

Bell System Data Communications

TECHNICAL REFERENCE

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DATA SETS

41481

401A

and 401E



April 1966

American Telephone & Telegraph Company

Data and Teletypewriter Planning Engineer



Bell System Data Communications

TECHNICAL REFERENCE

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Data Sets 401A and 401E

April 1966

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ENGINEERING DIRECTOR - DATA COMMUNICATIONS



P R E F A C E

This specification is specifically intended for designers of business machine equipment to be used with Bell System Data Sets 401A type and 401E type in DATA-PHONE and similar services.

If additional details on the interface and its operation are needed, please contact:

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N O T I C E

The Technical Reference replaces the Bell System Communications Technical Reference for Data Sets 401A and 401B Interface Specification – July 1963 and the Bell System Communications Technical Reference for Data Sets 401E and 401F Interface Specification – July 1963.

The Data Sets 401B and 401F have been superseded by the Data Set 401J type.

TABLE OF CONTENTS

	Page
1. GENERAL DESCRIPTION	1
2. 401A TRANSMITTER INTERFACE	2
3. 401E TRANSMITTER INTERFACE	4
4. SYSTEM OPERATION	7

FIGURES

1. Data Set 401A Transmitter	1
2. Data Set 401E Transmitter	1
3. 401A Interface Signals	2
4. 401E Interface Signals	5
5. 401A Block Diagram	8
6. 401E Block Diagram	9

1. GENERAL DESCRIPTION

The Data Set 401A Transmitter and the Data Set 401E Transmitter are intended to provide inexpensive one-way transmission of numerical and alphameric information respectively over the switched telephone network (DATA-PHONE service). They may also be used on private lines if desired.

The 401A set at the transmitting site will accept electrically from customer apparatus one of 24 possible characters asynchronously, a character at a time, at any rate up to twenty characters a second. The 401E transmitting set will accept electrically from the customer's apparatus one of 99 possible characters asynchronously, one character at a time, at any rate up to twenty characters a second. The receiving Data Set 401J will deliver the characters electrically to the customer's apparatus. If the Data Set 403A is the receiver then the maximum data rate is 10 characters per second and code is restricted to 16 possible characters of the A and B groups. Provision is made in the Data Sets 401A and 401E for answer-back from data receiver.

1.1 PHYSICAL CHARACTERISTICS



Fig. 1 Data Set 401A Transmitter

The 401A set and the 401E set shown in Figures 1 and 2 consist of a data transmitter and a voice telephone set combined in a single unit, two-tone gray in color. Both transmitters measure about 9 inches wide by 9 inches deep by 4-1/2 inches high and weigh about 6 pounds each. An earlier version of the 401A encased in a CALL DIRECTOR housing, was about 13 inches wide by 8 inches deep by 4 inches high, and weighed about 7 pounds.

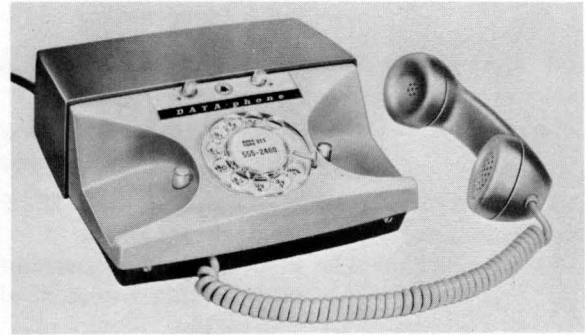


Fig. 2 Data Set 401E Transmitter

On both the 401A and 401E the left hand switchhook (cradle) plunger is arranged to be pulled up above its normal position. This operates the data switch to the data position.

1.2 CODES

The Data Set 401A transmitter provides ten channels divided into two groups, A and B, of five channels each. The channels are controlled by contact closures. The permissible characters are those which operate one and only one channel from each of the two groups. Thus the 401A accepts and delivers a restricted two-out-of-ten code allowing 25 characters (one character, AO, BO is reserved as an intercharacter separator).

The 401E transmitter provides 14 channels divided into 3 groups (groups A, B and C). Groups A & B contain 5 channels and group C contains 4 channels. Thus, the 401E accepts and delivers a restricted three-out-of-fourteen code allowing for 100 possible characters. One of these characters (A0, B0 and C0) is reserved as an intercharacter separator.

The arrangement of the channels is as follows:

Group	Channel	Data Set	
		401A	401E
A	A0	X	X
A	A1	X	X
A	A2	X	X
A	A3	X	X
A	A4	X	X
B	B0	X	X
B	B1	X	X
B	B2	X	X
B	B3	X	X
B	B4	X	X
C	C0	-	X
C	C1	-	X
C	C2	-	X
C	C3	-	X

1.3 POWER REQUIREMENTS

The 401A and 401E transmitters use power furnished over the telephone lines.

1.4 ENVIRONMENT

These data sets will perform with a reasonable degree of transmission reliability over most of the circuits in the switched

telephone network. They will perform satisfactorily over a temperature range of 40° to 120° F and a relative humidity of 20% to 95%.

2. 401A TRANSMITTER INTERFACE

The Data Set 401A Transmitter accepts data from a customer's data source, hereinafter referred to as a business machine.

TABLE 1

Pin Assignments in the Data Set 401A Interface Connector

Pin	Function	Pin	Function
1	Reserved*	14	Reserved
2	Reserved	15	Reserved
3	Data Channel A1	16	Reserved
4	Data Channel A2	17	Reserved
5	Data Channel A3	18	Reserved
6	Data Channel A4	19	Audible answer-back 1 (-)
7	Data Common	20	Audible answer-back 2 (+)
8	Reserved	21	Reserved
9	Data Channel B1	22	Reserved
10	Data Channel B2	23	Reserved
11	Data Channel B3	24	Keying - 1
12	Data Channel B4	25	Keying - 2
13	Reserved		

*The reserved pins in the Data Set 401A have been reserved to preserve compatibility with other data sets in the 401 family. These pins should not be used unless the customer's data source is also intended to be used in an alternate service with one of the other data sets.

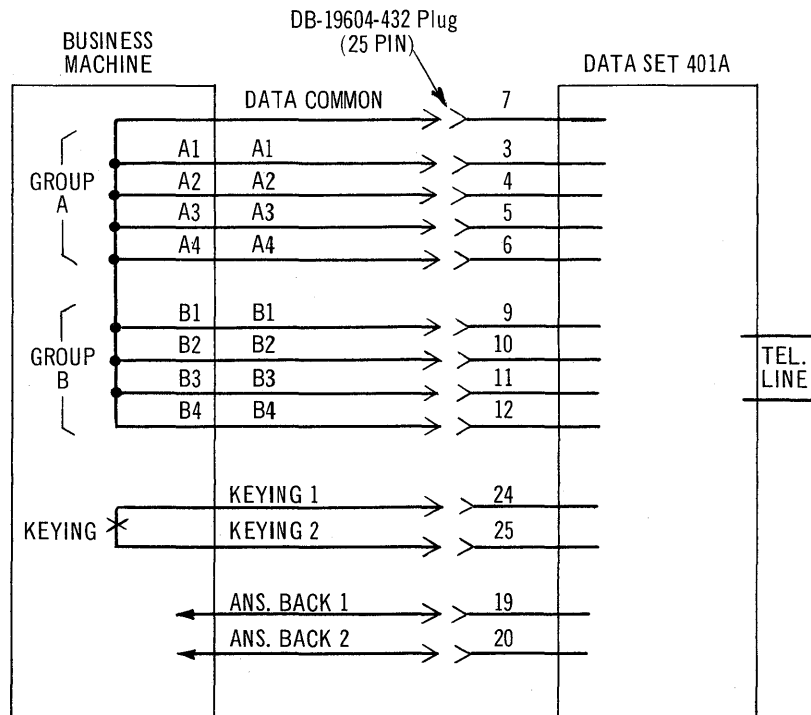


Fig. 3 Data Set 401A Transmitter Interface Signals

2.1 CONNECTOR

2.11 The allocation of the pins in the connector on the Data Set 401A Transmitter is shown in Table 1 and Figure 3.

2.12 To connect to the data set interface connector, the business machine should be equipped with a cable meeting the capacitance specifications cited in Paragraph 2.26. This cable should terminate in a Cinch or Cannon connector type DB-19604-432 or equivalent fitted with a Cinch hood type DB-51226-1.

2.2 CONTACTS

2.21 Data are accepted in the form of switch closures from the business machine. Each closure is made between the desired data lead and the data common lead. One or two such closures are required: One from pin 7 to pin 3, 4, 5, 6 or none and the other from pin 7 to pin 9, 10, 11, 12 or none.

2.22 The contact resistance measured from pin 7 through the closures to each of the data leads on the connector provided with the reader must not exceed 10 ohms. The Data Set 401A Transmitter will apply about 0.5 milliamperes peak ac to these closures.

2.23 Leakage resistance from pin 7 to each of the open data leads must be 400,000 ohms or greater. The data set may apply 1.5 volts peak ac between pin 7 and an open data lead.

2.24 The data set will present dc resistances ranging between 50 ohms and 500 ohms between pin 7 and the various data leads. The sum total of the dc current that the business machine may inject into the four data leads of either group must not exceed 1.0 ma. Isolation is provided between the data circuit (consisting of the data leads and data common) and ground or any other circuit. Data common may be tied to the frame of the reader or any other circuit point having a potential difference to ground of not more than 50 volts peak.

2.25 Contact protection must not be provided across the data contacts because such protection would impair the performance of the data set.

2.26 An allowance of 300 ± 150 pf has been made in the data set design for the stray capacitance between the data leads of the reader. This capacitance is measured in the following fashion:

- 1) The business machine is disconnected from the data set.

- 2) One of the eight data leads is selected on the reader interface connector.
- 3) All the remaining pins in the connector are shorted together.
- 4) The selected data lead is placed in the "OFF," or open condition.
- 5) The capacitance between the selected data lead and the shorted array of pins is measured.
- 6) This procedure is then repeated for the other seven data leads.

2.3 KEYING CONTACTS

2.31 The Data Set 401A Transmitter provides two interface leads (pins 24 and 25) to be shorted together by a contact in the business machine whenever data are to be transmitted. This contact must be isolated from other circuits. When this closure is made and the data switch on the data set has been operated, the transmitter will deliver tones continuously to the telephone line. The tones that are applied are determined by the data contacts in the business machine. If all data contacts in either group are open, as in an intercharacter rest interval, then a rest tone (A0 or B0) in that group is activated. The purpose of the rest tones is to protect the system against the possible interference of transmission echoes.

2.32 The data contacts may be closed either before or after the keying contacts are closed. A character will be transmitted only when the keying contacts and the appropriate data contacts have all been closed.

2.33 The data set will continue to deliver an output on the data leads for a 50 to 100 millisecond hangover period after the keying contacts have been opened. If the keying contacts are to be opened at the end of a character, the data contacts should be opened with or before the keying contacts. Delays in opening data contacts will reduce the margin of echo protection. A delay of up to 5 milliseconds will not appreciably reduce this margin.

2.34 The keying contacts must be opened to enable the Data Set 401A to receive answer-back signals.

2.35 The 401A set will normally apply about 20 volts across open keying contacts and a surge current of about 250 ma through closed keying contacts. The time constant on the surge decay is approximately 10 milliseconds. The steady-state current will normally be no greater than 10 ma through closed keying contacts. The potential at the keying contacts is derived from the telephone line.

2.36 Series RC contact protection is supplied for the keying contacts by the Data Set 401A. Additional protection should not be used, since this would change the duration of the hangover interval.

2.37 The keying leads must be electrically isolated from ground or other circuits in the business machine.

2.4 TIMING OF CONTACT OPERATIONS

2.41 Characters may be delivered to the 401A set at any rate up to and including 20 characters per second provided the data set receiver will handle the data rate. Thus, the duration of a character and an adjacent inter-character rest interval, which together form the character period, must be at least 50 milliseconds. This period may be divided between the character and the rest interval in any convenient ratio provided that 1) the character duration is at least 20 milliseconds and 2) the rest interval is at least 20 milliseconds.

2.42 Skew in the contact closures in the reader refers to the time interval between closures that nominally should occur simultaneously. There are three cases to consider:

2.421 If the keying contacts are closed before either data contact, the skew between the closures of the two data contacts may not exceed 6 milliseconds.

2.422 If both the data contacts are closed before the keying contacts are closed, there are no timing limitations except that the data contacts should not be closed during the 100 millisecond interval immediately following the last opening of the keying contacts.

2.423 If one data contact is closed before the

keying contacts and one after, then the later data contact closure should occur within 6 milliseconds after keying.

2.5 ANSWER-BACK

2.51 A loudspeaker may be provided in the business machine to detect the answer-back signal. This speaker should have an ac impedance of 100 to 600 ohms at 1800 cps and a dc resistance of 0 to 35 ohms. A receiver unit similar to the Western Electric Type U1 is suitable for this application.

2.52 The answer-back circuit will deliver about 25 milliwatts into a 150-ohm load. Somewhat less power will be delivered to a higher impedance load.

2.53 Up to 20 ma dc may flow through the speaker from the answer-back circuit. This current will flow into the speaker through pin 20 and return to the data set through pin 19.

2.54 A shunt volume control across the speaker may be provided in the business machine if desired.

2.55 The answer-back leads must be electrically isolated from ground and other circuits in the reader.

3. 401E TRANSMITTER

3.1 TRANSMITTER INTERFACE

The Data Set 401E Transmitter accepts data from a Customer's Data Source (business machine).

3.11 Connector

3.111 The allocation of the pins in the connector on the 401E is shown in Table 2 and Figure 4.

TABLE 2

Allocation of Pins in the 401E Transmitter Connector

Pin	Function	Pin	Function
1	Reserved	14	Data Channel C1
2	Reserved	15	Data Channel C2
3	Data Channel A1	16	Data Channel C3
4	Data Channel A2	17	Reserved
5	Data Channel A3	18	Reserved
6	Data Channel A4	19	Audible answer-back 1 (-)
7	Data Common (COM)	20	Audible answer-back 2 (+)
8	Reserved	21	Reserved
9	Data Channel B1	22	Reserved
10	Data Channel B2	23	Reserved
11	Data Channel B3	24	Keying - 1
12	Data Channel B4	25	Keying - 2
13	Reserved		

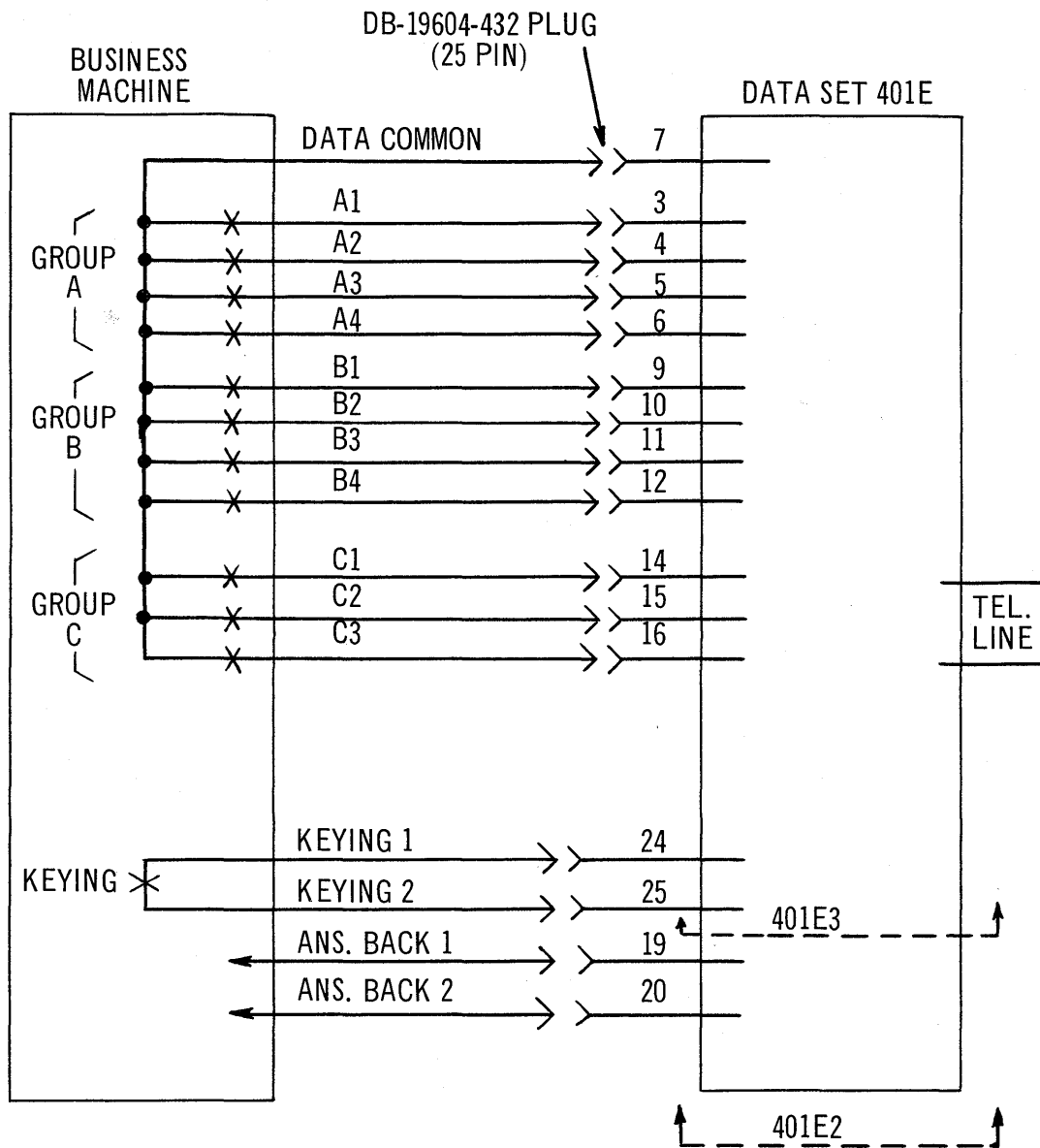


Fig. 4 Data Set 401E Transmitter Interface Signals

3.112 To connect to the data set interface connector, the business machine should be equipped with a cable meeting the capacitance specifications given in 3.127. This cable should terminate in a Cinch or Cannon connector type DB-19604-432 or equivalent fitted with a Cinch hood type DB-51226-1.

3.12 Contacts

3.121 Data are accepted in the form of contact closures from the business machine. Each closure is made between the desired data lead and the data common lead. Table 3 indicates the allowable possible contacts in each frequency group.

TABLE 3

Data Contacts for the 401E Transmitter

Group	Connect Data Common to any one of the following leads in each group*
A	A1, A2, A3, A4, or none
B	B1, B2, B3, B4, or none
C	C1, C2, C3, or none

Data Character – At least one lead closed
 Rest Character – All leads open

* "None" implies no connection is made in that group.

3.122 The contact resistance measured from pin 7 through the closures to each of the data leads on the connector provided with the business machine must not exceed 10 ohms. The 401E will apply about 0.5 milliamperes peak ac to these closures.

3.234 Leakage resistance from pin 7 to each of the open data leads must be 400,000 ohms or greater. The data set may apply 1.5 volts peak ac between pin 7 and an open data lead.

3.124 The data set will present dc resistance ranging between 50 ohms and 500 ohms between pin 7 and the various data leads. The sum total of the dc current that the business machine may inject into the four data leads of either group must not exceed 1.0 ma.

3.125 Isolation is provided between the data circuit (data leads and common) and ground or other circuits. Data common may be, if desired, tied to the frame of the business machine, or to any other circuit point whose potential difference to ground does not exceed 50 volts peak.

3.126 Contact protection (RC networks) must not be provided for the data contacts because such protection would impair the performance of the data set.

3.127 An allowance of 300 ± 150 pf (mmf) has been made in the data set design for the stray capacitance between the data leads of the Reader. This capacitance should be measured as follows:

- A) Disconnect the business machine from the data set.
- B) Select one of the 11 data leads on the business machine interface connector.
- C) Short all the remaining leads together.
- D) Insure that contacts within the business machine associated with the selected data lead are open.
- E) Measure the capacitance between the selected data lead and the shorted array; it should be 150-450 pf (mmf).
- F) Repeat the procedure for each of the other 10 data leads.

3.13 Keying Contacts

3.131 The 401E provides two interface leads (pins 24 and 25) to be closed together by a contact in the business machine whenever data are to be transmitted. When this closure is made and the data set has been placed in the data mode by operating the data switch, the transmitter will deliver tones continuously to the telephone line. The tones that are applied are determined by the data contacts in the business machine. If all the data contacts in a group are open the "rest" tone in the group is activated. In the 401E system the "rest" tones have two functions. One or two "rest" tones when used with two or one "data" tones, form allowable data characters. The transmission of A, B, and C "rest" after data characters protect the system against possible interference by transmission echoes.

3.132 The data contacts may be closed before or after the keying contacts are closed. When the keying contacts alone are closed, the three "rest" frequencies will be transmitted. A data character will be transmitted only when the keying contacts and the appropriate data contacts have all been closed.

3.133 The data set will continue to deliver an output for 40 to 100 milliseconds after the keying contacts have been opened. If the keying contacts are to be opened at the end of a character, the data contacts should be opened with or before the keying contacts. Delays in opening data contacts will reduce the margin of echo protection. However, if this reduction in margin does not exceed 5 ms, no significant degradation in performance should occur.

3.134 The keying contacts must be opened to enable the 401E to receive answer-back signals.

3.135 The 401E will apply about 20 volts between open keying contacts and a surge current of about 250 ma through closed keying contacts. The time constant on the surge decay is about 10 milliseconds. The steady-state current will be no greater than 10 ma through closed keying contacts.

3.136 Series RC contact protection is supplied for the keying contacts by the 401E. Additional protection should not be used.

3.137 The keying leads must be electrically isolated from ground or other circuits in the business machine.

3.14 Timing of Contact Operations

3.141 Characters may be delivered to the 401E set at any rate up to and including 20 characters per second. Therefore, the duration of a character and an adjacent intercharacter rest interval, which together form the character period, must be at least 50 milliseconds. The character must be presented to the 401E set for at least 20 milliseconds. The adjacent intercharacter rest interval must also be at least 20 milliseconds.

3.142 Skew in the contact closures in the business machine refers to the time intervals between closures that nominally should occur simultaneously. If the receiving data set is a 401J type receiver, no skew limitations are specified. If the 403A data receiver is used no output is available until two tones have been received for 40 milliseconds.

3.15 Answer-back

3.151 There are two versions of the Data Set 401E type. One allows tone answer-back and the other provides a voice answer-back channel.

3.152 The 401E2 will deliver across the customer interface on pins 19 and 20, tones transmitted from the data receiver (data receiver is in answer-back mode).

3.153 The 401E3 provides for a one-way voice answer-back channel by way of the telephone handset receiver. No information is delivered to the customer over the answer-back leads on pins 19 and 20 of the interface.

3.154 A loudspeaker may be provided in the business machine to detect the answer-back tones from a 401E2. This speaker should have an ac impedance of 100 to 600 ohms at 1800 cps and a dc resistance of 0 to 35 ohms. A telephone receiver unit similar to the Western Electric type U1 receiver unit would be suitable.

3.155 The answer-back circuit of the 401E2 will deliver about 25 milliwatts into a 150 ohm load. Somewhat less power will be delivered to a higher impedance load.

3.156 Up to 20 ma dc may flow into the speaker through pin 20 and return to the data set through pin 19.

3.157 A shunt volume control across the speaker may be provided if desired.

3.158 The answer-back leads must be electrically isolated from ground and other circuits in the business machine.

4. SYSTEM OPERATION

The Data Sets 401A and 401E are manually operated in all cases. The receiving station may be attended or unattended. Operation with 401 and 403 type receivers explained below.

4.1 OPERATION WITH ATTENDED RECEIVING STATION

4.11 The call may be placed by a person at either the transmitting station or the receiving station in the same manner as a voice call. Calls are answered by lifting the telephone handset at the called station.

4.12 When both parties are ready to commence data transmission, they so signify by voice and operate the data switches on their sets to transfer them to the data mode.

4.13 When transmission is completed both parties replace the telephone handsets on their cradles. During a call, if the two parties wish to return to the voice mode, they may do so if they both return their data switches to the voice position.

4.2 OPERATION WITH UNATTENDED RECEIVING STATION

4.21 The party at the transmitting station originates the call in the conventional manner. The call will be automatically answered by the receiving station which will initiate an answer-back signal (the 401J receiver and 403A receiver) to notify both the calling station and any telephone operators involved that the call has been answered.

4.22 After the calling party hears the end of the answer-back signal in his receiver, he may then operate his data switch and commence the data transmission.

4.23 To end the call, the business machine at the transmitting station must send an end-of-call data code before the transmitting station hangs up. This signal is used to signal the business machine at the receiving station to open the Data Terminal Ready Lead (Line Control) to disconnect the receiving station. In the event this signal is not sent before hanging up, the central office may eventually recognize the call has ended and disconnect the receiving station. However, the customer may be annoyed by the unnecessary delay, and by interference caused by the presence of transient noise on the line.

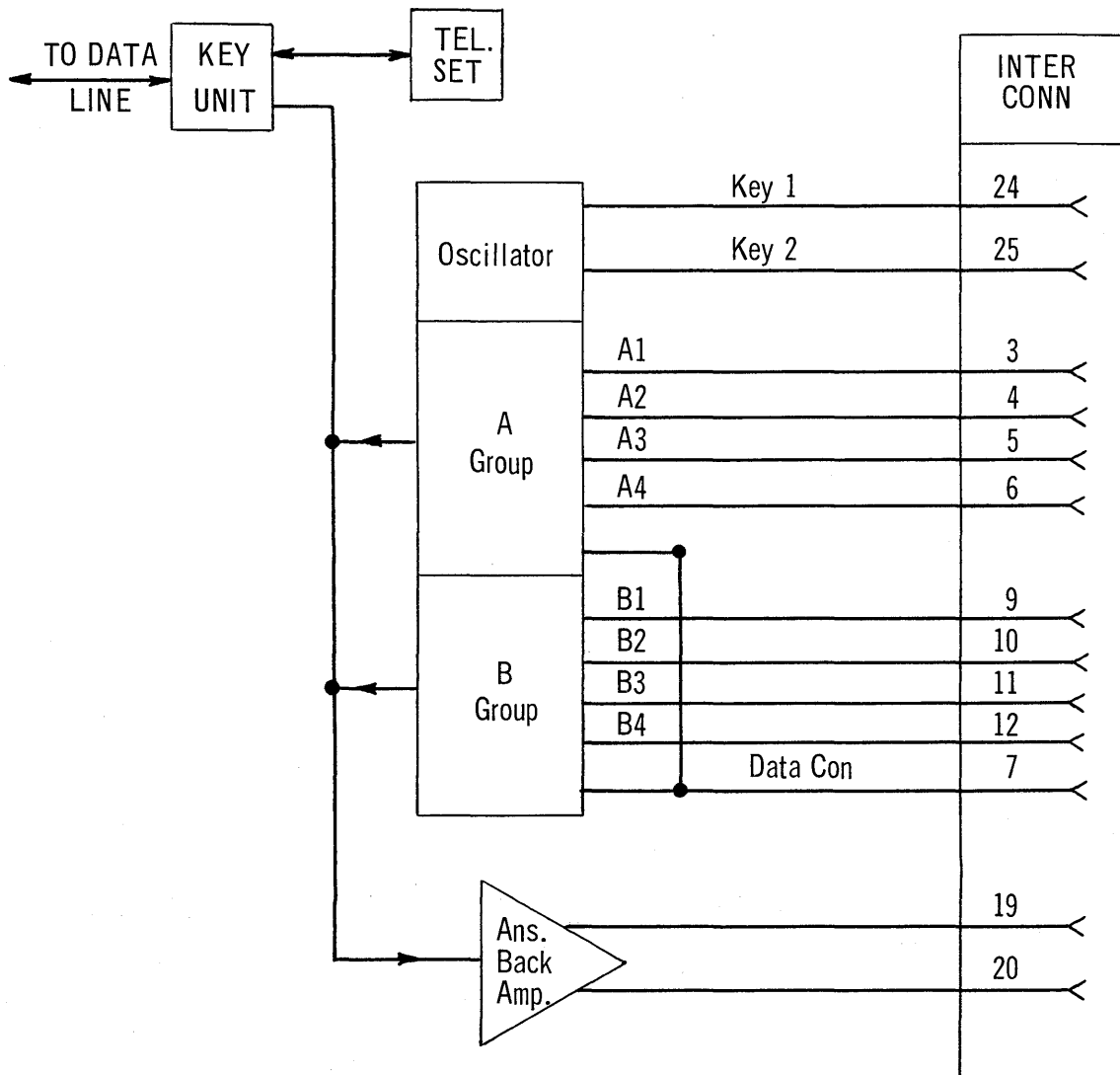


Figure 5 Data Set 401A Block Diagram

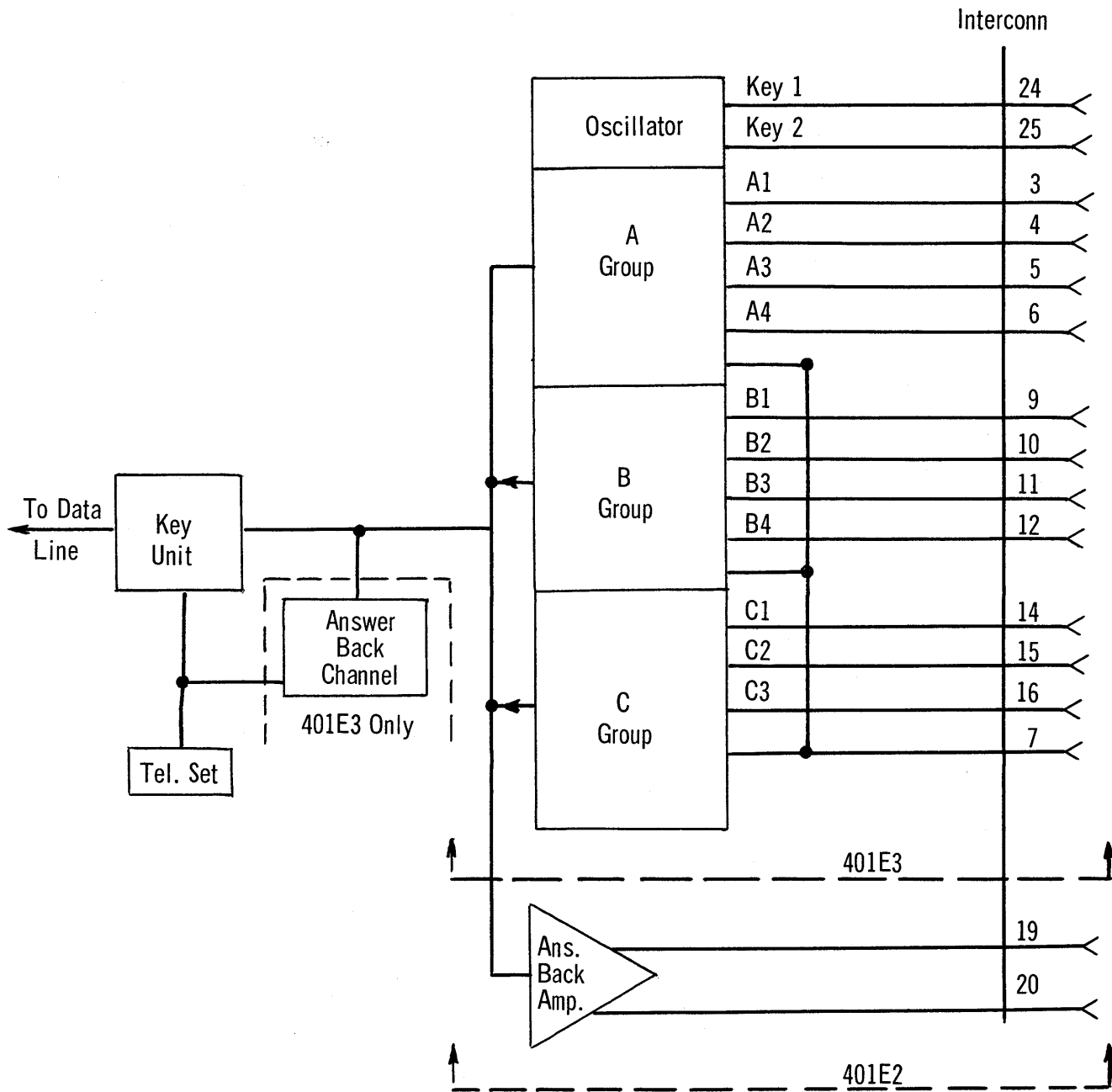


Figure 6 Data Set 401E Block Diagram

