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PRELIMINARY

Bell System Voice Communcations
TECHNICAL REFERENCE

Voice Connecting Arrangement CD6

Interface Specification

December 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.

If further information is required, please contact:

Engineering Director - Customer Telephone Systems
American Telephone and Telegraph Company
195 Broadway
New York, New York 10007

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 as set forth in the appropriate Tariff regulations.

In furnishing this material, the Bell System Telephone Companies make no claims 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.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

LIST OF FIGURES

1. GENERAL

F.C.C. Tariff No. 263 and corresponding intrastate Tariffs filed by the Bell System, provide for the direct 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. The Tariffs 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 CD6.

2. SYSTEM DESIGN CONSIDERATIONS

2.1 Voice Connecting Arrangement CD6

Voice Connecting Arrangement CD6 (Fig. 1) provides a means for automatically connecting the telecommunications network to a customer-provided one-way incoming PBX attendant circuit. This arrangement is arranged to handle incoming calls and provides voice-only frequency coupling. A talking path is established over the transmission leads. A pair of leads will be provided to the customer in order to give a

ringing indication of an incoming call by means of a dry contact. It is necessary for the customer to provide dry contacts for off-hook indication over one pair of leads.

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 state that:

> The Telephone Company shall not be responsible for the installation, operation or maintenance of any customer-provided communications systems. Long distance message telecommunications service is not represented as adapted to the use of customer-provided systems and where such systems are 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 systems or for the quality of, or defects in, such transmission, or (ii) the reception of signals by customer-provided systems.
>
> The Telephone Company shall not be responsible to the customer or otherwise if changes in minimum network protection 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 facilities obsolete or require modification or alteration of such equipment or otherwise affect its use or performance.

2.23 Trouble Reporting Procedure

When trouble is experienced with this service, 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 that 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 premises 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 the transmission leads that the customer's equipment may encounter due to foreign potential is 30 volts.

The customer is responsible for providing protection, internal to his equipment and facilities, against foreign and surge voltages from his equipment and facilities being applied to the voice connecting arrangement. The surge potential on the transmission leads shall be limited to 30 volts. The surge potential on the other conductors shall be limited to 600 volts peak between conductors or from one conductor to ground.

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, and unless otherwise specified in Paragraphs 4.2 and 4.3 of this Technical Reference, steady-state voltages applied by customer-provided equipment to conductors connected to Voice Connecting Arrangement CD6 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 center-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 CD6

3.1 Physical

Voice Connecting Arrangement CD6 (Fig. 1) is mounted by the Telephone Company in a panel that will accommodate a maximum of 18 of these arrangements. Each panel requires a connection to a customer-provided nominal 110 volts, 60 Hz power source separately fused at 15 amperes. This arrangement will function satisfactorily within a temperature range of 0° to 55°C and a humidity range of 5 to 95 percent. Leads from this arrangement will be 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-provided equipment. The customer-provided equipment must be located so that the maximum external loop resistance across the CS and CG leads measured at the Interface Connecting Block shall not exceed 70 ohms when indicating a closure.

3.2 Functions

The major functions of this voice connecting arrangement are:

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

(b) To limit abnormally high voice signal voltages.

(c) To provide dc isloation to the customer-provided equipment and protect personnel from hazardous voltages.

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

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

3.3 Incoming Call from the Central Office

When Voice Connecting Arrangement CD6 is seized by the Central Office, an alerting signal (contact closure) which follows the Central Office ringing is transmitted to the customer-provided equipment over the SIGNAL ALERT leads C1 and C2 (Figs. 3 and 4). To answer the call, the customer-provided equipment provides a contact closure that connects the SUPERVISORY leads CS and CG together. This closure trips ringing and initiates cut-through of the talking path via the voice-coupler over the TRANSMISSION leads CT and CR. A disconnect by the customer-provided equipment (removing the contact closure on leads CS and CG) will restore the circuit to the idle condition.

3.4 Interface Leads

Six interface leads per circuit are provided from Voice Connecting Arrangement CD6 to the Interface Connecting Block (Fig. 2) for the customer's use. Technical information pertaining to these leads is discussed in Paragraph 4. The first pair, designated CT and CR (TRANSMISSION), provides the voice transmission path from the voice connecting arrangement. The second pair, designated CS and CG (SUPERVISORY) provides for the function of answering an incoming call. The third pair, designated C1 and C2 (SIGNAL ALERT), provides for the function of alerting on an incoming call.

The customer must provide and install the conductors from the customer-provided equipment to the Interface Connecting Block. This block will accept leads of 18 gauge wire or smaller.

3.5 Method of Connection

Leads from Voice Connecting Arrangement CD6 will be terminated by the Telephone Company on the Interface Connecting Block. The customer or his representative must provide and install the conductors from the customer-provided equipment to the Interface Connecting Block and make the necessary connections to associate his equipment with the voice connecting arrangement at the block using 18 gauge wire or smaller. The leads will be designated as follows:

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

4. ELECTRICAL CHARACTERISTICS

4.1 General

The insertion loss of Voice Connecting Arrangement CD6 is a nominal 1 dB over the voice frequency range of 300 to 3000 Hz. No voice signal amplification is provided.

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 CD6 provides a one-to-one impedance transformation. The impedance is a function of the design of the connection between the voice connecting arrangement and the Central Office. For design purposes, input impedance of the voice connecting arrangement should be considered as 600 ohms and, therefore, the impedance of the customer-provided equipment should also be 600 ohms. The voice signal levels must comply with the applicable Tariffs. The Tariffs permitting electrical connection of customer-provided communications systems state that:

> "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 Voice Connecting Arrangement CD6, the maximum permissible 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 leads 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 connecting arrangement.

4.3 Signaling Paths

4.31 Supervisory Path

The SUPERVISORY leads (CS and CG) must be a dedicated pair and will provide a means of answering an incoming call. To answer an incoming call, the customer-provided equipment must provide a closure between CS and CG leads and maintain that closure for the duration of the call. A transmission path will be cut through after the closure on the SUPERVISORY leads and will remain closed until these leads are opened. The CS lead of the SUPERVISORY pair has a maximum of -28 volts dc through 915 ohms. The CG lead is grounded at the voice connecting arrangement. The SUPERVISORY pair will load the customer's supervisory contact with a maximum .5 ampere. The minimum open circuit insulation resistance between the CS and CG leads and from either lead to ground should be 20,000 ohms when the customer-provided off-hook contact is open. The maximum external loop resistance across the CS and CG leads measured at the Interface Connecting Block shall not exceed 70 ohms when indicating a closure.

4.32 Signal Alerting Path

The SIGNAL ALERT leads (C1 and C2) provide a contact closure to the customer which follows the network ringing cycle on an incoming call.

The closure between these leads will open and remain open when the customer answers an incoming call. The customer's equipment load on the SIGNAL ALERTING leads shall not exceed .5 ampere.

4.4 Grounding

In general, it is desirable that circuits in the customer's equipment which connect to the voice connecting arrangement have some path to ground. 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 when available. Self-powered or passive customer's equipment need not be grounded. Voice Connecting Arrangement CD6 is provided with a common signal ground which is always bonded to a metallic cold water pipe or other NEC approved ground serving as the electric power ground and telephone protector ground where present. The CG lead of the SUPERVISORY pair is grounded at the unit. If necessary, this SUPERVISORY ground lead may be connected to the frame ground of the customer's equipment. It is not permitted to derive the main ground for the customer's equipment through this lead from the voice connecting arrangement.

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. This lead shall not be fused and shall be on a separate damping device from that used for the telephone ground.

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 below, on power at the customer's location, have been set to meet an average of -12 dBm when all PBX loops in the Bell System are considered.

5.2 Maximum Available Power

The Central Office power criterion, in 5.1, 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 system should be so designed that the average power over any 3-second interval applied to the Interface Connecting Block associated with Voice Connecting Arrangement CD6 does not exceed -9 dBm. The recommended procedure for estimating the power is given in Paragraph 6.

*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 impedance are matched.

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 Hz. They are, however, relatively insensitive to energy at this frequency if sufficient energy is present at the same time in 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.

5.4 Out-of-Band Limits

To protect other services, it is necessary that the signal 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 not exceed 27 dB below the power of one milliwatt.

(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.

5.5 Internal Impedance

The internal 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, or 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 (3A) 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

*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.

does not necessarily hold for noise meters other than the Western Electric 3C [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 listed in Paragraph 8 have discussed statistical information on talker volumes (a), end-office losses and noise (b-d), loop characteristics (e), and other characteristics (f-h). In addition, five general information texts are listed.

The 1000 Hz 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 impedance 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 extends from about 300 to about 3000 Hz. In general, an

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 as following:

(a) McAdoo, K. L., "Speech Volumes on Bell System Message Circuits - 1960 Survey," Bell System Technical Journal (BSTJ), 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.

*Available through Graybar Electric Company.

*(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*

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

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 systems, are connected either electrically, acoustically or inductively.

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

INTERFACE CONNECTING BLOCK - the Telephone Company furnished 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 voice connecting arrangement.

OFF-HOOK SUPERVISION - the conditioning of the SUPERVISORY leads by the customer-provided equipment which indicates a customer's telephone is answering a call.

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

SUPERVISORY - the designation of the leads or the function which accepts answer and disconnect supervision from the customer's equipment.

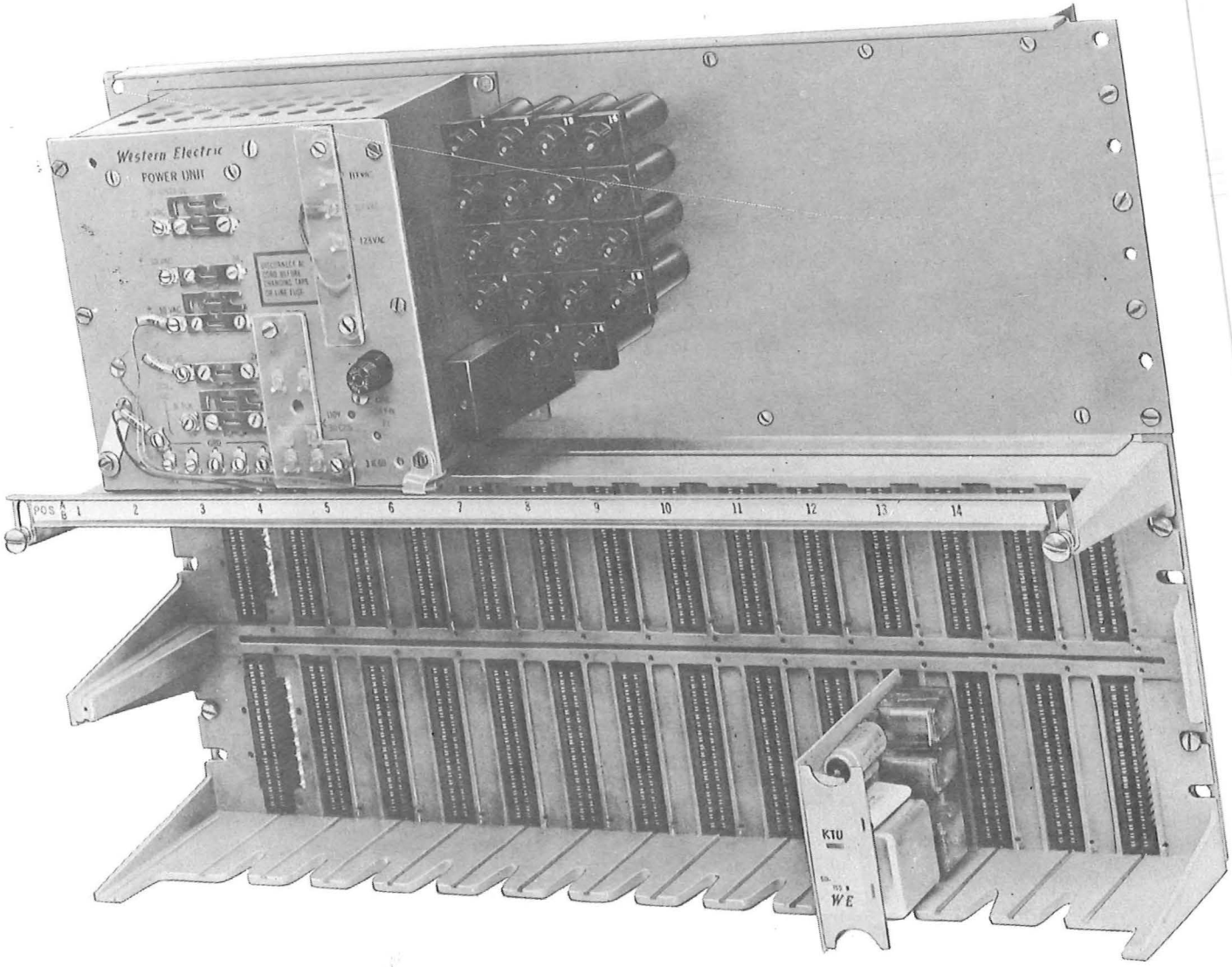
*May differ in letter from exact working as used in the Tariffs.

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

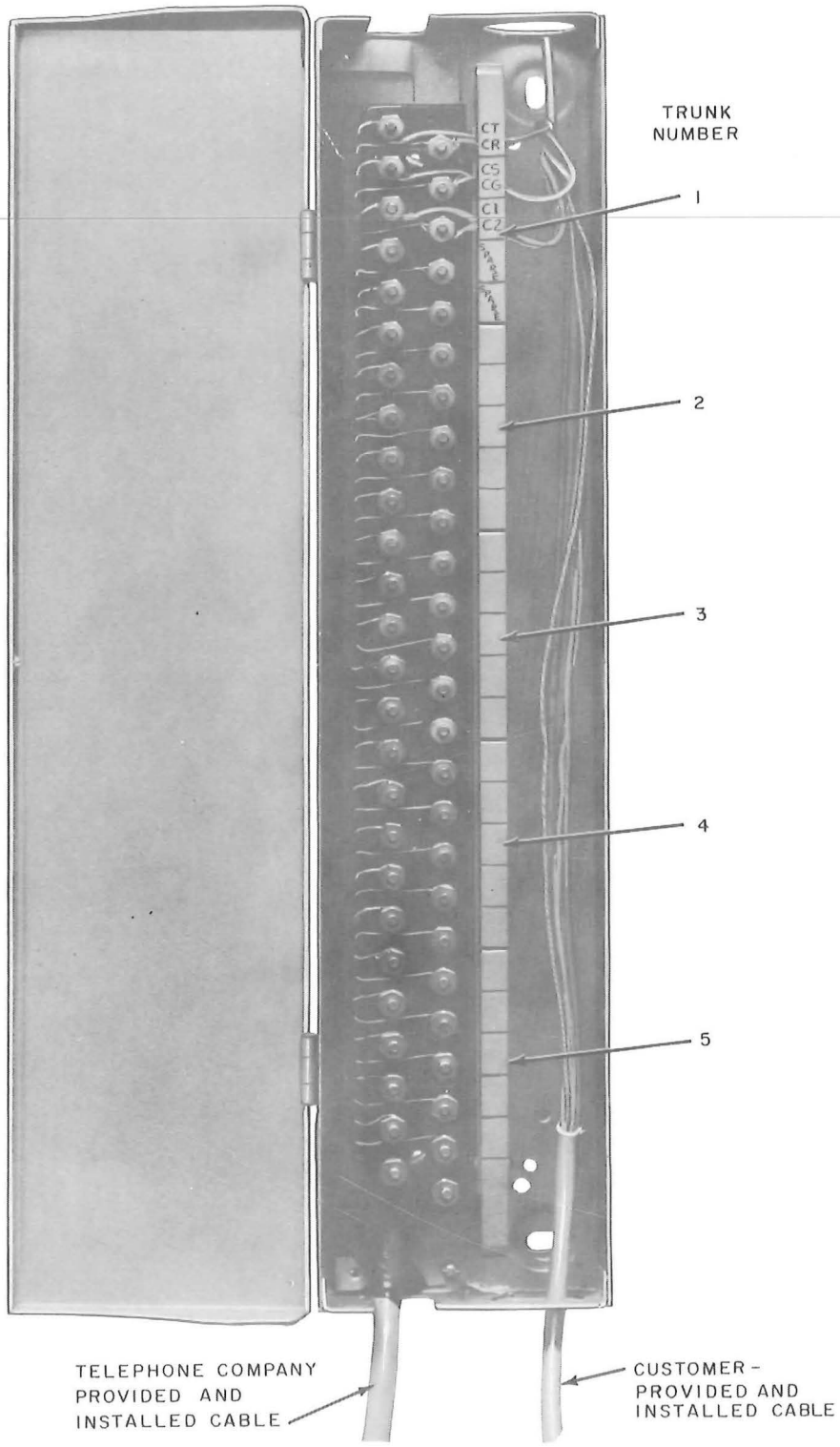
TELEPHONE COMPANY - denotes the American Telephone and Telegraph Company, the Long Lines Department, its concurring carriers and its connecting carriers, either individually or collectively.

VOICE CONNECTING ARRANGEMENT - Voice Connecting Arrangement CD6 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.

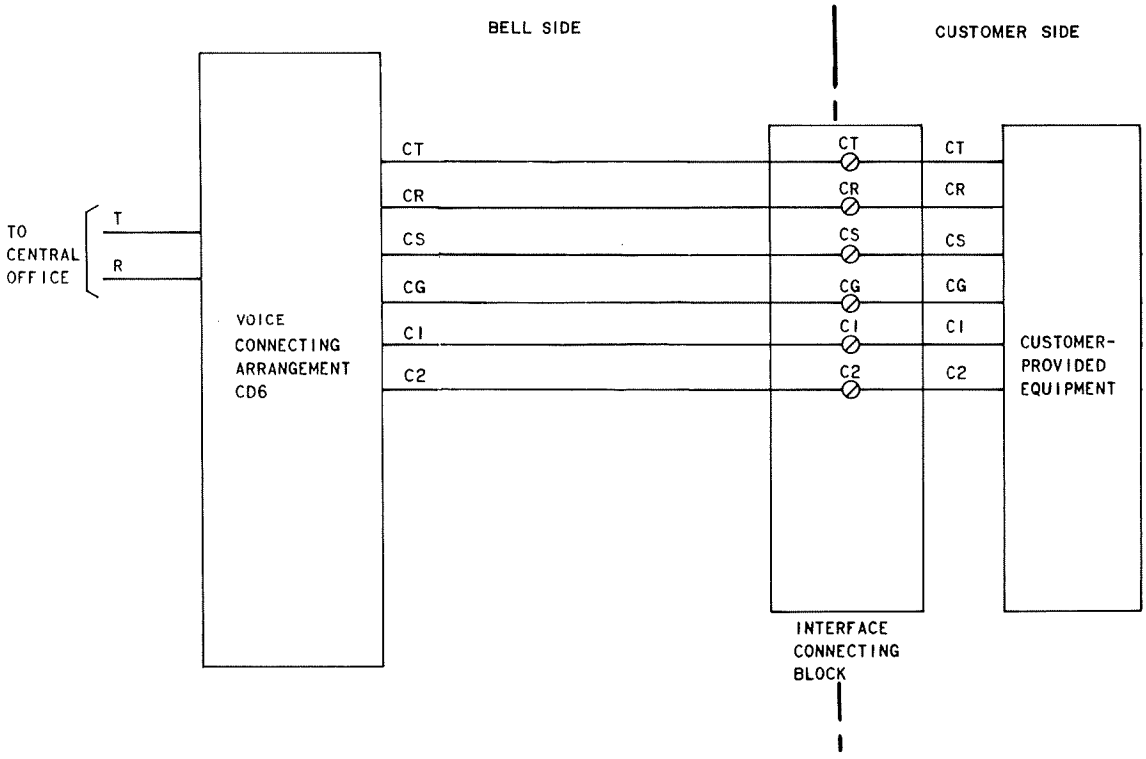
VOICE COUPLER - that part of Voice Connecting Arrangement CD6 which connects the transmission path from the customer-provided equipment to the telecommunications network.



VOICE CONNECTING ARRANGEMENT CD 6
FIG. 1

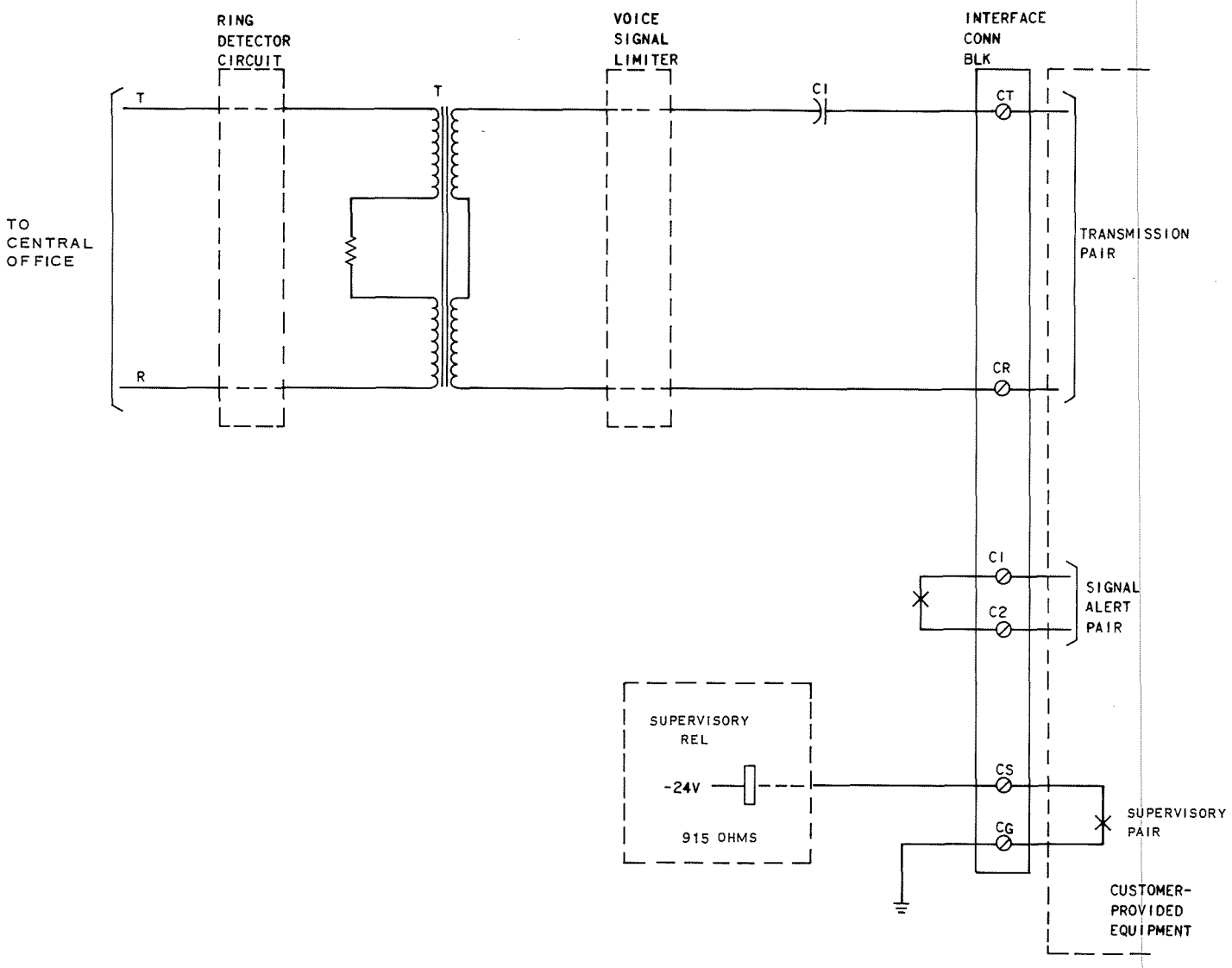


TYPICAL INTERFACE CONNECTING BLOCK
FIG. 2



BLOCK DIAGRAM – VOICE CONNECTING ARRANGEMENT CD6

FIG. 3



SIMPLIFIED SCHEMATIC – VOICE CONNECTING ARRANGEMENT CD6

FIG 4