PUB 42402

Bell System

TECHNICAL REFERENCE

VOICE CONNECTING ARRANGEMENTS CD7, CD8, AND CD9 AND CONNECTING ARRANGEMENT CBF

INTERFACE SPECIFICATION

REVISED MARCH 1974

PUB 42402

Bell System Voice Communications
TECHNICAL REFERENCE

Voice Connecting Arrangements CD7, CD8, and CD9

and

Connecting Arrangement CBF

Interface Specification

Revised MARCH 1974

ENGINEERING DIRECTOR - CUSTOMER TELEPHONE SYSTEMS

NOTICE

This Technical Reference is published by American Telephone and Telegraph Company as a guide for the designers, manufacturers, and consultants of customer-provided systems and equipment which connect with Bell System communications systems or equipment. American Telephone and Telegraph Company reserves the right to revise this Technical Reference for any reason, including, but not limited to, conformity with standards promulgated by ANSI, EIA, CCITT, or similar agencies; utilization of new advances in the state of the technical arts; or to reflect changes in the design of equipment or services described therein. The limits of responsibility and liability of the Bell System with respect to the use of customer-provided equipment and systems are set forth in the appropriate tariff regulations.

This Technical Reference supersedes and replaces Bell System Voice Communications Technical Reference for Voice Connecting Arrangements CD7, CD8, CD9 dated October 1971.

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VOICE CONNECTING ARRANGEMENTS CD7, CD8, CD9 AND CONNECTING ARRANGEMENT CBF

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1. GENERAL

1.1 Introduction

F.C.C. tariffs and corresponding intrastate tariffs filed by the Bell System provide for the electrical connection of customer-provided voice transmitting and receiving terminal equipment and communications systems to Bell System telecommunications network by means of a voice connecting arrangement. The connecting arrangement includes circuit elements to provide network control signaling unit functions as well as certain other network protection functions and is furnished, installed, and maintained by the Telephone Company. In addition, the tariffs require compliance by the customer-provided equipment with certain network protection criteria specified therein.

This Technical Reference is being reissued to include the interface specifications for Connecting Arrangement CBF. Additional text changes have been made to update the Technical Reference but since the basic specifications for Voice Connecting Arrangements CD7, CD8, and CD9 remain the same only significant changes are noted.

1.2 Application

Voice Connecting Arrangements CD7, CD8, and CD9 provide the means for automatically connecting a customer-provided communications system (typically a PBX) to the telecommunications network via loop start trunks to a local, foreign exchange or WATS central office (Fig. 1). These protective connecting arrangements provide dial service using customer-provided dc dial pulse or tone address signaling.

Voice Connecting Arrangement CD7 provides outgoing service only from the attendant's position of the customer-provided PBX.

Voice Connecting Arrangement CD8 provides outgoing service only (typically, "dial 9" local central office service or WATS) from the switching machine of the customer-provided PBX.

Voice Connecting Arrangement CD9 provides two-way (incoming and outgoing) service from the attendant's position of the customer-provided PBX.* It is not recommended that this arrangement be used for outward dial service from the switching machine. The reason for this is that the CD9 uses loop start signaling which has a relatively high probability of simultaneous seizure. In this case, the incoming call is connected to a random station rather than the attendant's position. For two-way dial service, a ground start trunk and Voice Connecting Arrangement CDH is recommended (see Technical Reference PUB 42401 for Voice Connecting Arrangement CDH).

Voice Connecting Arrangements CD7, CD8, and CD9 and their associated trunks are intended for speech and tone address signal transmission only and are not offered for the transmission of data signals. However, with the addition of Connecting Arrangement CBF to these arrangements, the customer is also permitted to transmit data as well as voice signals over those trunks from behind the customer-provided PBX. It should be noted that this does not constitute a data service offering, and, therefore, special conditioning of the trunks for data transmission is not provided. It is recommended that for optimal data transmission performance, direct central office lines bypassing the PBX and the appropriate Bell System data sets or data access arrangements be ordered by the customer.

* Although primarily intended for connection to central office lines, Voice Connecting Arrangement CD9 (CBF does not apply) may also be used for a special tie line application where tariffs permit and facilities are available. In this application, the CD9 is used to connect a trunk from a customer-provided PBX to a line in a Telephone Company-provided PBX. The voice connecting arrangement is required since the customer-provided equipment can gain access to the telecommunications network through the Telephone Company-provided PBX.

1.3 Power Outage Provisions

Voice Connecting Arrangements CD7, CD8, and CD9 and Connecting Arrangement CBF are normally powered by one or more power supplies provided by the Telephone Company which operate from commercial power. Connecting arrangement power outage protection can be provided by a Telephone Company battery back-up system, a customer-provided power supply and battery back-up system using Connecting Arrangement VCP, or a Telephone Company-provided telephone transfer system. These options are described in detail in Technical Reference Notice PUB 42607.

1.4 Ordering and Identification

The protective connection services described in this Technical Reference are identified by the Bell System as Voice Connecting Arrangements CD7, CD8, or CD9 and Connecting Arrangement CBF. One voice connecting arrangement of the desired type should be ordered for each loop start trunk which is to be connected to the customer-provided equipment. One Connecting Arrangement CBF is not sufficient for all trunks; one must be ordered for each of the above voice connecting arrangements and their associated trunks to which a customer-provided data terminal has access and which is intended to be used in addition for data transmission. The local Telephone Company business office or Marketing representative will provide information regarding availability and rates for these services. When ordering service, the customer should specify whether provision is to be made for any of the power outage protection methods described in Paragraph 1.3.

2. DESCRIPTION

2.1 Functions

(A) The major functions of Voice Connecting Arrangements CD7, CD8, and CD9 are:

(1) To protect Telephone Company personnel and facilities from hazardous voltages which may be applied by the customer-provided equipment.

(2) To provide isolation against longitudinal imbalance.

(3) To provide speech transmission to and from the telecommunications network.

(4) To provide for network control signaling to the telecommunications network, including dc dial pulses, on-hook, off-hook, etc.

(5) To permit customer-provided tone address to be transmitted to the central office for translation into network addressing signals (optional service where Telephone Company facilities permit).

(6) To limit abnormally high speech and tone address signal levels from the customer-provided equipment.

(7) To provide for accepting call supervisory signals from customer-provided equipment.

(8) To provide ringing indication to customer-provided equipment for incoming calls (Voice Connecting Arrangement CD9 only).

(9) To provide an indication to the customer-provided equipment that a toll call has been dialed on the trunk (optional service with Voice Connecting Arrangement CD8; only where Telephone Company facilities permit).

(B) The function of Connecting Arrangement CBF when used in conjunction with Voice Connecting Arrangements CD7, CD8, or CD9 is to permit data transmission and to limit average data signal levels from the customer-provided equipment.

2.2 Physical

Voice Connecting Arrangements CD7, CD8, and CD9 each consist of one 8-inch printed wiring board per line equipped and a mounting arrangement (Fig. 2). Connecting Arrangement CBF consists of one of six circuits mounted on a separate 8-inch printed wiring board. These boards are mounted typically in a panel which mounts in an apparatus cabinet or on a relay rack and accommodates up to 14 arrangements

for voice-only application and 12 for voice/data applications. When power is supplied by the Telephone Company, the associated 24-volt rectifier power supply requires a grounded outlet connection to a non-switched, customer-furnished, nominal 117 ±12 volt, 60 ±1 Hz source, fused at 15 amperes. The protective connecting arrangements will function satisfactorily within a temperature range of 0° to 55° C and a relative humidity range of 5 to 95 percent.

2.3 Interface Leads

The number of interface leads per circuit that are normally provided from Voice Connecting Arrangements CD7, CD8, or CD9 to the Interface Connecting Block for the customer's use varies accordingly to the particular arrangement (Fig. 1). Technical information pertaining to these leads is discussed in Section 3.

The leads and their functions are as follows:

Lead Designation	Function
CT, CR	Speech transmission and tone address signaling (data transmisssion available only with Connecting Arrangement CBF)
CS, CG	Service request, answer/disconnect, and dc dial pulsing
C1, C2	Incoming ringing (CD9 only)
CRV1, CRV2	Toll call indicator (optional where such service is available-CD8 only)

Leads from these protective connecting arrangements will be terminated on a Telephone Company-provided Interface Connecting Block conveniently located to permit testing, maintenance, trouble isolation, and ease of connection to the customer-provided equipment. The customer must provide and install the conductors and make the necessary connections of his equipment to the voice connecting arrangement at this block.

A typical Interface Connecting Block is shown in Fig. 3. This "quick connect" type "66" connecting block utilizes tin plated spring clip terminal strips which accommodate unstripped, insulated conductors of 20 to 26 gauge. A Reliable Electric R714B Tool or equivalent is used to press the insulated wire down into the slot. The spring pressure of the clip cuts away the insulation and makes the electrical connection. The Telephone Company will provide bridging clips between the second and third terminals of the block to interconnect the leads. The clips should be removed by the customer's representative when it is necessary to test toward the customer-provided equipment and then replaced to restore the circuit to service.

The customer-provided equipment must be located so that the maximum external loop resistance, including contact resistance, across the CS and CG leads measured at the block shall not exceed 100 ohms* when indicating a closure.

3. OPERATION

3.1 Incoming Call From the Central Office

On an incoming call from the central office (Voice Connecting Arrangement CD9 only), the connecting arrangement will detect incoming ringing and provide a contact closure over the C1 and C2 leads to the customer-provided equipment (Fig. 4). The closure is held during the ringing interval of the ringing cycle and is released during the silent interval. Since line signal transients, noise, and other conditions can cause false operation of the ring detection circuitry, customer-provided equipment should be designed to ignore closures on the C1 and C2 leads of less than 100 milliseconds.* When the call is answered at the attendant's position of the customer-provided system, the customer-provided equipment shall provide a contact closure across the CS and CG leads. The connecting arrangement responds by signaling the central office to trip the ring and cuts through the transmission path over the CT and CR leads.

*Changed from previous issue

3.2 Outgoing Call to the Central Office

On an outgoing call to the central office (from the attendant's position of the customer-provided system for Voice Connecting Arrangements CD7 and CD9 and from the switching machine of the customer-provided system for Voice Connecting Arrangement CD8), the customer-provided equipment shall provide an off-hook indication by closing a contact across the CS and CG leads. This closure causes the connecting arrangement to seize the line to the central office and cut through the talking path over the CT and CR leads. When the central office is ready to receive dc dial pulses or tone address signals, dial tone is returned on the CT and CR leads. The customer can then transmit dc dial pulse information over the CS and CG leads which is repeated to the central office by the network control circuitry in the connecting arrangement. If the customer subscribes to TOUCH-TONE® service from the serving central office, the customer may optionally transmit tone address signals over the CT and CR leads or utilize the CS and CG leads for dc dial pulse address signals.

As an optional service with Voice Connecting Arrangement CD8 (when available in the serving central office), a contact closure will be provided over the CRV1 and CRV2 leads when a toll call has been dialed. The closure may be momentary (at least 50* milliseconds duration) or continuous depending upon the central office. Closures of a duration less than 50 milliseconds should be ignored. With this service, the customer-provided equipment may disconnect from the arrangement and divert the call to the customer-provided announcement equipment or to his switchboard attendant in order to prevent call completion.

3.3 Disconnect

A disconnect by the customer-provided equipment (removing the contact closure on the CS and CG leads) will restore the arrangement and subsequently the central office trunk to the idle condition.

*Changed from previous issue

A disconnect by the distant party is not relayed by the voice connecting arrangement to the customer-provided equipment. If the customer-provided equipment does not disconnect after the distant party has disconnected, the serving central office, after a period of time which varies according to the type of office, will assume that a new call is being initiated and return dial tone to the customer-provided equipment over the CT and CR leads.

4. SPECIFIC DESIGN CONSIDERATIONS

4.1 Transmission Path (Leads CT and CR)

4.11 Insertion Loss and Signal Limiting

The insertion loss of Voice Connecting Arrangement CD7, CD8, or CD9 is a nominal 1 dB over the voice-frequency range of 300 to 3000 Hz. No voice signal amplification is provided. A voice signal limiter is incorporated in the transmission path of the voice connecting arrangements to protect the telecommunications network from applications of abnormally high signal levels. This has no effect on normal voice or normal tone address signal levels.

Connecting Arrangement CBF provides a special data limiter circuit which continuously monitors the data (or speech) signal level passing through the associated voice connecting arrangement. In the event this level becomes high enough to exceed the preset threshold for power averaged over a 3-second interval, the limiter circuit activates and linearly attenuates the signals in both directions so as to limit the signals to the threshold value. This value is set so as to provide adequate enforcement of the specified signal power protection criteria. When the signal power level is reduced to below the threshold, Connecting Arrangement CBF returns to the passive monitor mode in which condition it adds approximately 0.1 dB insertion loss. Although loud talkers may invoke the limiter causing a noticeable signal loss at the distant end, subjective tests have shown that this limiting does not degrade voice quality for most talkers.

These limiters do not abrogate the customer's responsibility to meet the network protection criteria, as prescribed in the tariffs and as outlined in Paragraph 4.15.

4.12 Impedance

Voice Connecting Arrangements CD7, CD8, and CD9 are transformer-coupled to the line and, while the impedance of the CT and CR leads is a function of the impedance of the line to the central office, for design purposes, the input impedance of these arrangements should be considered to be 600 ohms. Therefore, the impedance of the customer-provided equipment likewise should be 600 ohms for optimum speech or data transmission performance.

The data limiter circuit in Connecting Arrangement CBF controls excessive signal power by shunting the line with an impedance which varies inversely as the power in excess of the threshold level.

4.13 Bandwidth

The normal voice-frequency bandwidth of the telecommunications network extends from about 300 to 3000 Hz. In general, an end-to-end connection may be expected to have a loss characteristic which increases on either side of this band. These voice connecting arrangements do not limit this bandwidth.

4.14 Envelope Delay Distortion

The combination of Voice Connecting Arrangements CD7, CD8, or CD9 and Connecting Arrangement CBF introduces a delay distortion over the frequency band from 500 to 3000 Hz of less than 75 microseconds which is small with respect to that encountered in the telecommunications network.

4.15 Signal Power Levels

The tariffs state that the average power (in any 3-second interval) delivered at the central office should not exceed -12 dBm in order to prevent excessive noise and crosstalk from interfering with other services. To meet this specification for voice-only applications using Voice Connecting Arrangements CD7, CD8, and CD9 alone, the maximum available power from a customer-provided source when averaged over any 3-second interval (measured at the CT and CR leads with a 600 ohm load substituted for the connecting arrangement) should not exceed -9 dBm. This limit has been set so that when the average loss of PBX trunks in the Bell System are considered (including the insertion loss of the voice connecting arrangement), the limit of -12 dBm at the local central office will be met.

When Connecting Arrangement CBF is used with Voice Connecting Arrangements CD7, CD8, and CD9, the maximum permissible speech and data signal power from the customer-provided equipment will be set by the Telephone Company and will range between -5 dBm and -11 dBm depending on the loss of the line between the connecting arrangement and the central office. The maximum input signal power level to the arrangement will be posted at the Interface Connecting Block for the customer's information.

Using measuring Method A (see Paragraph 4.16), the power averaged over any 3-second interval, can, in almost all cases, be found for speech by subtracting 93 dB from the maximum meter swing and for data by subtracting 90 dB. With the additional damping of measuring Method B, the power averaged over any 3-second interval can be found by using a 91 dB correction for speech and 90 dB for data.

4.16 Measuring Maximum Available Inband Power

The measuring methods described below are satisfactory for estimating the maximum power averaged over a 3-second interval to determine that the inband signal power criterion specified in Paragraph 4.15 is being met.

Method A

Operate the customer-provided equipment into a 600 ohm load (this assumes that the customer-provided equipment has a 600 ohm source impedance), bridged by a Hewlett-Packard Transmission and Noise Measuring Set — Model 3555B, or a Western Electric 3-Type

Noise Measuring Set, or the equivalent.* To ensure a proper measurement technique, the control settings on these meters should be as shown below.

Western Electric 3-Type
Noise Measuring Set

Control	Setting
FUNCTION (Switch)	BRDG
NORM/DAMP (Switch)	DAMP
WTG (Plug-in Network)	3Kc FLAT

Hewlett-Packard Transmission
and Noise Measuring Set
Model 3555B

Control	Setting
INPUT (Switch)	NOISE/BRDG
FUNCTION (Pushbutton)	VF/Nm-600 BAL
NOISE WTG (Switch)	3kHz FLAT
NORM/DAMP (Switch)	DAMP

Method B

The accuracy of Method A can be somewhat improved by increasing the size of the damping capacitance in the Western Electric 3-Type Noise Meter by 150 microfarads. To do this, connect the negative lead of a 150 microfarad capacitor to either terminal of the NORM/DAMP switch and connect the positive lead to ground. This allows the meter to more nearly approximate a 3-second averaging meter. (NOTE: This modification does not necessarily hold for the Model 3555B or noise meters other than the Western Electric 3-Type.)

* These meters do not have a 3-second averaging time but, when used to measure speech or data signals, they give a reliable estimate of a 3-second average. The use of meters with shorter time constants, such as VU meters or standard voltmeters, is not recommended.

4.17 Signal Power Distribution

The telecommunications network incorporates tone signaling devices that are used for interface network control functions. These devices, which are connected at all times to the telephone circuit, are designed to detect a single-frequency tone at 2600 Hz. They are, however, relatively insensitive to energy at this frequency if sufficient energy is present at the same time at other frequencies in the voiceband.

In order to prevent the interruption or disconnection of a call, or interference with network control signaling, it is necessary that the signal applied by the customer-provided equipment to the voice connecting arrangement at no time have energy solely in the 2450 to 2750 Hz band. If signal power is in the 2450 to 2750 Hz band, it must not exceed the power present at the same time in the 800 to 2450 Hz band.

4.18 Out-of-Band Signal Power Limits

To protect other services, it is necessary that the signal which is applied by the customer-provided equipment to the Telephone Company interface, located on the customer's premises, meet the following limits:

(a) The power in the band from 3995 Hz to 4005 Hz shall be at least 18 dB below the signal level specified in Paragraph 4.15.

(b) The power in the band from 4000 Hz to 10,000 Hz shall not exceed 16 dB below one milliwatt.

(c) The power in the band from 10,000 Hz to 25,000 Hz shall not exceed 24 dB below one milliwatt.

(d) The power in the band from 25,000 Hz to 40,000 Hz shall not exceed 36 dB below one milliwatt.

(e) The power in the band above 40,000 Hz shall not exceed 50 dB below one milliwatt.

4.19 Tone Address Signaling

When TOUCH-TONE service has been ordered by the customer, Voice Connecting Arrangements CD7, CD8, and CD9 permit customer-provided tone address signals to be transmitted to a central office TOUCH-TONE

receiver for the purpose of network address signaling. The signaling code for the Bell System TOUCH-TONE calling system provides for 16 distinct signals. Each signal is composed of two voiceband frequencies, one from each of two mutually exclusive frequency groups of four frequencies each. The signal frequencies are spaced and selected on the basis that the two frequencies of any valid signal combination are not harmonically related. The frequency pairs assigned for the signaling are as follows:

		Nominal High Group Frequencies (Hz)			
		1209	1336	1477	1633
Nominal	697	1	2	3	Spare
Low Group	770	4	5	6	Spare
Frequencies	852	7	8	9	Spare
(Hz)	941	*	0	#	Spare

In order for the central office receiver to properly register the digits, the tone address signals shall meet the following requirements (measured by the customer into a 600 ohm test termination on the CT and CR leads at the interface):

1. Signal Levels

   Nominal level per frequency: -6 to -4 dBm

   Minimum level per frequency — Low Group: -10 dBm; High Group: -8 dBm

   Max. difference in levels between frequencies: 4 dB

   Max. level per frequency pair: +2 dBm

2. Frequency Deviation

   Tone frequencies should be within ±1.5 percent of their nominal values.

3. Extraneous Frequency Components

   The total power of all extraneous frequencies accompanying the signal should be at least 20 dB below the signal power, in the voiceband above 500 Hz.

4. Voice Suppression

   Voice energy from the telephone transmitter or other source should be suppressed (e.g., the transmitter should be muted) at least 45 dB during tone signal transmission. In the case of automatic dialing the suppression should be maintained continuously until pulsing is completed.

5. Rise Time

   Each of the two frequencies of the signal should attain at least 90 percent of full amplitude within 5 ms, and preferably within 3 ms for automatic dialers, from the time that the first frequency begins.

6. Pulsing Rate

   Minimum duration of two-frequency tone signal: 50 ms

   Minimum interdigital time: 45 ms

   Minimum cycle time (period): 100 ms

7. Tone Leak

   Tone leak during signal off time should be less than -55 dBm.

8. Transient Voltages

   Peak transient voltages generated during tone signaling should be no greater than 12 dB above the zero-to-peak voltage of the composite two-frequency tone signal.

4.2 DC Signaling Paths

4.21 Service Request Path

The CS and CG leads will provide a means of answering an incoming call, initiating an outgoing call, and transmitting dc dial pulse information to the voice connecting arrangement from the customer-provided equipment which should provide a dry contact closure, e.g., dc isolation from foreign potentials. The CS lead has a maximum

potential of 26 volts dc through 5830* ohms. The CG lead is grounded at the voice connecting arrangement but cannot be used by the customer to ground his equipment.

The CS and CG leads will offer the customer-provided equipment a maximum noninductive load of 5* milliamperes. The minimum open circuit insulation resistance of the customer-provided dry contact between the CS and CG leads, and from either lead to ground, should be 100,000 ohms. When indicating a closure, the maximum external loop resistance including contact resistance across the CS and CG leads measured at the Interface Connecting Block toward the customer-provided equipment shall not exceed 100* ohms.

The dc dial pulses shall be generated on the CS and CG leads at a nominal rate of 10 pulses-per-second, with a minimum of 8 pulses-per-second and a maximum of 11 pulses-per-second (see Fig. 5). The percent break should be a minimum of 50 percent and a maximum of 64 percent. The minimum interdigital time must be 600 milliseconds.

4.22 Signal Alerting Path

The C1 and C2 leads with Voice Connecting Arrangement CD9 provide a contact closure to the customer's equipment during the ringing interval of the central office ringing cycle on an incoming call. The closure is opened during the silent interval. However, line signal transients, noise, and other conditions can cause false operation of the detection circuitry. Therefore, the customer-provided equipment should be designed to ignore closures on these leads of less than 100 milliseconds. The customer's equipment load on the C1 and C2 leads shall not exceed 250 milliamperes, noninductive. The maximum voltage which may be applied by the customer-provided equipment is 50 volts RMS. The customer's equipment shall provide appropriate contact protection.

* These figures are changes from the previous values as a result of improved equipment design.

4.23 Toll Call Indicator Path (Optional)

The CRV1 and CRV2 leads with Voice Connecting Arrangement CD8 provide a momentary (minimum 50** milliseconds) or continuous contact closure, depending on the type of central office, to the customer-provided equipment when the central office has determined that a toll call (as defined by the Telephone Company) has been dialed. Closures of shorter duration should be ignored. This is an optional service which is available from certain Telephone Company central offices and, where available, the requirement for this service must be specified by the customer. Because availability cannot be guaranteed, it is recommended that the customer-provided communications system be equipped to provide internal toll call indication. The customer's equipment load on the CRV1 and CRV2 leads shall not exceed 250 milliamperes, non-inductive. The maximum voltage which may be applied by the customer-provided equipment is 50 volts RMS. The customer's equipment shall provide appropriate contact protection.

4.3 Grounding

Voice Connecting Arrangements CD7, CD8, and CD9 are provided with a common signal ground (a metallic cold water pipe or other approved ground) which is always bonded to the electric power ground and telephone protector ground, where present. Although the CG lead is grounded at the protective connecting arrangement, it is not permitted to use this lead to derive the main ground for the customer's equipment. The general grounding requirements for the customer-provided equipment are covered in Paragraph 5.2.

5. GENERAL DESIGN CONSIDERATIONS

5.1 Foreign and Surge Voltage Protection

Where telephone lines are exposed to foreign voltages by direct contact or induction (e.g., power line crosses or lightning), protective devices are installed at the central office and on the customer's premises. Typically, these

** Changed from previous issue

devices will provide a path to ground for foreign voltages that exceed about 600 volts peak. Since the customer's equipment is connected to the telephone line through the voice connecting arrangement, the customer's equipment is protected from any resulting longitudinal surges. Residual metallic surges on the transmission leads due to foreign potentials will be limited by the protective connecting arrangement to no greater than 30 volts.

The customer is responsible for providing protection, internal to his equipment and facilities, against foreign and hazardous voltages from his equipment and facilities being applied to the voice connecting arrangement.

5.2 Grounding

It is expected that the customer's equipment will be grounded in accordance with applicable electrical codes, e.g., National Electrical Code (NEC), and where required should be bonded to the ground electrode to which the telephone protector is grounded but not using the telephone ground clamp. Provisions should be made within the customer's equipment for connecting together all internal signal grounds. This connection shall be isolated from both the grounding (green) conductor run with the power supply primary conductors and the chassis or frame of the customer-provided equipment.

The customer's signal ground may be obtained with a proper connection to a metallic cold water pipe, using a single No. 14 AWG, or larger copper conductor. The other end should be connected to the ground return terminal of the customer's equipment. The run should be short, straight, and a continuous piece of wire. Proper attention should be given to providing the lowest possible resistance connection at each end of the circuit. It is imperative that this ground be connected at the same location to the water piping system or ground electrode as the telephone protector or signal ground lead but not using the Telephone Company ground clamp. This lead shall not be fused.

5.3 Telecommunications Network Characteristics

5.31 End-to-End Electrical Loss

The end-to-end electrical loss of a connection is a function of the impedances of both end terminations and the losses of the interoffice trunks, the serving central offices, and the facilities to the serving offices. The information found in the REFERENCES in Appendix B may be used to determine statistical loss distributions for different types of calling patterns on the telephone network.

5.32 Nonlinearities

Nonlinearities such as compression, clipping, phase shift, and harmonic distortion can exist on the telecommunications network. Normally, these are insignificant for speech transmission. It is expected that harmonic distortions caused by the network will result in single tones which are no greater than about 5% of the fundamental.

6. SERVICE AND MAINTENANCE CONSIDERATIONS

6.1 Responsibility of the Customer

The tariffs regulating the connection to the telecommunications network by means of connecting arrangements of customer-provided terminal equipment or communications systems state that where long distance message telecommunications service is available under these tariffs for use in connection with customer-provided terminal equipment or communications systems, the operating characteristics of such equipment or systems shall be such as not to interfere with any of the services offered by the Telephone Company. Such use is subject to the further provisions that the equipment or systems provided by a customer do not endanger the safety of Telephone Company employees or the public; damage, require change in or alteration of, the equipment or systems or other facilities of the Telephone Company; interfere with the proper functioning of such equipment or systems or facilities; impair the operation of the telecommunications network or otherwise injure the public in its use of the Telephone Company's services. Upon notice from the Telephone Company that the equipment or

system provided by a customer is causing or is likely to cause such hazard or interference, the customer shall take such steps or make such change as shall be necessary to remove or prevent such hazard or interference.

6.2 Responsibility of the Telephone Company

The tariffs regulating the connection to the telecommunications network by means of connecting arrangements of customer-provided terminal equipment and communications systems state that the Telephone Company shall not be responsible for the installation, operation or maintenance of said terminal equipment or communications systems. Long distance message telecommunications service is not represented as adapted to the use of customer-provided equipment or systems and where such equipment or systems are connected to Telephone Company facilities, the responsibility of the Telephone Company shall be limited to the furnishing of facilities, including the protective connecting arrangements and network control signaling units, suitable for long distance message telecommunications service and to the maintenance and operation of such facilities in a manner proper for such services. Subject to this responsibility the Telephone Company shall not be responsible for (i) the through transmission of signals generated by the customer-provided equipment or systems or for the quality of, or defects in, such transmission, (ii) the reception of signals by customer-provided equipment or systems, or (iii) address signaling where such signaling is performed by customer-provided tone-type signaling equipment. The Telephone Company shall not be responsible to the customer if changes in minimum network protection criteria contained in the tariffs (and in this Technical Reference) or in any of the facilities, operations or procedures of the Telephone Company render any customer-provided facilities obsolete or require modification or alteration of such equipment or systems or otherwise affect its use or performance.

6.3 Trouble Reporting Procedure

When trouble is experienced with this service, the customer should perform the necessary testing at the interface to sectionalize the difficulty, i.e., determine whether the service impairment is located in the customer-provided equipment or in the equipment provided by the Telephone Company. If the tests indicate that the trouble is in the Telephone Company-provided equipment, it should be promptly reported to the Telephone Company. Trouble reports should be called into the listed "Repair Service" number which can be found in the front of the telephone directory. The repair attendant should be given:

(a) Customer's name
(b) Customer's address
(c) Listed telephone number
(d) Uniform Service Order Code (USOC) if known (e.g., CD7, CD8, CD9, CBF)
(e) Description of the trouble
(f) Customer's contact for additional information

If a Telephone Company service call results in the location of the trouble in the customer-provided equipment, the customer will be charged for the service call.

APPENDIX A
GLOSSARY

ADDRESS SIGNALS — denotes dc dial pulses or appropriate pairs of tone signals transmitted to a central office that represent the telephone number of the distant party.

COMMUNICATIONS SYSTEM — denotes channels and other facilities which are capable, when not connected to the Long Distance Message Telecommunications Service, of communications between customer-provided terminal equipment or Telephone Company stations.

CONNECTING ARRANGEMENT — protective equipment provided by the Telephone Company to accomplish the electrical connection of customer-provided equipment with the telecommunications network.

CUSTOMER — the term "Customer" denotes the person, firm or corporation which orders service and is responsible for the payment of charges and compliance with Telephone Company regulations.

CUSTOMER-PROVIDED TERMINAL EQUIPMENT — denotes devices or apparatus and their associated wiring, provided by a customer, which do not constitute a communications system and which, when connected to the communications path of the telecommunications network, are so connected either electrically, acoustically, or inductively.

DIAL PULSE RATE — repetition of pulses for switching purposes, usually expressed in pulses-per-second.

INTERDIGITAL TIMING — the minimum time required between digits for the switching equipment to respond to the last digit received and ready itself for receiving the next digit.

INTERFACE CONNECTING BLOCK — the Telephone Company-provided connecting point to which the customer brings and connects the leads of his equipment and to which the Telephone Company brings and connects leads from the protective voice connecting arrangement.

NETWORK CONTROL SIGNALING — denotes the transmission of signals used in the telecommunications network which perform functions such as supervision (control, status, and charging signals), address signaling (dialing), calling and called number identification, audible tone signals (call progress signals indicating reorder or busy conditions, alerting, coin denominations, coin collect and coin return tones) to control the operation of switching machines in the telecommunications network.

NETWORK CONTROL SIGNALING UNIT — denotes the terminal equipment furnished, installed, and maintained by the Telephone Company for the performance of network control signaling. (See Note)

OFF-HOOK SUPERVISION — the conditioning of the SERVICE REQUEST leads by the customer-provided equipment which indicates a customer's telephone is answering or originating a call.

ON-HOOK SUPERVISION — the conditioning of the SERVICE REQUEST leads by the customer-provided equipment which indicates that the customer's telephone has disconnected or that the equipment is idle.

PERCENT BREAK — the period of time of an open interval in a dial pulse sequence compared to the total time of an open and closed interval, expressed as a percentage.

SUPERVISORY SIGNALS — signals used to initiate a request for service by the calling party (off-hook); to notify the called party that he is being called (ringing); to indicate an answered call (off-hook); to indicate a disconnect (on-hook); and to recall an operator or distant party to a connection (switchhook flash).

TELECOMMUNICATIONS NETWORK —central office dial switching equipment, associated interoffice and intraoffice facilities, and terminal equipment which provide Long Distance Message Telecommunications Service or private line service.

TELEPHONE COMPANY — denotes the American Telephone and Telegraph Company, the Long Lines Department, its concurring carriers, and its connecting carriers, either individually or collectively.

VOICE CONNECTING ARRANGEMENT — a protective connecting arrangement designed primarily to transmit speech signals as contrasted to one designed primarily to transmit data signals.

NOTE: Under the tariff regulations, the terms "connecting arrangement" and "network control signaling unit" are separate and distinct from each other, however, the term "connecting arrangement" is generally used to include the functions of network control signaling.

APPENDIX B

REFERENCES

Some references describing various transmission characteristics of the telecommunications network are listed below:

*(a) McAdoo, K.L., "Speech Volumes on Bell System Message Circuits — 1960 Survey," Bell System Technical Journal (BSTJ), Vol. 42, No. 5 (September 1963), p. 1999.

*(b) Gresh, P.A., "Physical and Transmission Characteristics of Customer Loop Plant," BSTJ, Vol. 48, No. 10 (December 1969), p. 3337.

*(c) Breen, C., and Dahlbom, C.A., "Signaling Systems for the Control of Telephone Switching," BSTJ, Vol. 39, No. 6 (November 1960), p. 1381.

*(d) Bodle D.W., and Gresh, P.A., "Lightning Surges in Paired Telephone Cable Facilities," BSTJ, Vol. 40, No. 2 (March 1961), p. 547.

**(e) Bell System Data Communications Technical Reference — PUB 41007 — 1969-1970 Switched Telecommunications Network Connection Survey (Reprints of Bell System Technical Journal articles) — April 1971.

**(f) Bell System Data Communications Technical Reference — PUB 41008 — Analog Parameters Affecting Voiceband Data Transmission — Description of Parameters — October 1971.

***(g) "Principles of Electricity Applied to Telephone and Telegraph Work," by American Telephone and Telegraph Company, New York, New York.

***(h) "Switching Systems," by American Telephone and Telegraph Company, New York, New York.

(i) "Notes on Transmission Engineering," by United States Independent Telephone Association, Washington, D.C.

***(j) "Transmission Systems for Communications," by Bell Telephone Laboratories, Inc.

***(k) "Notes on Distance Dialing — 1968," by American Telephone and Telegraph Company, New York, New York.

*These journals may be purchased by writing to:

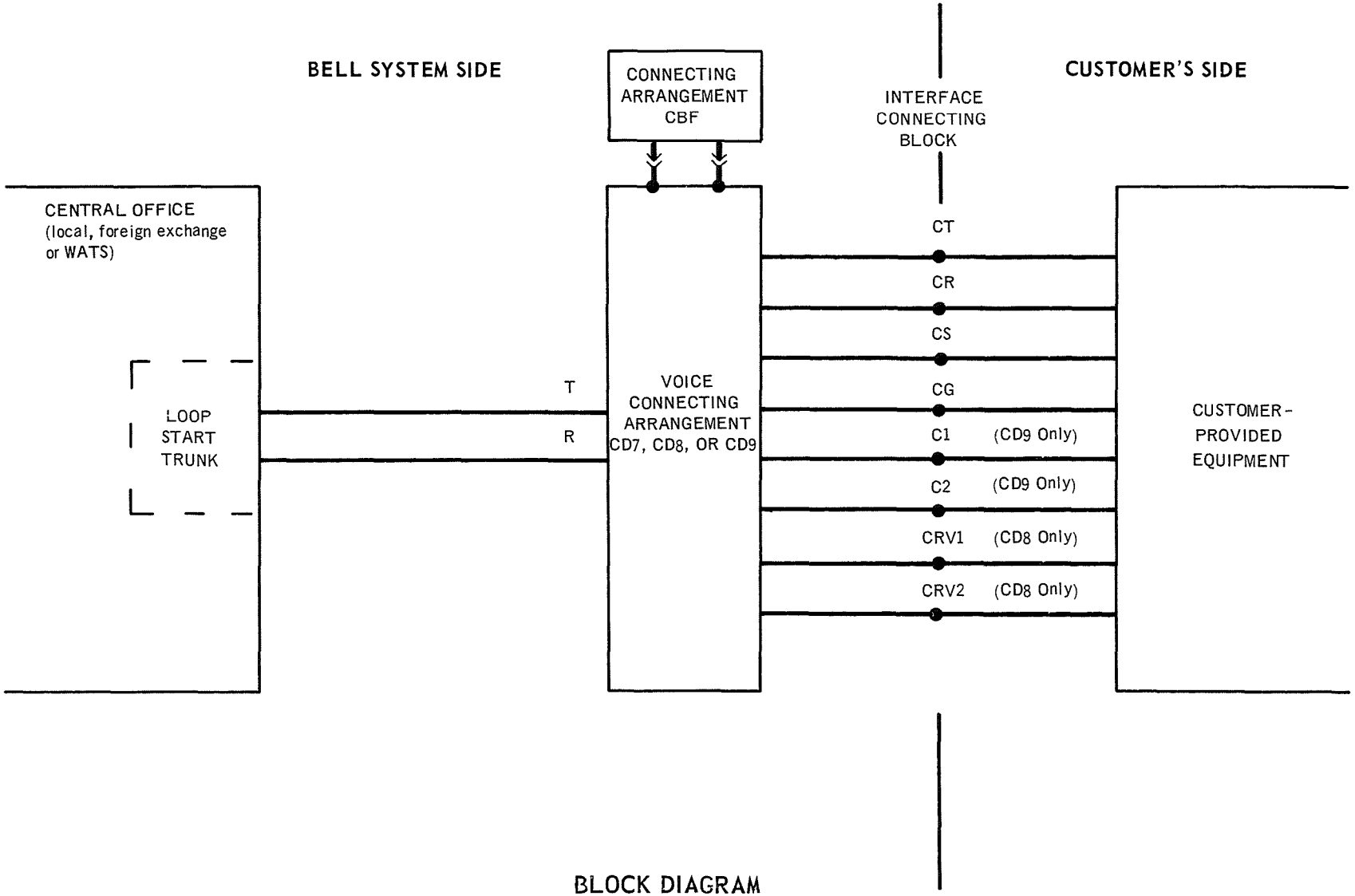
Bell Telephone Laboratories, Inc.
Circulation Supervisor
Mountain Avenue, Room 3C109
Murray Hill, New Jersey 07974

**These references may be purchased by writing to:

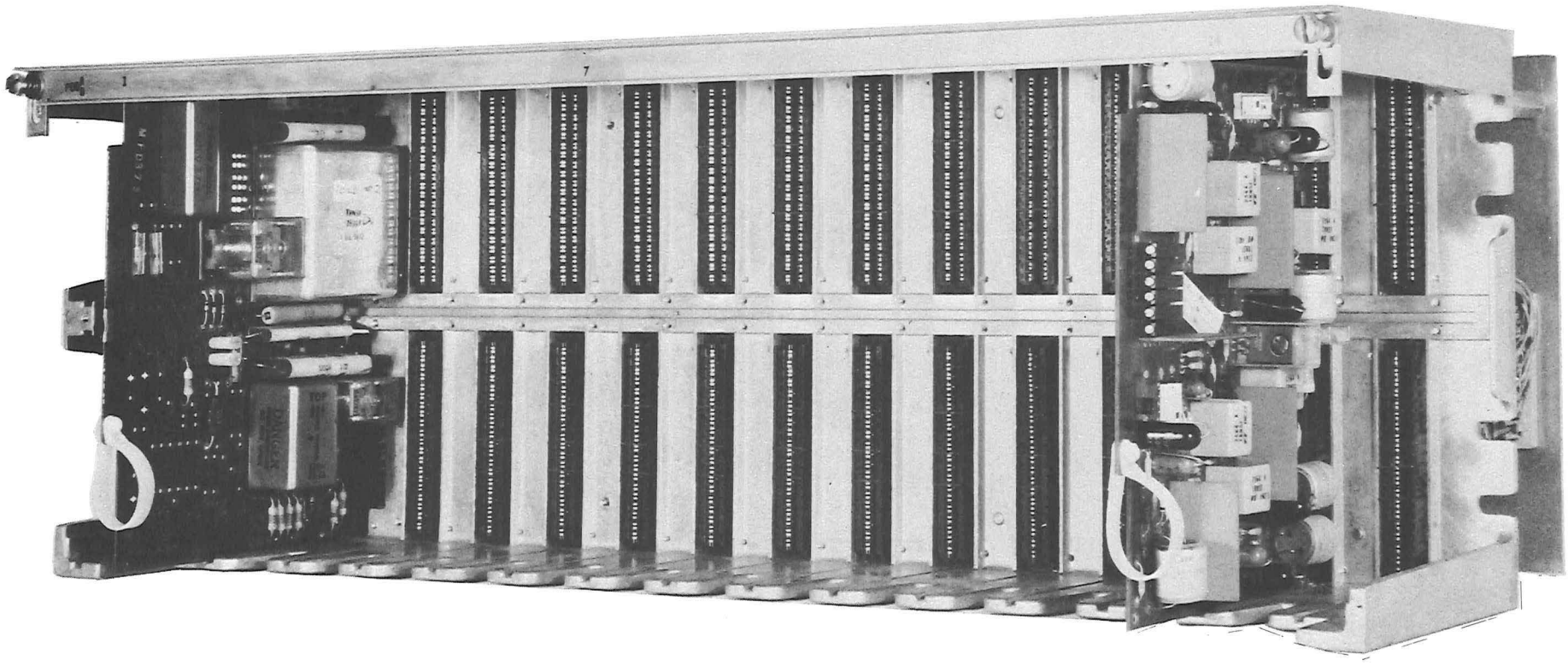
American Telephone and Telegraph Company
Supervisor — Information Distribution Center
195 Broadway, Room 208
New York, New York 10007

***These publications may be purchased by writing to:

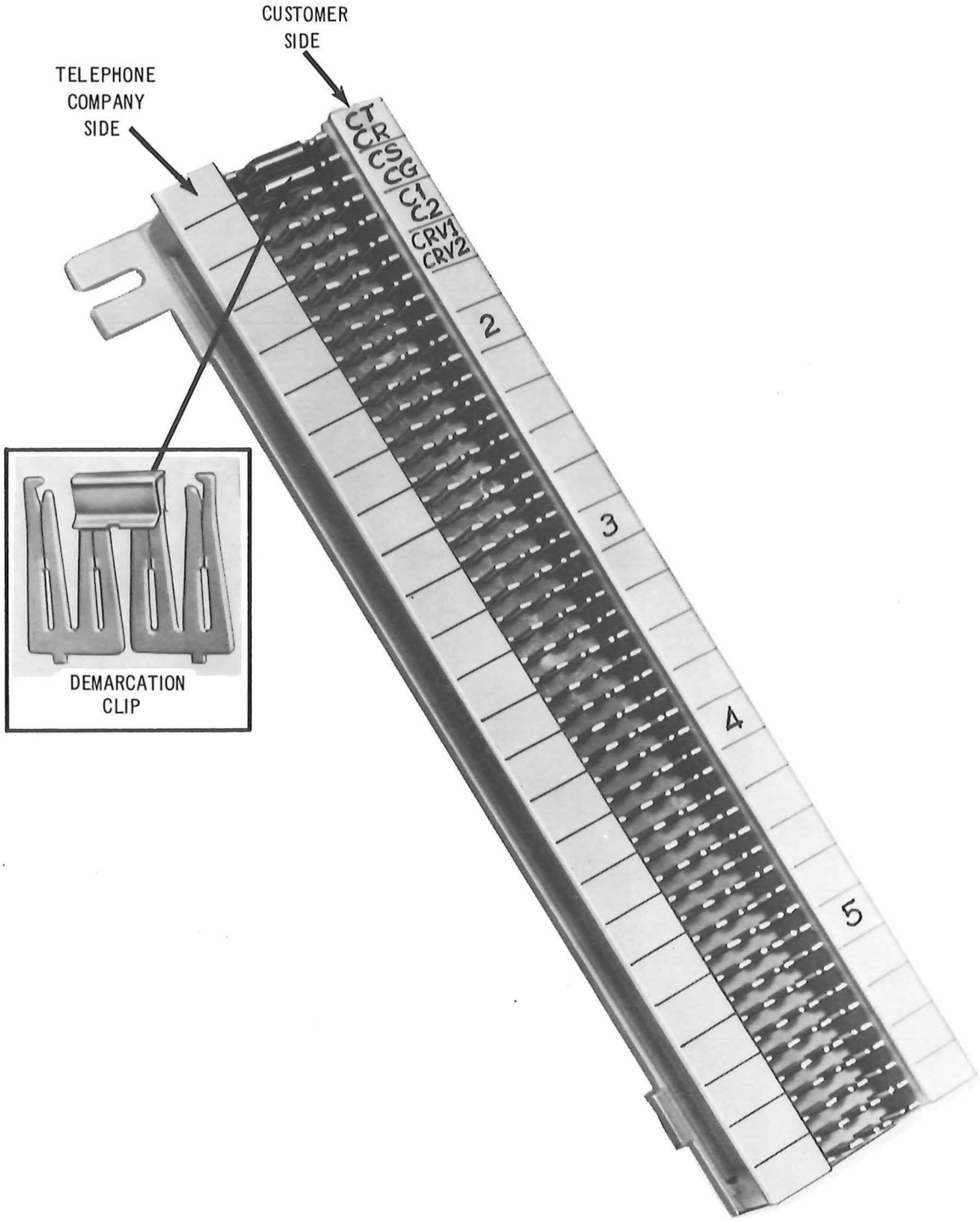
Western Electric Company, Inc.
Commercial Relations
P.O. Box 1579
Newark, New Jersey 07102



BLOCK DIAGRAM
VOICE CONNECTING ARRANGEMENT CD7, CD8,
AND CD9 AND CONNECTING ARRANGEMENT CBF
FIG. 1

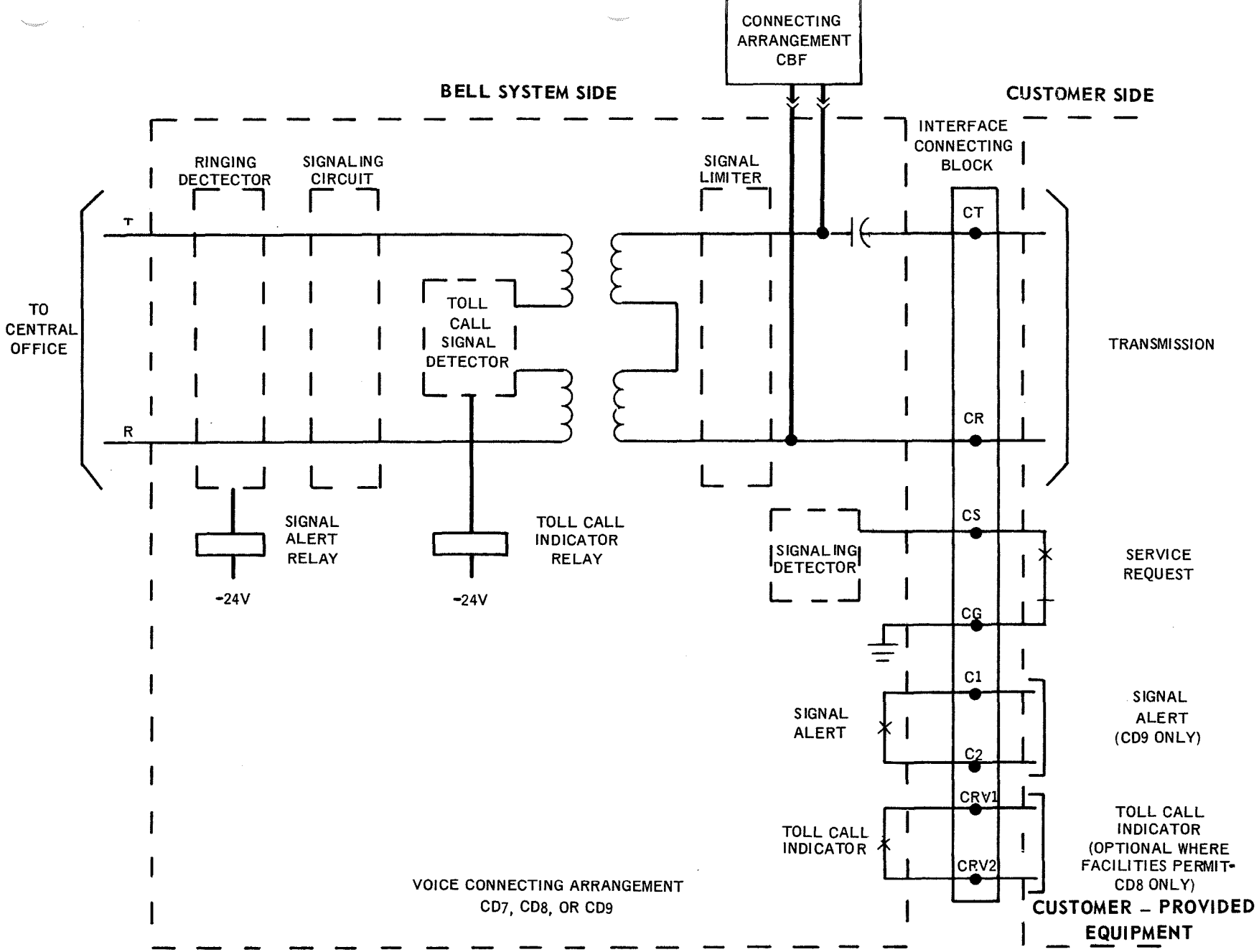


TYPICAL MOUNTING ARRANGEMENT FOR VOICE
CONNECTING ARRANGEMENTS CD7, CD8, AND CD9
AND CONNECTING ARRANGEMENT CBF
FIG. 2



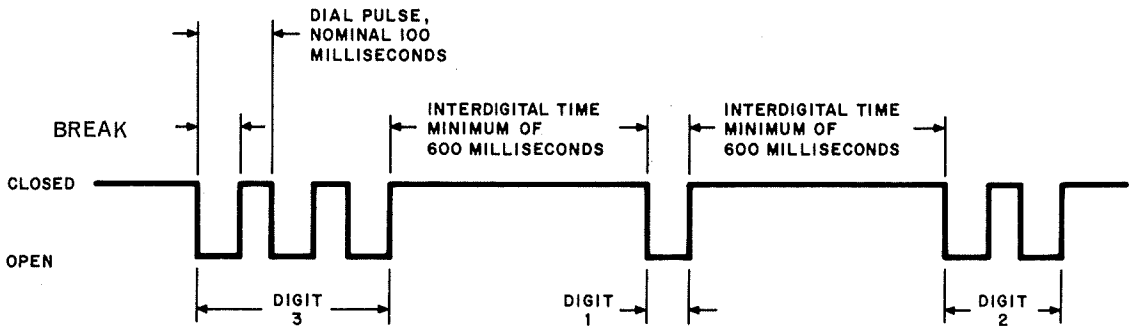
TYPICAL INTERFACE CONNECTING BLOCK

FIG.3



SIMPLIFIED SCHEMATIC
VOICE CONNECTING ARRANGEMENTS CD7, CD8 AND CD9 AND CONNECTING ARRANGEMENT CBF
FIG. 4

TYPICAL PATTERN OF DIAL PULSES EXPECTED
FROM CUSTOMER-PROVIDED EQUIPMENT
OVER LEADS CS AND CG (DIALING NUMBER 312)



DIAL PULSE RATE – NOMINAL 10 PULSES PER SECOND (8 MIN. – 11 MAX.)
PERCENT BREAK – (50 MIN. – 64 MAX.)
INTERDIGITAL TIME – MINIMUM OF 600 MILLISECONDS

DIAL PULSE CHARACTERISTICS
FIG. 5