PUB 42304

PRELIMINARY

Bell System Voice Communications
TECHNICAL REFERENCE

Voice Connecting Arrangement CD1

Interface Specification

July 1969

ENGINEERING DIRECTOR - CUSTOMER TELEPHONE SYSTEMS

PRELIMINARY

NOTICE

This Technical Reference is specifically intended for the developers and designers of telephone voice communications systems and equipment which interface with the Bell System telecommunications network and for technical consultants to use in designing communications systems and arrangements requiring connections to the Bell System telecommunications network. The right to revise this Technical Reference for any reason, including conformity with USASI, EIA, CCITT or other standards, to utilize new advances in the state of the technical arts, or to reflect changes in the design of the equipment and/or service described herein, is expressly reserved.

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PREFACE

The material in this Technical Reference is intended for use by designers and manufacturers of telephone equipment who expect to connect their communications equipment to the Bell System telecommunications network. This material covers guides which, if followed, should permit the transmission and reception of voice signals without interference to other Telephone Company services.

The responsibility of the Bell System with respect to the use of customer-provided equipment is set forth in the appropriate Tariff regulations.

In furnishing this material, the Bell System Telephone Companies make no claim or representations and assume no responsibility, beyond that set forth in the Tariff regulations, for the suitability of the transmission path or the performance of the telecommunications system. The Bell System is in no way responsible for the design, performance, installation, operation, or maintenance of the communications systems, or equipment provided by others which are connected to the telecommunications network and does not endorse or approve any such system or equipment. The material in this Technical Reference is furnished in the interest of preventing interference to other Telephone Company services and users, and is not furnished with the intent to provide complete design specifications or parameters, or to assure the quality or performance of customer-provided telephone systems and equipment.

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LIST OF FIGURES

1. GENERAL

F.C.C. Tariff No. 263 and corresponding intrastate Tariffs filed by the Bell System provide for the connection of customer-provided voice transmitting and receiving terminal equipment and communications systems to the Bell System telecommunications network. Direct electrical connection is made through a voice connecting arrangement furnished, installed, and maintained by the Telephone Company. They also provide for the indirect (acoustic or inductive) connection of such equipment or systems.

In addition, the Bell System retains responsibility for network control signaling. This includes the switchhook, dialing and control functions, as well as the protective function of voice signal limiting and isolation of Central Office battery from the customer-provided equipment.

For new or additional service, contact your local Telephone Company business office or Marketing representative. For ready identification, the Telephone Company describes this service as Voice Connecting Arrangement CD1.

2. SYSTEM DESIGN CONSIDERATIONS

2.1 Voice Connecting Arrangement CD1

Voice Connecting Arrangement CD1 (Fig. 1) provides 2-wire, manual access to the Bell System telecommunications network from a customer-provided PBX equipped with a cord switchboard. Supervision is not provided with this arrangement. It is arranged to handle voice-only calls in either direction.

The attendant at the customer-provided PBX uses the Voice Connecting Arrangement CD1 to provide network control functions. One key per circuit provides the following: (1) In the IDLE position, opens the transmission path; (2) In the DIAL position, inserts a dial into the transmission path to the Central Office; (3) In the TALK position, opens the dialing path and closes the transmission path through the voice-coupler circuit.

2.2 Service and Maintenance Considerations

2.21 Responsibility of the Customer

The Tariffs permitting direct electrical connection of customer-provided communications systems state that:

> Where long distance message telecommunications service is available under this Tariff for use in connection with customer-provided communications systems, the operating characteristics of such 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 customer-provided systems do not endanger the safety of Telephone Company employees or the public; damage, require change in or alteration of, the equipment or other facilities of the Telephone Company; interfere with the proper functioning of such equipment or facilities; impair the operation of the telecommunications system or otherwise injure the public in its use of the Telephone Company's services. Upon notice from the Telephone Company that the customer-provided system is causing

or is likely to cause such hazard or interference the customer shall make such change as shall be necessary to remove or prevent such hazard or interference.

2.22 Responsibility of the Telephone Company

The Tariffs permitting direct electrical connection of customer-provided communications systems that:

The Telephone Company shall not be responsible for the installation, operation or maintenance of any customer-provided terminal equipment. Long distance message telecommunications service is not represented as adapted to the use of customer-provided equipment and where such equipment is connected to Telephone Company facilities the responsibility of the Telephone Company shall be limited to the furnishing of facilities suitable for long distance message telecommunications service and to the maintenance and operation of such facilities in a manner proper for such telecommunications service; 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 for the quality of, or defect in, such transmission, or (ii) the reception of signals by customer-provided equipment.

The Telephone Company shall not be responsible to the customer or otherwise if changes in the criteria contained

in the Tariffs and Paragraph 5 of this Technical Reference, or in any of the facilities, operations or procedures of the Telephone Company render any customer-provided equipment obsolete or require modification or alteration of such equipment or otherwise affect its use or performance.

2.23 Trouble Reporting Procedure

Even though there is an adequate maintenance operation for service, there will be occasions when trouble is experienced with this service. When this occurs the customer should perform the necessary testing to sectionalize the difficulty by opening the circuit at the Interface Connecting Block and testing only toward the customer-provided equipment. If the tests indicate the trouble is in the Telephone Company-provided equipment, it should be promptly reported to the Telephone Company. Trouble reports should be called to 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) Description of the trouble.

(e) Customer's contact for additional information.

2.3 Foreign and Surge Voltage Protection

Where telephone lines are exposed to lightning, power circuit contact, or induction, protective devices are installed at the Central

Office and on the customer's premise that 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 longitudinal surges by transformer isolation. The maximum surge between conductors CT and CR due to foreign potential that the customer's equipment should encounter is 30 volts.

The customer is responsible for providing protection, internal to his equipment and facilities, against surge and hazardous voltages from his equipment and facilities being applied to the voice connecting arrangement. The surge potential on the conductors CT and CR shall be limited to 30 volts.

2.4 Hazardous Voltage Limitations

When it is necessary for the customer to apply an operational voltage to facilities interconnected with telephone facilities, certain voltage limitations shall be observed. These limitations are for the purpose of providing adequate protection to personnel and plant facilities, unless otherwise specified in Paragraphs 4.2 and 4.3 of this Technical Reference, steady-state voltages applied by the customer's equipment to conductors connected to the Voice Connecting Arrangement CD1 should not exceed the following:

	dc	ac (RMS)
Maximum voltage, any conductor to ground	135	50
Maximum voltage, conductor to conductor	(135 (270*	(50 (100*

* Permitted only if voltage source is centered-tapped to ground.

The power supplies and wiring methods used in the customer-provided equipment should meet the provisions of the National Electrical Code (NEC), Article 725, for Class 2 remote control and signal circuits.

3. DESCRIPTION OF VOICE CONNECTING ARRANGEMENT CD1

3.1 Physical

Voice Connecting Arrangement CD1 is a console approximately 9 inches wide, 24 inches long, and 6 inches high. It should be located in close proximity to the attendant of the customer-provided equipment. This arrangement will function satisfactorily within a temperature range of 0^{o} to 55^{o}C and a humidity range from 5 to 95 percent. Leads from this arrangement are terminated on a Telephone Company-provided interface connecting block (Fig. 2) conveniently located to permit testing, maintenance, trouble isolation, and ease of connection to the customer's equipment. The interface connecting block must be located within 25 feet of the voice connecting arrangement.

3.2 Functions

The major functions of this voice connecting arrangement are:

(a) To provide voice-only access to and from the switched telecommunications network.

(b) To provide network control signaling to the network.

(c) To limit abnormally high voice signal voltages.

(d) To provide dc isolation to customer-provided equipment.

(e) To provide for signal alerting to the customer-provided equipment.

3.3 Originating and Receiving a Call

3.31 Outgoing Call Toward the Central Office

When a customer-provided station signals the attendant and requests service on a Telephone Company Central Office line, the attendant plugs the associated cord into an idle Central Office line jack. The attendant then operates the associated level key on the console from the IDLE position to the DIAL position. When dial tone is heard the attendant dials the desired number using the dial on the console. After dialing is completed the attendant operates the associated lever key to the TALK position. This connects the customer-provided station to the Telephone Company Central Office line through the voice-coupler circuit. The attendant must then determine, by monitoring from time to time, that the call has been terminated. When the call is terminated the attendant removes the cords and operates the lever key on the console to the IDLE position, restoring the circuit to normal.

3.32 Incoming Call from the Central Office

Ringing current over the Central Office line operates a realy in the Telephone Company ringup circuit. The relay, which follows the ringing sequence, provides a contact closure over the SIGNAL ALERT leads (C1, C2) to the customer-provided equipment. The attendant plugs a cord into the jack associated with the incoming signal and operates the associated lever key on the console from the IDLE to the TALK position. This trips the ring and connects the attendant to the line through the voice-coupler circuit. The attendant then

completes the call to the customer-provided station in the usual manner. The attendant must then determine, by monitoring from time to time, that the call has been terminated. When the call is terminated, the attendant removes the cords and operates the lever key on the console to the IDLE position, restoring the circuit to normal.

3.4 Interface Leads

Four interface leads per Central Office trunk circuit are provided from Voice Connecting Arrangement CD1 to an interface connecting block for termination of customer-provided equipment. Technical information pertaining to these leads is discussed in Paragraph 4, ELECTRICAL CHARACTERISTICS. The first pair designated CT and CR provides the two-way voice transmission path between the voice connecting arrangement and the customer-provided equipment. The second pair designated C1 and C2 provides a means of alerting the attendant at the customer-provided equipment of an incoming call from the Telephone Company Central Office.

3.5 Method of Connection

The leads from the Voice Connecting Arrangement CD1 will be terminated by the Telephone Company in a terminal box equipped with the interface connecting block (Fig. 2). The customer or his representative will make the necessary connections to associate his equipment with the voice connecting arrangement at this terminal box. The leads from the voice connecting arrangement will be terminated on studs of an interface connecting block mounted in the box. Separate

nuts and washers on the same studs will be provided for the customer's connections. These will be designated as follows:

Lead Designation	Function
CT CR	voice pair
C1 C2	signal alert pair
2	designates second circuit
3	designates third circuit

4. ELECTRICAL CHARACTERISTICS

4.1 General

The insertion loss of the Voice Connecting Arrangement CD1 is approximately 1 dB over the voice frequency range of 300 to 3000 Hz. The customer's equipment must furnish its own talk and signal battery. No voice signal amplification is provided by this arrangement.

4.2 Transmission Path - Leads designated CT and CR

4.21 Voice Signal Limiter

A voice signal limiter is incorporated in the transmission path to protect the Bell System telecommunications network from applications of abnormally high signal levels. This has no effect on normal voice signal levels.

This limiter does not remove the customer's responsibility to meet the network protection criteria as prescribed in the Tariffs and as outlined in Paragraph 5 of this Technical Reference.

4.22 Transmission Parameters

Voice Connecting Arrangement CD1 provides a one-to-one impedance transformation. For design purposes, the impedance of the customer-provided equipment should be 600 ohms. The voice signal levels must comply with the applicable Tariffs. The Tariffs permitting electrical connection of customer-provided communications systems state:

> "To prevent excessive noise and crosstalk in the network, it is necessary that the power of the signal at the Central Office not exceed 12 dB below one milliwatt when averaged over any 3-second interval. To insure that this limit is not exceeded the power of the signal which may be applied by the customer-provided equipment to the Telephone Company interface located on the customer's premises will be specified for each type of connecting arrangement, but in no case shall it exceed one milliwatt."

For the Voice Connecting Arrangement CD1 the maximum permissable voice signal power at the interface connecting block is -9 dBm when averaged over any 3-second interval.

4.23 DC Voltages

The maximum dc voltages across terminals CT and CR or from ground to CT or CR, measured at the interface connecting block, shall not exceed 100 volts. The dc signals from customer-provided equipment are blocked by a capacitor in the voice-coupler.

4.3 Signal Alert Path - Leads designated C1 and C2

These leads provide a contact-closure from the Telephone Company ringup circuit each time the Central Office rings during an incoming call. Nominally the rings will be 2 seconds in duration with a silent interval of 4 seconds. The contact will have a nominal 5 ohms dc resistance measured at the interface connecting block when the contact is closed.

Current must be limited to a maximum of 0.5 amperes. With the contact open the maximum peak voltage across the C1 and C2 leads shall not exceed 200 volts. The contact is not equipped with an arc suppression network.

4.4 Grounding

In general, it is desirable to have some circuit ground path in the customer's equipment which connects to the voice connecting arrangement. A direct or resistive ground on one side of the power supply would be an example of such a path. This practice avoids the possibility of the entire circuit involved being at an indeterminate potential with respect to ground. Such a potential, perhaps as a result of electrostatic induction, could result in an insulation breakdown in this arrangement. It is expected that the customer's equipment, if powered from commercial power, will be grounded in accordance with applicable electrical codes (NEC) and should be bonded to the telephone protector ground electrode when available. Self-powered or passive customer's equipment need not be grounded. One side of the customer's ringing generator supply, when provided, should be grounded.

Voice Connecting Arrangement CD1 is provided with a ground which is always bonded to the cold water pipe or other ground approved by the NEC serving as the electric power ground and telephone protector ground (where present).

As an example, a good ground may be obtained with a proper connection to a metallic cold water pipe, using a single No. 6 copper AWG conductor. The other end should be connected to the ground return terminal of the customer's equipment. The run should be short, straight, and if possible, 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 as the telephone protector or signal ground. A preferable connecting point is on the same pipe where grounding terminal of the telephone protector is present. This lead shall not be fused.

5. POWER AND IMPEDANCE CONSIDERATIONS FOR CUSTOMER-PROVIDED EQUIPMENT

5.1 Average Power at the Central Office

The average power (in any 3-second interval) delivered to a 900 ohm resistive load at the Central Office should not exceed -12 dBm. The limitations described in 5.2 and 5.3 below, on power at the customer's location have been set to meet an average of -12 dBm when all loops in the Bell System are considered.

5.2 Maximum Available Power

The Central Office power criterion, in 5.1 above, can be satisfied by limiting the maximum available power* from a customer-provided 600 ohm source to -9 dBm when averaged over any 3-second interval. The customer-provided communications systems should be so designed that the average power over any 3-second interval applied to the interface block associated with Voice Connecting Arrangement CD1 does not exceed -9 dBm. The recommended procedure for estimating the power is given in Paragraph 6.

5.3 Signaling Considerations

The telecommunications network incorporates tone signaling devices that are used for network control functions. These devices, connected at all times to the telephone circuit, are designed to be sensitive to single frequency tones at 2600 Hertz. They are, however, relatively insensitive to energy at this frequency if sufficient energy is present at the same time as 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 Hertz band. If signal power is in the 2450 to 2750 Hertz band, it must not exceed the power present at the same time in the 800 to 2450 Hertz band.

*The available power of a source is the maximum power that the source can deliver to a load. Maximum power transfer occurs when the load and source impedances are matched.

5.4 Out-of-Band 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 Hertz to 4005 Hertz shall not exceed 27 dB below one milliwatt.

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

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

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

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

5.5 Internal Impedance

The source impedance of the customer's equipment should be approximately 600 ohms.

6. TESTING AND MEASURING METHODS

6.1 Measuring Maximum Available Power

The following measuring method is satisfactory for estimating the maximum power averaged over a 3-second interval to determine that the inband criterion is being met:

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 Telephone Test Meter 3555B, a Western Electric 3C (3A) Noise Measuring Set, or the equivalent.* The meter FUNCTION switch should be in the BRIDGE position, the slide switch marked DAMP/NORM in the DAMP position, and 3 kHz flat weighting should be used. In almost all cases the speech power averaged over any 3-second interval will not exceed -9 dBm if the maximum meter swing does not exceed 84 dBrn.

The accuracy of this method can be somewhat improved by increasing the size of the damping capacitance in the Western Electric 3C or 3A Noise Meter by 150 micro-farads. To do this connect the negative lead of a 150 micro-farad 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 noise meters other than the Western Electric 3C or 3A.) With the additional damping the power averaged over any 3-second interval will not exceed -9 dBm if the maximum meter swing does not exceed 82 dBrn. The use of meters with shorter time constants, such as a VU meter or a standard voltmeter, is not recommended.

7. TELECOMMUNICATIONS NETWORK CHARACTERISTICS

7.1 Transmission Parameters

Information describing the component parts and operating characteristics of the Bell System telecommunications network has been published. Various articles have discussed statistical information

*These meters do not have a 3-second averaging time, but when used on speech they give a reliable estimate of a 3-second average.

on talker volumes (a), end-office losses and noise (b-d), loop characteristics (e), and other characteristics (f-h). These articles are listed in Paragraph 8. In addition, five general information texts are listed.

The 1000 Hertz insertion loss for this voice connecting arrangement (with a customer's communication device having a 600 ohm source impedance) and its associated loop will average about 3 dB with a standard deviation of about 1 dB.

7.2 End-to-End Electrical Loss

The end-to-end electrical loss of a connection is a function of the impedances of both end terminations, the losses of the loops at both ends, and the end-office loss. The information given in the references may be used to determine statistical loss distributions for different types of calling patterns on the telephone network.

7.3 Bandwidth and Frequency Response

The nominal voice frequency bandwidth of the telecommunications network is about 300 to 3000 Hertz. In general, and end-to-end connection may be expected to have a loss characteristic which increases with increasing frequencies in the upper half of the band. This voice connecting arrangement does not limit this bandwidth.

7.4 Nonlinearities

Nonlinearities such as compression, clipping, and harmonic distortion can exist on the telecommunications network. Normally, these are low enough to be ignored. It is expected that total harmonic distortions no greater than about 5 percent of the fundamental will normally be encountered.

8. 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," Bell System Technical Journal, 42, No. 5 (September 1963), p. 1999.

(b). Nasell, I., "The 1962 Survey of Noise and Loss on Toll Connections," BSTJ, 43, No. 2 (March 1964), p. 697.

(c). Nasell, I., "Some Transmission Characteristics of Bell System Toll Connections," BSTJ, 47, No. 6 (July-August 1968), p. 1001.

(d). Nasell, I., Ellison, C. R., and Homstrom, R., "The Transmission Performance of Bell System Intertoll Trunks," BSTJ, 47, No. 8 (October 1968), p. 1561.

(e). Hinderliter, R. G., "Transmission Characteristics of Bell System Subscriber Loop Plant," IEEE Transactions, Communications and Electronics, September 1963, p. 464.

(f). Alexander, A. A., Gryb, R. M., and Nast, D. N., "Capabilities of the Telephone Network for Data Transmission," BSTJ, 39, No. 3 (May 1960), p. 431.

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

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

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

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

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

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

(*m). "Transmission Systems for Communications" by Bell Telephone Laboratories.

*Available through Graybar Electric Company.

9. GLOSSARY*

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

CONNECTING ARRANGEMENT - Voice Connecting Arrangement CD1 provided by the Telephone Company to accomplish the direct electrical connection of customer-provided facilities with the facilities of the Telephone Company and to connect the transmission path from the customer-provided equipment to the telecommunications system.

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

END-OFFICE - the last serving Central Office in the switching hierarchy of the telecommunication network.

INTERFACE CONNECTING BLOCK - the Telephone Company furnished connecting point to which the customer brings and connects the leads of his equipment.

*May differ in letter from exact wording as used in the Tariffs.

NETWORK CONTROL SIGNALING - the transmission of signals used in the telecommunications system 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 re-order or busy condition, alerting, coin denominations, coin collect and coin return tones) to control the operation of switching machines in the telecommunications system.

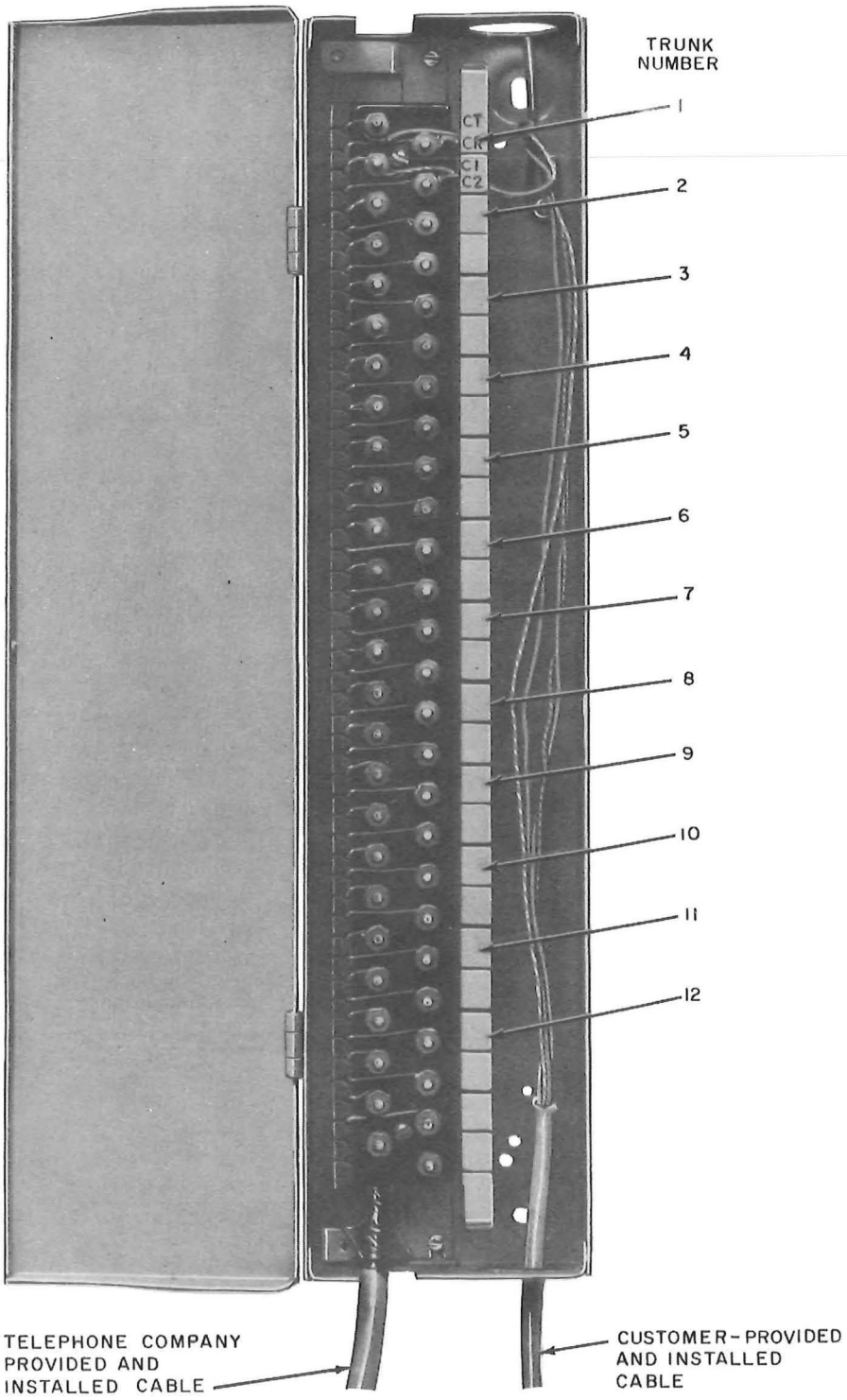
NETWORK CONTROL SIGNALING UNIT - the Bell System console furnished, installed and maintained by the Telephone Company for the provision of network control signaling used with the Voice Connecting Arrangement CD1.

TELECOMMUNICATION NETWORK - the Bell System voice switching equipment, associated interconnecting facilities and station equipment which connects its subscribers together.

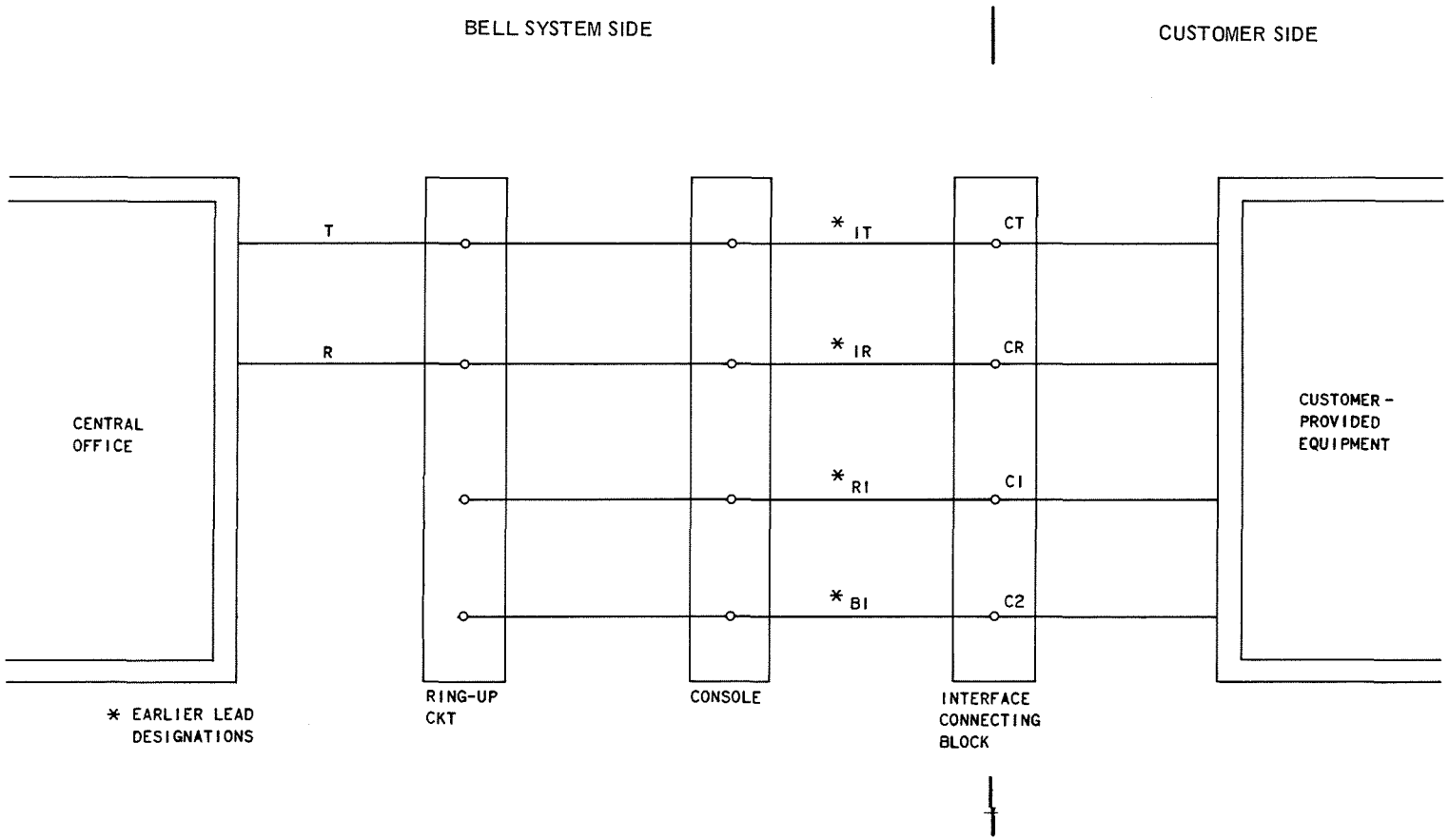
TELEPHONE COMPANY - denotes the American Telephone and Telegraph Company, the Long Lines Department, its concurring carriers and its connecting carriers, either individually or collectively.

VOICE COUPLER - the part of Voice Connecting Arrangement CD1 which connects the transmission path from the customer-provided equipment to the telecommunications network.

VOICE CONNECTING ARRANGEMENT CDI
FIG. 1



INTERFACE CONNECTING BLOCK
FIG. 2



BLOCK DIAGRAM – VOICE CONNECTING ARRANGEMENT CDI
FIG. 3

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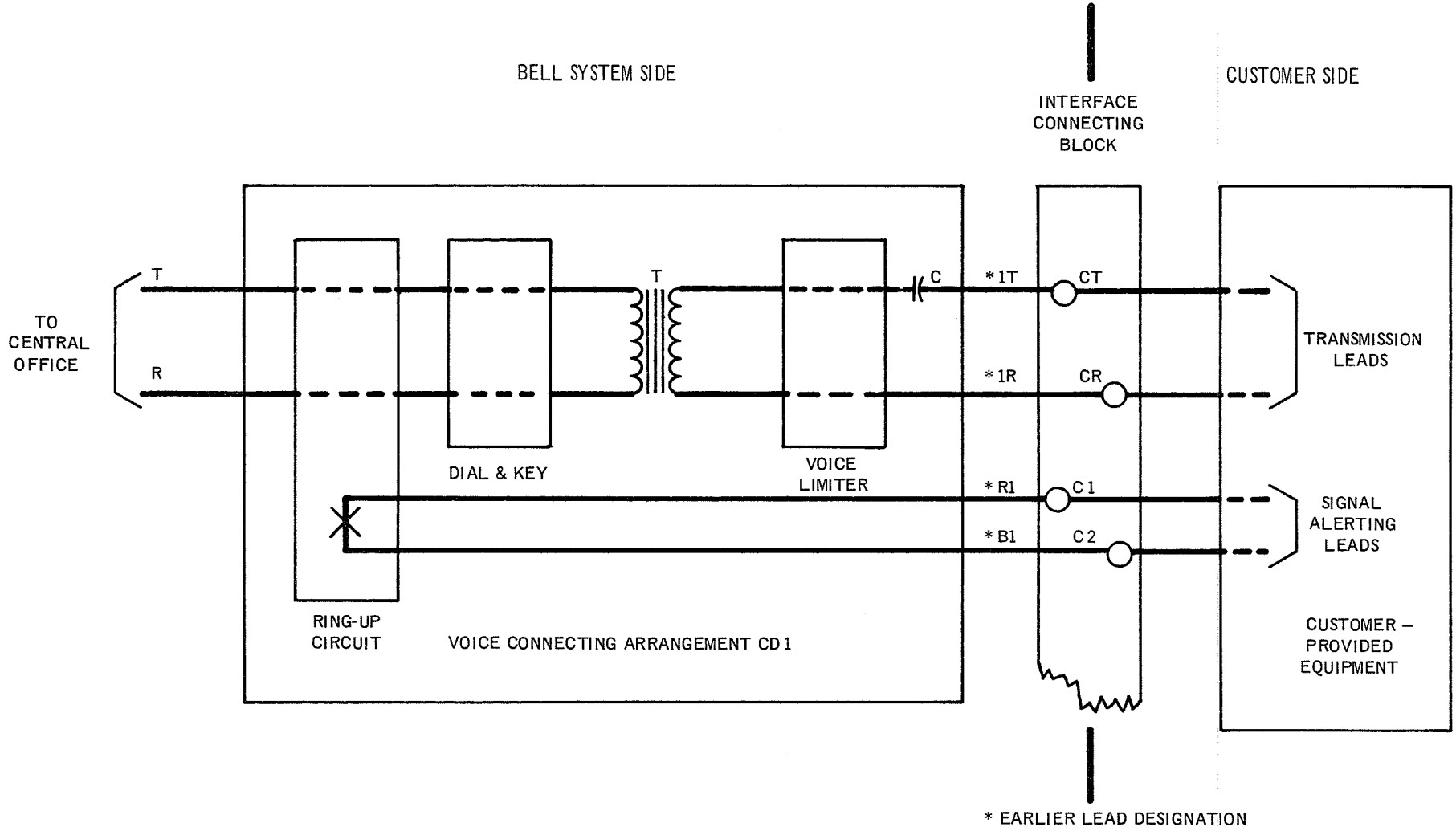

SIMPLIFIED SCHEMATIC – VOICE CONNECTING ARRANGEMENT CD1

Fig. 4

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