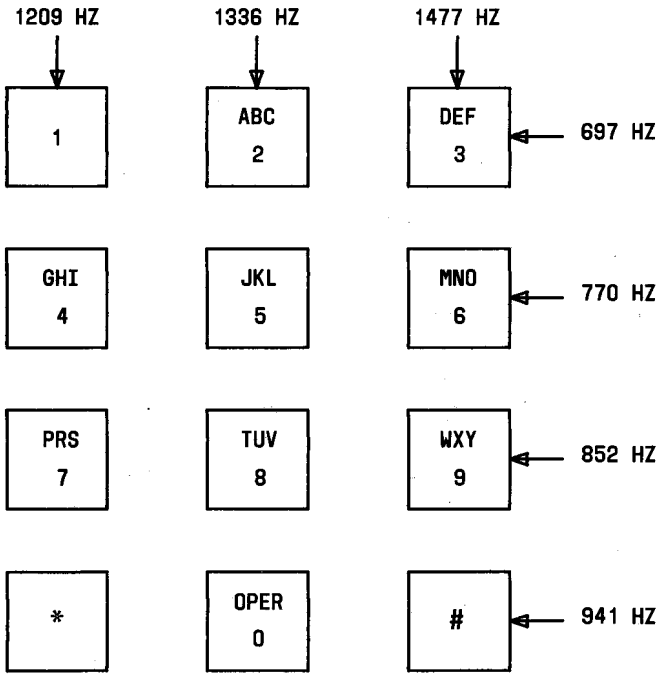


Fig. 6—TOUCH-TONE Pad Layout

High group (Hz): 1209, 1336, 1477.

Each TOUCH-TONE signal is composed of one frequency out of the low group and one frequency out of the high group. This yields 12 combinations which are used to represent the digits 0 through 9, plus * and # (Fig. 6).

E. Alerting Signals

Ringing

4.43 The usual ringing signal consists of 20 Hz at a nominal voltage of 84 to 88 volts RMS ac superimposed on a direct current tripping battery voltage ranging from 37 to 50 volts. The ringing current is obtained from a generator at the serving office and is applied to the customer loop to activate the ringer in the station set. Longer ranges are sometimes obtained by the use of 20 Hz at a nominal voltage of 90 to 130 volts RMS ac without the dc tripping battery. Ringing current is applied to the loop at an interval of 2 seconds on and 4 seconds off. This signal will persist until either the called customer answers or the calling customer disconnects.

4.44 In single party arrangement, the ringer is connected across the tip and ring. When the serving office rings the customer, the ringing voltage is applied to the ring and ground on the tip (Fig. 7).

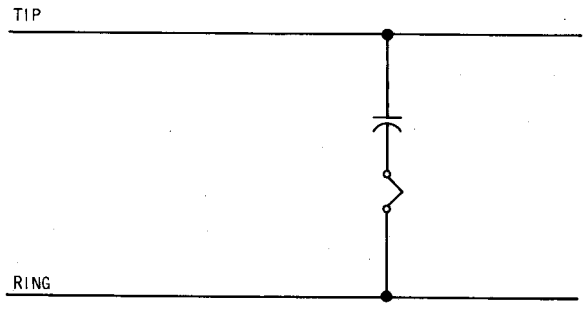


Fig. 7—Bridged Ringing Used on Individual Lines

4.45 In 2-party selective ringing (Fig. 8), the ringers are connected either from tip to ground (tip party) or from ring to ground (ring party). When the serving office rings either party, it applies ringing voltage to either the tip or ring side of the line depending on which party is being rung. Four-party semiselective ringing is achieved by adding another party to each conductor of the loop. Ringing voltage is applied to the loop in the same manner as 2-party selective, but codes of one ring for party 1 and two rings for party 2 are used (Fig. 9).

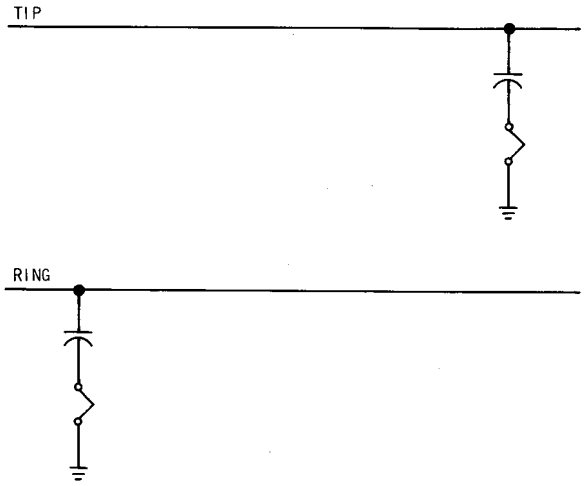


Fig. 8—Two-Party Full Selective Grounded Ringing

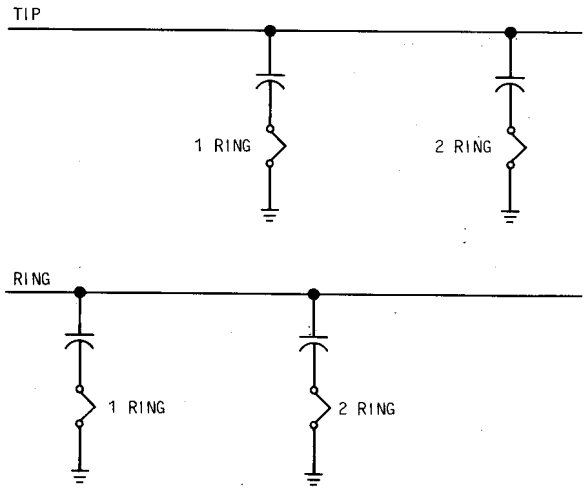


Fig. 9—Four-Party Semiselective Grounded Ringing

4.46 Four-party selective ringing (Fig. 10) has two parties from tip to ground and two parties from ring to ground. An electronic diode

in the station set consists of two anodes and a gate. This provides four-party selective ringing for the respective tip and ring parties. The space between anode 1 and anode 2 forms a "control gap" that becomes conductive when a positive potential (normally 70 through 80 volts) is applied to the gate. At this time, the gate will fire (conduct) and ringing current is applied to the ringer.

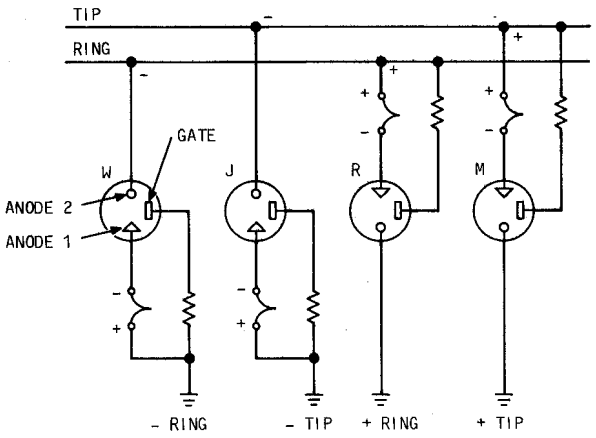


Fig. 10—Four-Party Semiselective Ringing With Electronic Diode Sets

Receiver Off-Hook (ROH)

4.47 ROH tone is an audible tone (at -2.4 dB) which consists of 1400 + 2060 + 2450 + 2600 Hz at 300 IPM. Some systems will provide a recorded announcement to the effect that "the call cannot be completed as dialed and that the customer should hang up and place the call again" before ROH tone is applied. After ROH tone has been applied to the line (40 to 50 seconds), the line will be connected to a permanent signal trunk unless the customer goes on-hook.

5. SIGNALING RANGE LIMITS

5.01 There are many factors involved in the determination of maximum permissible signaling range. Some of these factors include:

(a) Range of supply voltage

(b) Battery feed resistance

(c) Rotary dial pulse receiving range

(d) TOUCH-TONE signaling range

(e) Ringing range

(f) Ringing trip range

(g) Switching system supervisory range.

This section has not been expanded to reflect the complex calculations required for determining signaling range data requirements for the many common applications involved. Data for the common individual applications are provided in the Bell System Practices referenced at the end of this section.

6. CUSTOM CALLING FEATURES

6.01 Where offices are equipped, custom calling features are available to residential customers for an additional charge over residential service. These services are: call waiting, 3-way calling, and call forwarding.

Call Waiting

6.02 This feature allows a calling party to alert a called customer when the called customer is talking to another person. The called customer hears a short burst of tones and the calling party hears audible ringing. By flashing the switchhook, the called customer holds the first call while the second calling party is answered. The called customer can alternate between calls by flashing the switchhook.

3-Way Calling

6.03 This feature enables a customer to add a third party to an established connection. When the third party answers, a private 2-way conversation can be held before bridging the connection (by flashing the switchhook) for a 3-way conference. This feature can be used for both outgoing and incoming calls.

Call Forwarding

6.04 This feature allows a customer to automatically transfer all incoming calls, during the period it is activated, to another telephone. This can be at either the customer's local calling area or to a telephone outside the local calling area involving a toll charge, by dialing special codes from the

originating (base) telephone. Outgoing calls can be made from the base telephone even though a transferred call is in progress.

Hold

6.05 The holding feature on a station set permits the station to hold a line while using another line. Holding is achieved by depressing a hold key on key telephone sets or flashing the switchhook of a station set with custom calling features (if they are provided by the serving office). This signal connects a holding bridge across the line and releases the user from that line.

7. CUSTOMER LOOP SIGNALS USED FOR SPECIAL SERVICES

7.01 Special services are different from residential telephone services because the engineering specifications go beyond ordinary services in respect to transmission signaling and/or customer use. Some of the more common types of special services, such as foreign exchange (FX) lines and PBX-CO trunks, usually follow the same signaling sequences described in this section. Further information on switched special services can be found in Part 9.

Switched Special Services

7.02 A ***foreign exchange line*** provides a direct connection between a station at a customer premises and a serving office other than the serving office which normally would serve that customer location. Further reference to foreign exchange lines is located in Part 9.

7.03 An ***off-premises extension line*** connects an extension station to a main station line. The extension set is at a customer location which is remote from the main station location. The extension line may be bridged at the main station location, but more often the main station line and the extension line are bridged at the central office serving the main station. Further reference to off-premises extension line is located in Part 9.

7.04 ***Secretarial service line*** provides telephone answering service when a customer is not available to answer calls. These lines, similar to off-premises extension lines, bridge the customer line to the secretarial service location and usually terminate in a secretarial service switchboard or console.

8. OPEN SWITCHING INTERVAL PROTECTION

8.01 Open switching interval (OSI) periods are produced by the serving office common control switching equipment and can occur on both incoming calls to and outgoing calls from the customer's station equipment. Certain types of equipment at the customer's premises, eg, keysets, automatic call distributors, data sets, etc, contain circuits which are held operated by battery and ground from the serving office. Each time switching equipment connections are changed at the serving office, such as when switching from common control equipment to an audible ringing circuit, battery and ground is momentarily removed from the customer's line. The resulting unprotected dc open interval is treated as a disconnect signal (4.15 and 4.16) by the customer's equipment and will then terminate the call.

8.02 Open switching interval protection (OSIP) is a feature that connects central office battery and ground to the customer's line to prevent false disconnects during periods when network connections are changed. In general, any customer equipment that cannot tolerate an OSI of at least 350 milliseconds (ms) is subject to false disconnect due to the OSI problem. These open circuit conditions may persist for as long as 350 ms during heavy traffic conditions in the case of No. 5 crossbar. No. 1 and No. 2 ESS offer significantly longer switching intervals. Transmission noise produced by switching connections is also suppressed by the OSIP feature. Sections 231-070-192 and 232-190-206 provide information for OSIP equipment for use with No. 1 and No. 2 ESS offices respectively.

9. REFERENCES

9.01 This section was developed from data obtained from the following references:

SECTION	TITLE
231-090-912	No. 1 Electronic Switching System—Open Switching Interval Protection (OSIP) and Noise Protection
232-190-206	No. 2 Electronic Switching System—Open Switching Interval Protection (OSIP) and Noise Protection

SECTION	TITLE
311-200-180	Description of Circuit Arrangements for Providing Foreign Exchange and Other Special Access Services
500-114-100	Station Ringing Apparatus—Selection and Limitations
781-030-100	Notes on Distant Dialing
800-610-165	Circuit Voltage Limits
812-015-170	Ringing Ranges and Ringing Bridge Limitations for Lines in Dial Offices
814-013-170	Extension of Subscriber Loop Ranges—Engineering Information—Step-By-Step Systems
819-021-170	Range Limits—Customer Lines and Interoffice Trunking—Engineering Information—No. 5 Crossbar System
820-010-170	Signaling Range Limits—No. 1 ESS Engineering Information—Electronic Switching Systems
851-300-100	Transmission Design Considerations and Objectives—Switched Special Services and Private Branch Exchange Services
851-300-165	Standard Design of Switched Special Service Circuits—General DC Signaling Information Customer Line Signaling
851-300-170	Standard Design of Switched Special Service Circuits—Signaling Range Information
851-311-121	Transmission and Signaling Design of Foreign Exchange and Remote Wide Area Telephone Service Lines—Short Haul
851-311-122	Transmission and Signaling Design of Foreign Exchange, Long Distance, and Remote Wide Area Telephone Service Trunks—Short Haul
851-316-111	Transmission and Signaling Design of Off-Premises Station Lines—Long Haul
851-316-122	Transmission and Signaling Design of Foreign Exchange Trunks—Long Haul
951-920-100	TOUCH-TONE Calling
958-110-100	No. 5 Crossbar System—General Descriptive Information
958-120-100	No. 5 Crossbar Centrex Service—General Descriptive Information
966-100-100	2-Wire No. 1 Electronic Switching System—General Description
966-102-100	2-Wire No. 1 and No. 1A—Business Customer Service (Centrex Service and PBX-Co)—General Description
966-120-100	2-Wire No. 1A Electronic Switching System—General Description
966-202-100	Centrex Central Office Service—General Description—No. 2 Electronic Switching System
966-210-100	No. 3 ESS—General Description
984-120-100	Automatic Intercept System—General Description