PUB 42102

Bell System

TECHNICAL REFERENCE

VOICE CONNECTING ARRANGEMENT CDX

INTERFACE SPECIFICATION

REVISED FEBRUARY 1973

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Bell System Voice Communications

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CDX

Interface Specification

Revised February 1973

ENGINEERING DIRECTOR - CUSTOMER TELEPHONE SYSTEMS

NOTICE

This Technical Reference is published by the 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. The 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 systems and equipment are set forth in the appropriate tariff regulations.

This Technical Reference supersedes and replaces Bell System Voice Communications Technical Reference for Voice Connecting Arrangement CDX dated December 1969.

If further information is required, please contact:

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

TECHNICAL REFERENCE
VOICE CONNECTING ARRANGEMENT CDX
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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 direct electrical connection of customer-provided voice transmitting and receiving terminal equipment and communications systems to the Bell System telecommunications network. The tariffs also provide for the indirect (acoustic or inductive) connection of such equipment or systems. Both methods require compliance with network protection criteria specified in the tariffs.

Direct electrical connection is made through a voice connecting arrangement and associated network control signaling unit furnished, installed, and maintained by the Telephone Company.

This Technical Reference is revised to include connecting information for single-cord switchboards.

1.2 Application

Voice Connecting Arrangement CDX provides a means for manually connecting an incoming Central Office call through a Bell System manual PBX switchboard to an outgoing Central Office trunk.

This voice connecting arrangement is terminated at the manual PBX cord switchboard in a patching jack and provides 2-way voice-only transmission between the PBX and the customer-provided equipment. The start leads provide a dry contact closure to the customer-provided equipment. One pair of transmission leads provides a transmission path from an incoming Central Office line via a special patching jack to the customer-provided equipment. Another pair of transmission leads provides a transmission path from the customer-provided equipment to the outgoing Central Office line.

1.3 Ordering and Identification

The connection service described in this Technical Reference is identified by the Bell System as Voice Connecting Arrangement CDX. One voice connecting arrangement should be ordered for each simultaneous call which is to be patched. The local Telephone Company business office or Marketing representative will provide information regarding availability and rates for this service.

2. DESCRIPTION

2.1 Functions

The major functions of this voice connecting arrangement are:

(a) To protect Telephone Company personnel and facilities from hazardous voltages which may be applied to the voice connecting arrangements from the customer-provided equipment.

(b) To provide isolation from longitudinal imbalance.

(c) To limit abnormally high speech levels to the telecommunications network.

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

2.2 Physical

Voice Connecting Arrangement CDX consists of two voice coupler units, each mounted on a 4-inch by 2-1/2 inch metal base equipped with a plastic cover two inches high (Fig. 2), a patching jack, and an interface connecting block (Fig. 3). The units will be installed by the Telephone Company in a convenient location to permit testing, maintenance, trouble isolation, and ease of connection to the customer-provided equipment. This arrangement will function satisfactorily over a temperature range of 0° to 55°C and a humidity range of 5 to 95 percent.

2.3 Interface Leads

Four interface leads, designated CT, CR, CT1, CR1, (see Fig. 4 and 5) provide 2-way transmission paths between the voice connecting arrangement and the customer-provided equipment. Two leads, designated CS and CG, provide a dry contact closure to the

customer-provided equipment when a cord is inserted into the patching jack. Technical information pertaining to these leads is discussed in Part 4 — SPECIFIC DESIGN CONSIDERATIONS.

3. OPERATION

Standard operating procedures and functions of the PBX switchboard are not affected. Voice Connecting Arrangement CDX is used only when an incoming line is to be connected to an outgoing line.

3.1 Single-Cord Switchboard

When a call is received, an incoming signal appears at the switchboard, the attendant inserts the intercept cord into the jack directly beneath the lighted lamp of the incoming signal, operates the DIAL or TALK key to the TALK position, and answers the call (see Fig. 4).

The attendant secures the necessary information to complete the call and then restores the DIAL or TALK key to its normal position to hold the incoming line. This intercept cord may be used for monitoring when required.

The attendant takes another intercept cord and inserts it into a Central Office (CO) trunk jack (patch jack) associated with a patching jack, operates the DIAL or TALK key to the dial position, and dials the requested number. After completion of dialing, the attendant restores the DIAL or TALK key to its normal position to hold the dialed number.

The attendant then takes the double-ended patch cord and inserts one end into the transfer jack connected to the incoming line and inserts the other end into the connecting arrangement jack (patching jack) associated with the CO trunk jack used to dial the requested number. The intercept cord should then be removed from the CO trunk jack. When a plug is inserted into a patching jack, the CS and CG leads are connected to provide a seizure signal to the customer-provided equipment and voice coupler 2 (VC2) is connected in series with the CO trunk. The incoming line is now connected through the connecting arrangement via voice coupler 1 (VC1) and customer-provided equipment to the outgoing line.

3.2 Two-Cord Switchboard

When a call is received, an incoming signal appears at the switchboard, the attendant inserts the left or back (trunk) cord into the jack directly beneath the lighted lamp of the incoming signal, operates the DIAL or TALK key to the TALK position, and answers the call (see Fig. 5).

The attendant secures the necessary information to complete the call and then restores the DIAL or TALK key to its normal position to hold the incoming line. This cord may be used for monitoring when required.

The attendant takes the left or back (trunk) cord of an adjacent cord pair, inserts it into a Central Office (CO) trunk jack (patch jack) associated with a patching jack, operates the DIAL or TALK key to DIAL position, and dials the requested number. After completion of dialing, the attendant restores the DIAL or TALK key to its normal position to hold the dialed number.

The attendant then takes the right or front (station) cord associated with the cord connected to the incoming line and inserts it into the connecting arrangement jack (patching jack) associated with the CO trunk jack used to dial the requested number. The left or back (trunk) cord should then be removed from the CO trunk jack. When a plug is inserted into the patching jack, the CS and CG leads are connected to provide a seizure signal to the customer-provided equipment and voice coupler 2 (VC2) is connected in series with the CO trunk.

The incoming line is now connected through the connecting arrangement via voice coupler 1 (VC1) and customer-provided equipment to the outgoing line.

3.3 Disconnection

Voice Connecting Arrangement CDX does not provide any form of supervision. If supervision is not provided by the customer's equipment, it will be necessary for the attendant to periodically monitor the circuit and remove the cords when conversation is terminated.

3.4 Method of Connection

Leads from Voice Connecting Arrangement CDX will be terminated by the Telephone Company in a terminal box equipped with the Interface Connecting Block (Fig. 3). 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 this terminal box, using 20-gauge wire or smaller. The leads will be designated as follows:

DESIGNATION	FUNCTION
CT	voice transmission
CR	pair from connecting arrangement jack voice coupler
CS	start pair
CG	
CT1	voice transmission
CR1	pair from outgoing Central Office trunk-voice coupler

4. SPECIFIC DESIGN CONSIDERATIONS

4.1 Transmission Path (Leads CT, CR, CT1, and CR1)

4.11 Insertion Loss

The 600-ohm insertion loss of Voice Connecting Arrangement CDX is approximately one dB per voice coupler unit over the voice-frequency range of 300 to 3000 Hz. No voice signal amplification is provided by this arrangement.

4.12 Internal Impedance

The internal impedance of the customer's equipment should be approximately 600 ohms. Other impedances may seriously degrade transmission.

4.13 Bandwidth

The nominal voice-frequency bandwidth of the telecommunications network extends from 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. This voice connecting arrangement does not limit this bandwidth.

4.14 Voice Signal Power Level

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, the maximum available power from a customer-provided 600-ohm source when averaged over any 3-second interval and measured at the transmission leads at the interface connecting block should not exceed -8 dBm. This limit has been set so that when the average loss of loops in the Bell System is considered (including the insertion loss of the voice connecting arrangement), the limit of -12 dBm at the local Central Office will be met.

Using measuring Method A (see 4.15), in almost all cases the speech power averaged over any 3-second interval will not exceed -8 dBm if the maximum meter swing does not exceed 85 dBrn. With the additional damping of measuring Method B, the power averaged over any 3-second interval will not exceed -8 dBm if the maximum meter swing does not exceed 83 dBrn.

4.15 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 criteria specified in 4.14 are 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)	3 Kc 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)	3 kHz FLAT
	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. Generally a loss greater than or equal to 0 dB between terminal pairs CT, CR and CT1, CR1, will ensure that the above inband power criteria are met.

*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. The use of meters with shorter time constants, such as VU meters or standard voltmeters, is not recommended.

Note: This modification does not necessarily hold for the Model 3555B or noise meters other than the Western Electric 3-Type.

4.16 Signal Power Distribution

The telecommunications network incorporates tone signaling devices that are used for network control functions. These devices, which are connected at all times to the telephone circuit, are designed to be sensitive to 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.

4.17 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 not exceed 26 dB below one milliwatt (18 dB below the signal level specified in 4.14).

(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.

4.18 Signal Limiting

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 or normal tone address signal levels. This limiter does not abrogate the customer's responsibility to comply with the criteria in the tariffs.

4.2 DC Voltage

The maximum dc voltage across leads CT, CR, CT1, and CR1, measured at the Interface Connecting Block, shall be 52 volts. The dc signals from the customer-provided equipment are blocked by a capacitor in the couplers.

4.3 Signaling Path

This dedicated pair of leads provides a contact closure to the customer-provided equipment when an incoming call is connected to the patch jack. This closure will be opened when the patch jack is removed. The customer's equipment load on the leads shall not exceed .25 ampere non-inductive.

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 the arrangement. It is expected that the customer's equipment, if powered from commercial power, will be grounded in accordance with applicable electrical codes, ie, National Electrical Code (NEC) and should be bonded to the telephone protection 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, must be grounded.

The Bell System PBX switchboard is provided with a common signal ground which is always bonded to a metallic 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. 14 AWG or larger copper conductor. The other end of the conductor 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 wire be connected to the water piping system at the same location as the telephone protector or signal ground, but should not use the Telephone Company ground clamp. This lead shall not be fused.

5. GENERAL DESIGN CONSIDERATIONS

5.1 Foreign and Surge Voltage Protection

Where telephone lines are exposed to foreign voltages by direct contact or induction (eg, power line crosses or lightning), 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. Metallic surges on the transmission leads due to foreign potentials will be limited 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 from facilities being applied to the voice connecting arrangements.

5.2 Telecommunications Network Characteristics

5.21 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.

5.22 Nonlinearities

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

6. SERVICE AND MAINTENANCE CONSIDERATIONS

6.1 Responsibility of the Customer

The tariffs permitting connection 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 terminal equipment or communications systems provided by a customer, 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 system provided by a customer does 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 system of facilities, 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 permitting connection of terminal equipment and communications systems provided by a customer 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, or (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, ie, 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) Description of the trouble.

(e) Customer's contact for additional information.

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

APPENDIX A

GLOSSARY

COMMUNICATIONS SYSTEM — 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 and the telecommunications network.

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

CUSTOMER-PROVIDED TERMINAL EQUIPMENT — 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 system, are so connected either electrically, acoustically, or inductively.

INTERFACE CONNECTOR — The Telephone Company-provided connecting point to which the customer brings and connects the mating plug or cable of his equipment to the voice connecting arrangement.

TELECOMMUNICATIONS NETWORK — The Bell System voice switching equipment, associated interconnecting facilities, and station equipment which provide Long Distance Message Telecommunications Service or private line service.

TELEPHONE COMPANY — 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 to transmit speech signals, as contrasted to one designed 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) Bell System Data Communications Technical Reference — PUB 41007 1969-1970 Switched Telecommunications Network Connection Survey (Reprints of Bell System Technical Journal Articles) — April 1971.

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

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

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

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

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

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

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

APPENDIX C

WHERE TO OBTAIN REFERENCE MATERIAL

1. Bell System Technical References

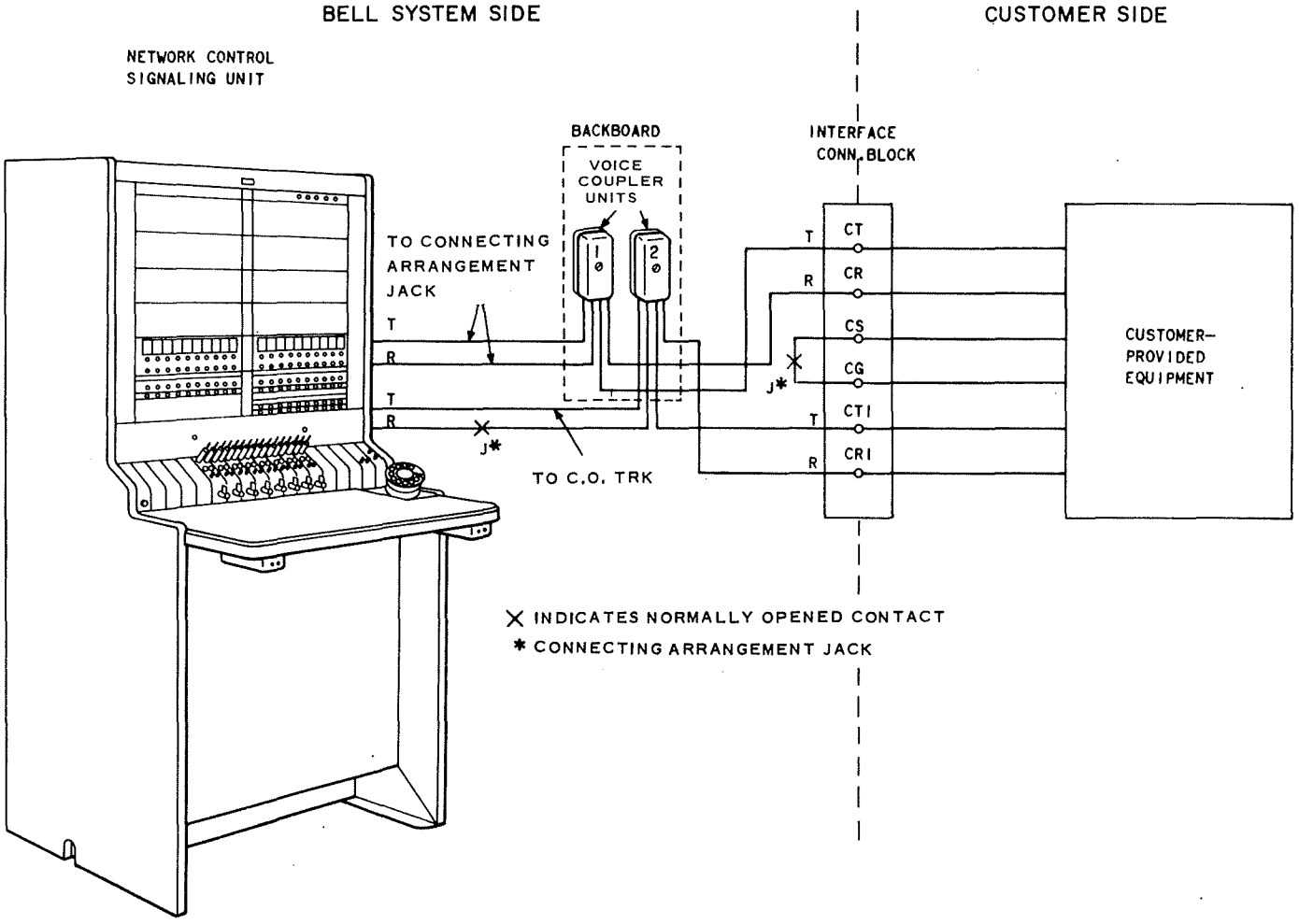
These references may be purchased by writing to:

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

2. Bell System Technical Journals (BSTJ)

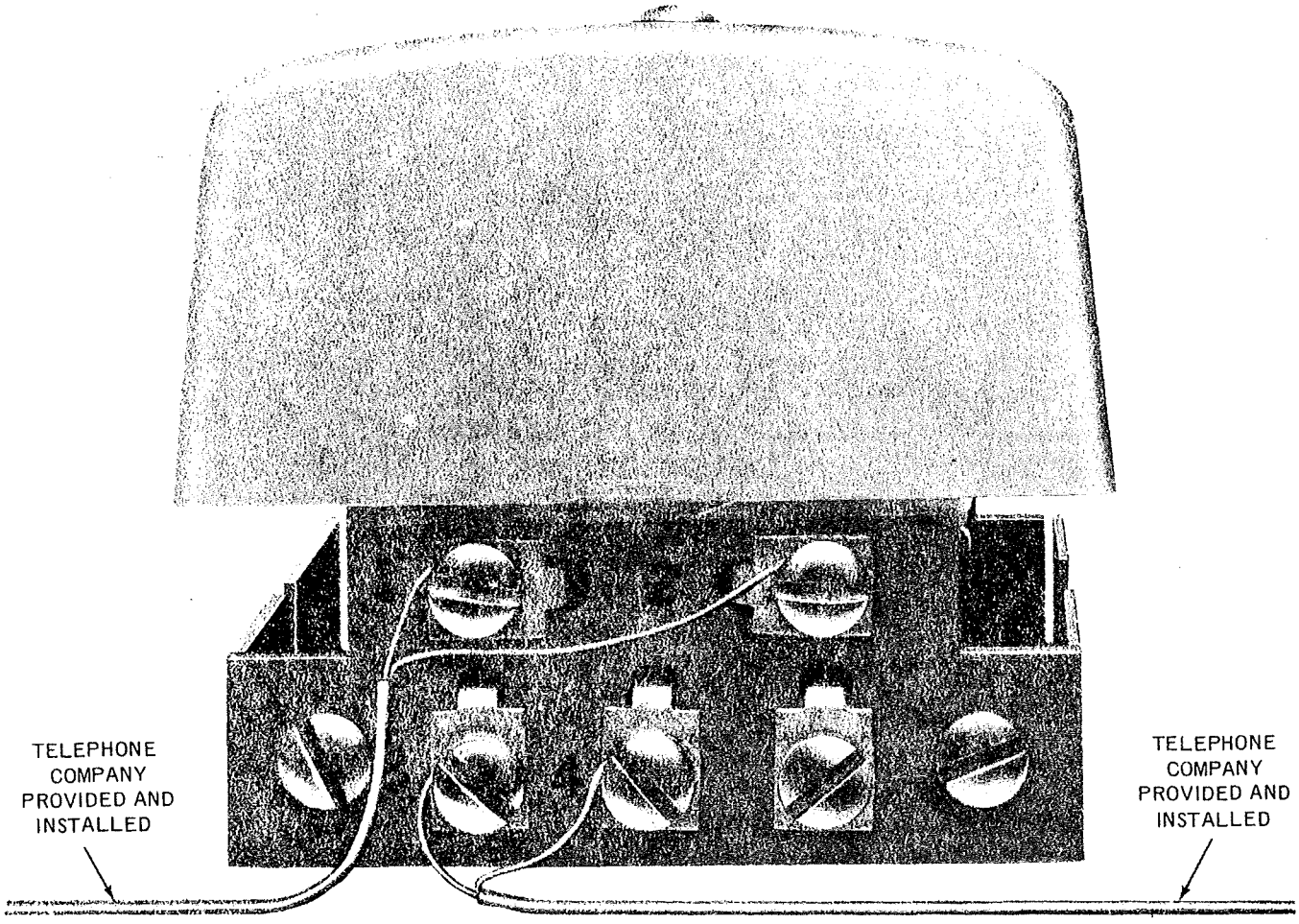
These journals may be purchased by writing to:

Mr. F.J. Schwetje
Bell Telephone Laboratories, Inc.
Mountain Avenue, Room 3C115
Murray Hill, New Jersey 07974

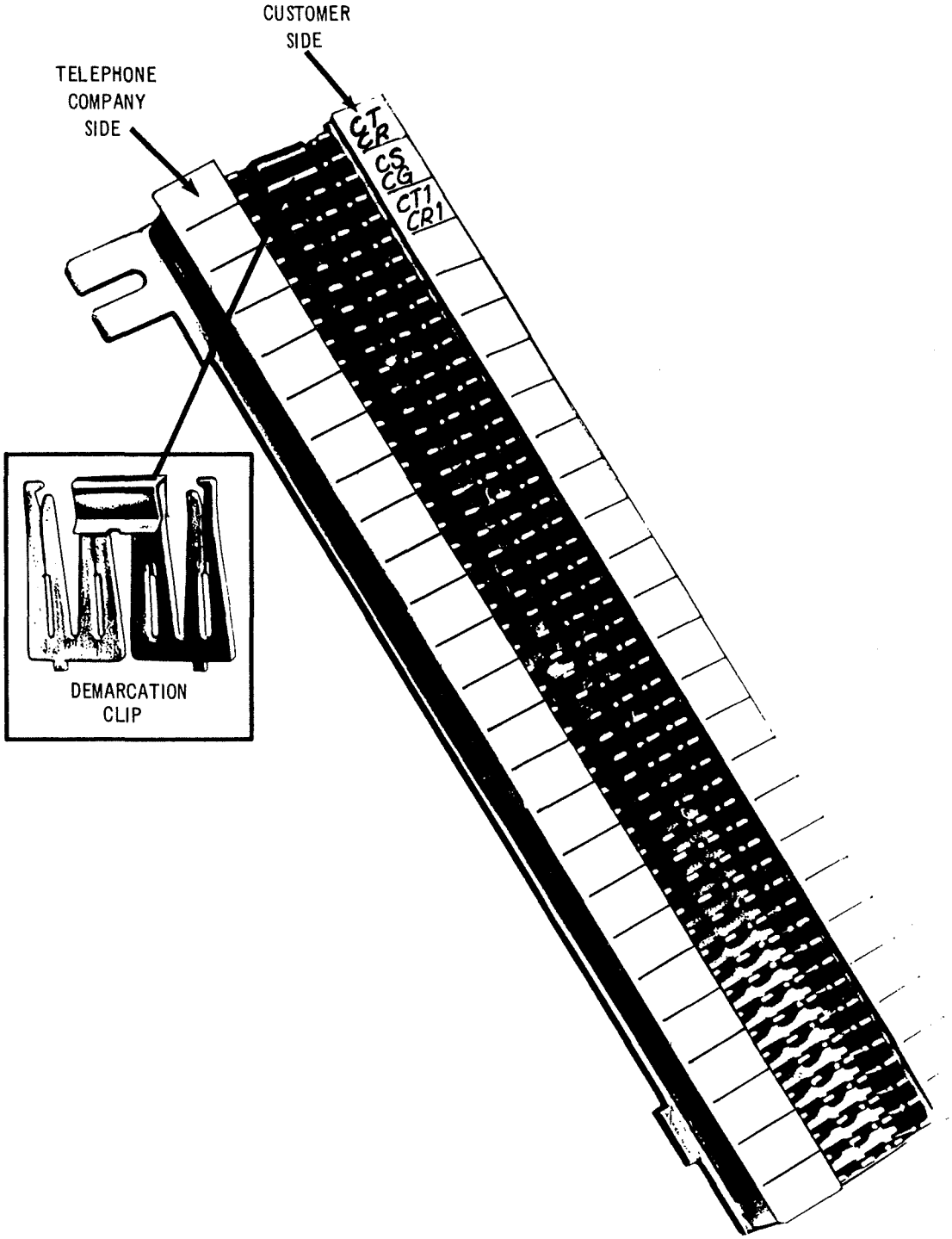


BLOCK DIAGRAM – VOICE CONNECTING ARRANGEMENT CDX AND NETWORK CONTROL SIGNALING UNIT

FIG. 1

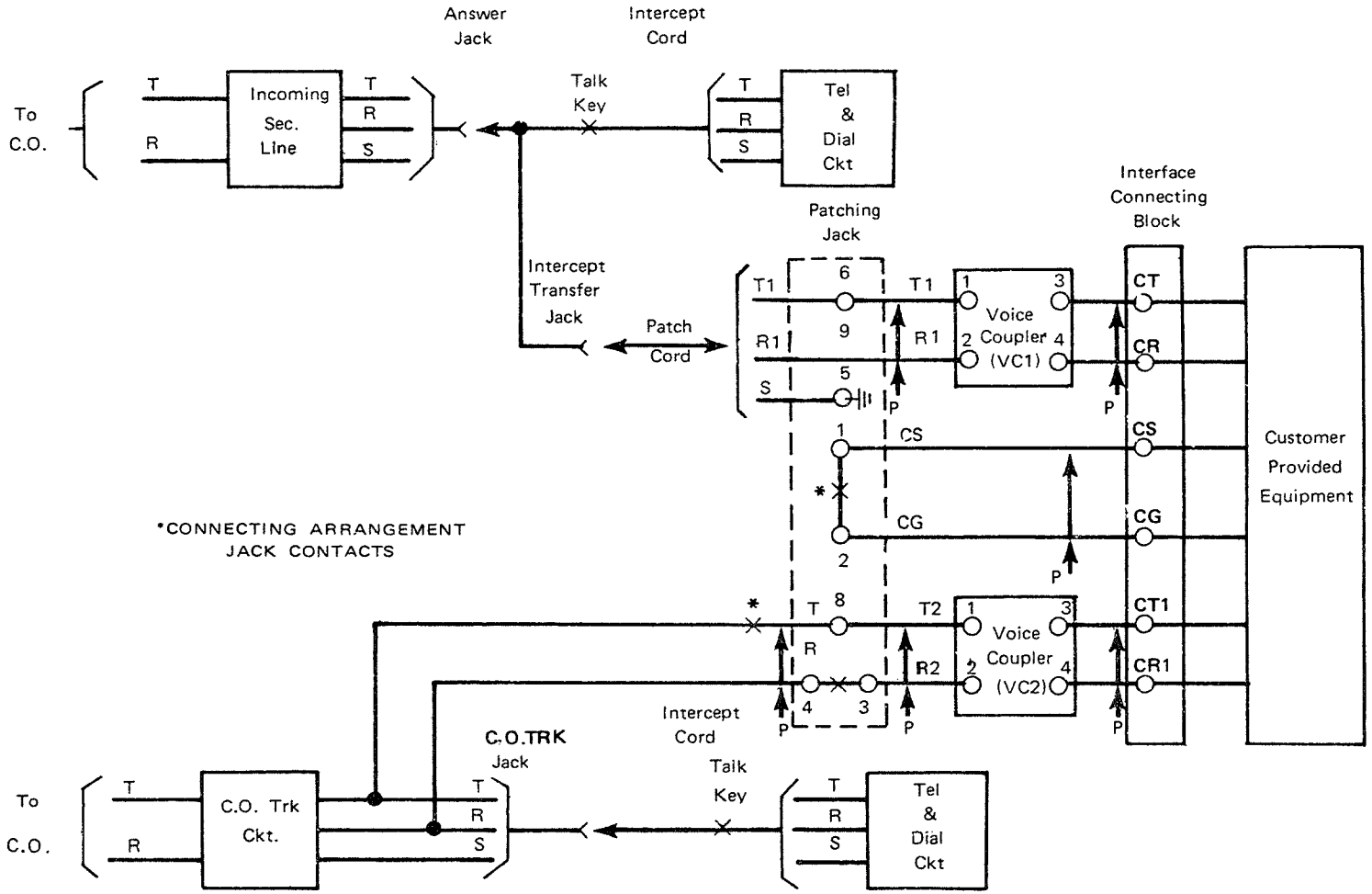


VOICE COUPLER UNITS USED IN
VOICE CONNECTING ARRANGEMENT CDX
FIG. 2

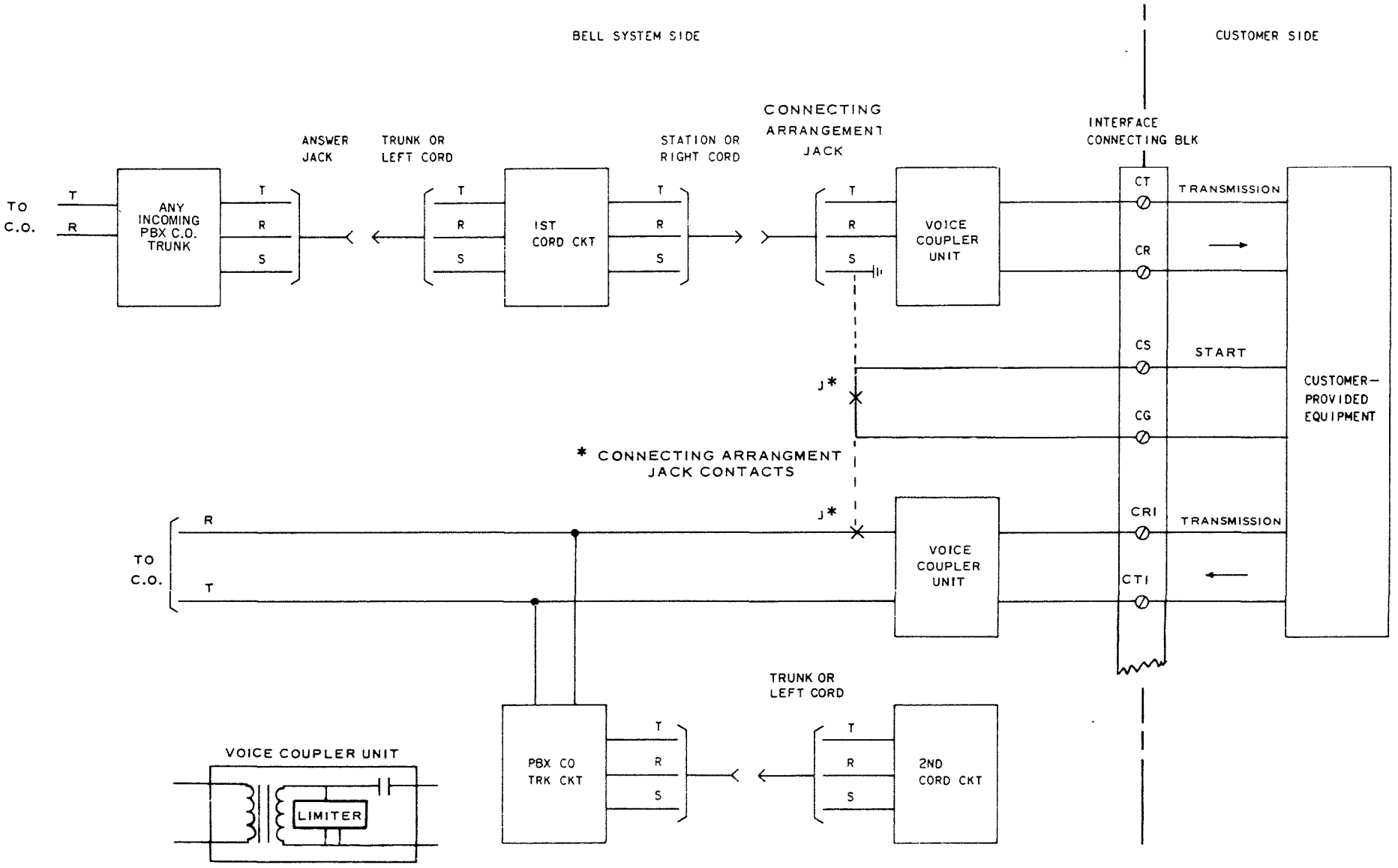


TYPICAL INTERFACE CONNECTING BLOCK

FIG. 3



Simplifed Block Diagram
Single-Cord PBX Switchboard
Voice Connecting Arrangement CDX
FIG. 4



SIMPLIFIED BLOCK DIAGRAM–VOICE CONNECTING ARRANGEMENT CDX TWO–CORD P.B.X. SWITCHBOARD

FIG. 5