

STATION SYSTEMS
KEY TELEPHONE SYSTEM NO. 1A2
"TOUCH-TONE[®]" ADAPTER CIRCUIT
TYPE D4

CHANGES

B. Changes in Apparatus (Components)

<u>B.1 Superseded</u>	<u>Superseded By</u>
Capacitor C18, App Fig. 1, KS-19066,L1, 0.022 μ F	Capacitor C18 App Fig. 1, KS-19066,L1 or KS-19774,L16 or KS-20977,L4, 0.022 μ F
Capacitor C25, App Fig. 1, KS-19066,L1, 3300 pF	Capacitor C25, App Fig. 1, KS-19066,L1 or KS-20977,L4 or KS-19774,L16, 3300 pF
Capacitor C9, App Fig. 2, 570 pF	Capacitor C9, App Fig. 2, 570 pF or KS-20676,L7 or 577A, 0.0232 μ F
Capacitor C10, App Fig. 2, 570 KR	Capacitor C10, App Fig. 2, 570 KR, KS-20676,L7 or 577A, 0.0205 μ F

D. Description of Changes

- D.1 The component list for four capacitors is changed to permit the use of more than one code for cost reduction purposes.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 4131-MS-EGS

STATION SYSTEMS
KEY TELEPHONE SYSTEM NO. 1A2
"TOUCH-TONE®" ADAPTER CIRCUIT
TYPE D4

CHANGES

B. Changes in Apparatus (Components)

B.1 Superseded

446B Diode CR8 - FS1 -
Module Ckt Board

Superseded By

808B Diode CR8 - FS1 -
Module Ckt Board

D. Description of Changes

D.1 The code of one diode is changed on a cost reduction basis.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 3232-GCB-OFG

STATION SYSTEMS
 KEY TELEPHONE SYSTEM NO. 1A2
 "TOUCH-TONE" ADAPTER CIRCUIT
 TYPE D4

CHANGES

B. Changes in Apparatus (Components)

<u>B.1 Superseded</u>	<u>Superseded By</u>
Resistor R30 - FS1 - Module Ckt Board KS-13491, L1, 560 ohms	Resistor R30 - FS1 - Module Ckt Board KS-20289, L6C, 562 ohms
Capacitor C16 - FS1 - Module Ckt Board 575B	Capacitor C16 - FS1 - Module Ckt Board 702C, 0.511 μ F
Capacitor C18 - FS - Module Ckt Board KS-19066, L1, 0.022 μ F	Capacitor C18 - FS1 - Module Ckt Board KS-20977, L4, 0.022 μ F
Capacitor C25 - FS1 - Module Ckt Board KS-19066 L1, 3300 pF	Capacitor C25 - FS1 - Module Ckt Board KS-20977 L4, 3300 pF
Capacitors C5-C8, C12-C14 - FS2 - Master Ckt Board 575B	Capacitors C5-C8, C12-C14 - FS2 Master Ckt Board 702C, 0.511 μ F

D. Description of Changes

- D.1 The code and value of one resistor (R30) is changed on a cost reduction basis.
- D.2 The code of ten capacitors is changed on a cost reduction basis.
- D.3 No record is kept of these changes because no 440A KTUs have been manufactured.

F. Changes in Description of Operation

- F.1 In SECTION I, 3.01, last table, add the following:

Digit	Pair
*	L4, H1
#	L4, H3

- F.2 In SECTION II, 5.03, add the following to TABLE A:

Digit	Output Lead(s)
*	XY
#	PP

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 4132-MS-RCC

STATION SYSTEMS
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SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 The TOUCH-TONE (TT) adapter circuit, coded the 440A key telephone unit (KTU), permits TT telephone sets to be used with the 1A2 key telephone system (KTS). The circuit is required to receive the voice-frequency TT signals generated by the subscriber station, recognize the frequencies which are present, and convert these frequencies into relay operations which provide proper signaling to the selected station.

1.02 The telephone transmitter may be exposed to speech or noise which contains energy at the TT signaling frequencies. The adapter circuit provides protection against false operation caused by such energy.

2. ENVIRONMENT

2.01 The TT adapter circuit type D4 is a plug-in unit consisting of two printed circuit boards bolted together and having electrical interconnections working with KTS No. 1A2. The use of this adapter permits the KTS No. 1A2 dial intercom to provide signaling by conventional dial pulses or TT signals.

3. SIGNALING CODE

3.01 TT signals are multifrequency signals consisting of one frequency from a low group and one frequency from a high group. The frequencies are:

Low Group		High Group	
Desig	Hz	Desig	Hz
L1	697	H1	1209
L2	770	H2	1336
L3	852	H3	1477
L4	941		

Thus the signaling code is a 4 by 3 code which can provide up to 12 unique pairs. Of these, ten pairs correspond to the ten tele-

phone set digits as follows:

Digit	Pair	Digit	Pair
1	I1, H1	6	L2, H3
2	I1, H2	7	L3, H1
3	I1, H3	8	L3, H2
4	L2, H1	9	L3, H3
5	L2, H2	0	L4, H2

4. GENERAL DESCRIPTION OF OPERATION

INPUT CIRCUIT

4.01 The input circuit of the TT adapter provides a high impedance termination while providing attenuation to longitudinally induced energy at power frequency harmonics and to dial tone originating from the 423A KTU. The input amplifier provides gain as well as impedance transformation.

CUT-APART FILTER

4.02 The cut-apart filter separates the multifrequency signal at the output of the input amplifier into its two component frequencies. The section which drives the low-group limiter rejects all frequencies above 1175 Hz. The section which drives the high-group limiter rejects all frequencies below 965 Hz.

LIMITERS

4.03 There is a separate limiter for each frequency group. Each limiter produces a square wave of fixed amplitude whose transitions occur at the zero voltage crossings of the incoming ac signal. Ideally, the input to the limiter is a single-frequency sinusoid. Thus, the limiter output consists of the fundamental and its odd harmonics. The output at the fundamental of a signaling frequency is large enough to operate the channel circuit. However, if a TT frequency is simulated by telephone speech or noise, a number of different frequencies will appear simultaneously at the input to the limiter. These extraneous frequencies act to reduce the level of a simulated TT signal frequency at the limiter output so that it is too small to operate the channel circuit. Thus, the limiters provide protection against false operation caused by speech and noise pickup. This is known as limiter guard action.

FREQUENCY RECCGNITION AND DETECTION

4.04 Each limiter connects to a group of series-resonant circuits, each of which in turn connects to a threshold detector circuit. The detector operates when the tuned circuit is exposed to a signal at or near its resonant frequency. The operating threshold of the detector is set about 2 dB below the

peak of the tuned circuit response, and the frequencies at which the tuned-circuit output just exceeds the threshold define the detector bandwidth. The operated detector turns on an output transistor which operates the channel relay.

TRANSLATION AND OUTPUT

4.05 The contacts of the seven channel relays are wired to translate the two-out-of-seven TT signaling code to the one-, two-, or three-out-of-five code required by the 407B or 424A KTU. In addition to outputs corresponding to the ten digits, outputs for TT signals generated by the eleventh and twelfth buttons of the TT dial are available for future use.

SECTION II - DETAILED DESCRIPTION

1. INPUT CIRCUIT - FS1

1.01 To prevent distortion of dial pulses, the input impedance of the TT adapter is relatively high. This is provided by the series combination of resistors R23, R24, and the 10,000-ohm input impedance of transformer T8. Capacitors C15 and C16 prevent direct current from flowing through the input transformer. These capacitors also provide some attenuation to longitudinally induced energy at power frequency harmonics and to the dial tone originating from the 423A KTU. Varistor RV3 suppresses large amplitude transients resulting from noise or dial pulses.

1.02 The required matching impedance of 600 ohms for transformer T8 is provided by the parallel combination of resistors R25, R26, and the input impedance of transistor Q15. Resistors R27 and R28 in series set the quiescent collector current and capacitor C17 eliminates the degenerative feedback of resistor R27. The voltage gain of transistor Q15 is approximately the resistance ratio of resistor R29 to resistor R28. Capacitor C18 causes the voltage gain of transistor Q15 to fall off at frequencies above 10,000 Hz. This prevents the development of high frequency spurious oscillations.

1.03 Transistor Q15 is directly coupled to transistor Q16, an emitter-follower which provides an output impedance of approximately 40 ohms. Resistor R30 sets the quiescent emitter current. The low output impedance, in series with resistor R31, provides the required input impedance for the cut-apart filters.

2. CUT-APART FILTER - FS1

2.01 This filter consists of a high-pass and a low-pass section for separating the multifrequency TT signal at the emitter of transistor Q16 into its two constituent groups.

2.02 The low-pass section, consisting of inductors L1 and L2 and capacitors C20 and C21, serves the low-group limiter and rejects all frequencies above 1175 Hz. The high-pass section consisting of inductor L3 and capacitors C19, C22, and C23 serves the high-group limiter and rejects all frequencies below 965 Hz.

2.03 The insertion loss in the rejection band is 17.5 dB or more for the low-pass filter and 12.5 dB or more for the high-pass filter. The nominal input and output impedances for both filter sections are 240 ohms.

3. LIMITER CIRCUITS - FS1

3.01 The low-group limiter (transistor Q17 and its associated components) is coupled to the cut-apart filter through the dc blocking capacitor C24. Resistors R32 and R33 bias the base of transistor Q17 midway between ground and the supply voltage and provide the termination for the low-pass section of the cut-apart filter. The emitter of transistor Q17 is approximately at base potential because of the low resistance of the base-emitter diode. The quiescent current through resistor R37 is the sum of the emitter current of transistor Q17 and the current supplied through varistor RV4 and resistor R40 in series. The voltage drop across resistor R37 (which is approximately half the supply voltage) is very nearly equal to the voltage drop across resistor R40, because varistor RV4 acts as a forward-biased diode at this point. Since resistor R40 has about twice the resistance of resistor R37, the direct current supplied through resistor R40 is half that in resistor R37. The other half of the current through resistor R37 is supplied by the emitter of transistor Q17. Since the transistor collector current is approximately equal to its emitter current, the direct current in resistor R36 is about half the current of resistor R37. Since both resistors have nearly the same value of resistance, the voltage drop of resistor R36 is half of that across resistor R37. Thus, the dc collector voltage of transistor Q17 is approximately one quarter of the supply voltage.

3.02 Varistor RV4 is composed of two oppositely-poled silicon diodes connected in parallel. The resistance of each diode is relatively large until a forward-bias of more than 0.5 volt is exceeded. Above this voltage the diode has a low resistance. The reverse bias on the normally conducting half of varistor RV4 (described below) does not exceed 0.5 volt. Therefore, the normally nonconducting half of the varistor has a high resistance. Because of this the varistor performs as a silicon diode in this application.

3.03 In the quiescent state outlined in 3.01, half of varistor RV4 is back-biased and the other half is conducting in the manner described. When a positive going ac signal

is present at the base of transistor Q17, the emitter also goes positive. This acts to back bias the conducting half of the varistor since capacitor C26 holds one side of the varistor at a fixed potential. Since the maximum signal which the adapter must handle does not result in a reverse varistor voltage exceeding 0.5 volt, the varistor may be treated as a reverse-biased silicon diode. Because current no longer flows through varistor RV4, the entire current through resistor R37 must now be supplied by the emitter of transistor Q17. Thus, the effect of a positive going ac base signal is to approximately double the emitter and collector current of transistor Q17.

3.04 When the ac signal at the base of transistor Q17 swings negative, the emitter-to-base junction of transistor Q17 is reverse-biased. This is because the emitter is held at a fixed voltage by current flowing from capacitor C26 and resistor R40 through varistor RV4 and resistor R37. Thus, the emitter of transistor Q17 is prevented from following the base, and both emitter and collector currents go to zero.

3.05 When the ac signal at the base of transistor Q17 is sinusoidal in form, the action described above results in a square wave at the collector. The limiter output is taken across varistor RV1 of FS2 which results in a second limiting action and also provides a low-impedance voltage source to drive the series tuned channel circuits. Capacitor C28 blocks direct current from flowing through varistor RV1 of FS2, and capacitor C25 prevents high-frequency parasitic oscillations.

3.06 Transistor Q18 and its associated components form the high-group limiter which is similar to the low-group limiter with one exception. The emitter capacitor C27 is smaller than its low-group counterpart, capacitor C26. This is due to the increased sensitivity of the limiter at the higher frequency signals.

4. FREQUENCY RECOGNITION AND DETECTION - FS2

4.01 Each limiter drives a group of series resonant circuits, each of which is associated with both a detector and an output circuit. These form seven channel circuits used to recognize the TT signaling frequencies and convert them to relay contact closures. Since the seven channel circuits differ only in minor details, a description of the 697-Hz channel L1 of FS2 will suffice to illustrate the operation of any of the channels.

4.02 With no 697-Hz signal applied, no voltage is developed across transformer T1, and the base of transistor Q1 is at ground. The emitter of transistor Q1 is at a negative potential of nominally 7.9 volts provided by the group bias supply (the high group bias is 7.5 volts), and the base-to-emitter junction

is back-biased so that the transistor is cut off. Capacitor C5 is discharged.

4.03 With a 697-Hz signal applied to the TT adapter, the limiter output contains the fundamental along with its odd harmonics. Since capacitor C1 and transformer T1 are tuned to this fundamental, a sinusoid will build up at the base of transistor Q1. When the base voltage reaches an instantaneous value which is slightly negative with respect to the biased emitter, current will flow into the collector circuit of the transistor. Similarly, when the instantaneous base voltage becomes positive with respect to the emitter, the transistor will cease to conduct. Thus the emitter bias provides a threshold value, which when exceeded permits a pulse of collector current to flow during a portion of each negative cycle of the input signal. During this period the low impedance of the forward-biased base-to-emitter junction clamps the transformer voltage at the threshold value.

4.04 The channel bandwidth is defined as the frequency range over which a detector responds to an input signal. Thus, the bandwidth is directly affected by the frequency response and hence the Q of the tuned circuit. Other factors which affect the channel bandwidth are the amplitude of the limiter output and the detector threshold level. These latter factors affect the bandwidth of every channel in a group, whereas the Q affects only the bandwidth of the associated channel. By providing a means of adjusting the tuned circuit Q, compensation is provided for various channel circuit parameters such as the gain of the detector and output transistors, the sensitivity of the channel relay, and component tolerances. The Q of the 697 channel is set by the value of resistor R1. This resistor is selected in manufacture to provide the proper bandwidth.

4.05 Once the Q adjusting resistor R1 is selected, the bandwidth is still subject to variation. This is because the relay sensitivity is a function of the supply voltage which may vary from -18 to -26 volts. Therefore, additional compensation is provided by the emitter-bias voltage of the first detector transistor, Q1. This bias sets the detector threshold level. Compensation is also provided for a narrowing of the channel bandwidth at high ambient temperatures. In this case, the variable component of bias voltage is developed across the series arrangement of resistor R42 and the parallel combination of resistor R46, thermistor RT1, and diode CR9. As the ambient temperature increases above 68°F, the resistance of thermistor RT1 decreases, reducing the magnitude of the detector threshold level. At room temperature and above, the voltage drop across the parallel combination is low enough so that the impedance of diode CR9 is high relative to resistor R46 and thermistor RT1; it therefore has negligible effect on the bias voltage. As the ambient temperature falls below 68°F, the resistance of RT1

increases, which tends to increase the bias voltage. This would produce an unwanted narrowing of channel bandwidth and a corresponding loss in sensitivity. However, as the voltage across the parallel combination increases, the impedance of diode CR9 decreases. The diode acts to clamp the voltage and prevents an excessive sensitivity loss. This also provides compensation for the effect of power supply voltage. In this instance, the bias voltage change with power supply variation is developed across resistor R42 and the parallel combination of diode CR9, resistor R46, and thermistor RT1. Compensation for the 5 percent variation in zener diode CR8 voltage is provided by the selection of resistor R44 during manufacturing tests.

4.06 As previously described, the operated detector sends a train of current pulses into the associated collector circuit. The capacitor in the collector circuit, which in this case is capacitor C5, is quickly charged and develops a voltage which is in the direction to forward-bias the base-to-emitter junction of output transistor Q5. Resistor R5 supplies base current and transistor Q5 conducts, thus operating channel relay L1. During the portion of the cycle when transistor Q1 is not conducting, transistor Q5 is held on by base current flowing through resistor R5 due to the discharge of capacitor C5.

4.07 Upon the removal of TT signals from the adapter input, a square wave no longer appears at the output of the limiter; thus, the tuned circuit response rapidly decays to a value below the threshold level. The detector transistor becomes nonconducting, and capacitor C5 discharges to the point where it is no longer able to keep transistor Q5, and consequently relay L1, operated. Capacitor C5 discharges completely through resistors R5 and R6. Diode CR1 protects transistor Q5 from the inductive voltage surge generated by the coil of relay L1. Use of the diode alone would make release of the relay too slow for proper circuit operation. Resistor R22 in series with the diode speeds the release of the relay. Resistor R22 is associated with all the other protective diodes and serves the same function.

5. TRANSLATION AND OUTPUT - FS2

5.01 The channel relays which are operated as discussed in 4.06 provide the contacts required for a two-out-of-seven to one-, two-, or three-out-of-five translation circuit in order to operate the appropriate relays in the selector circuit (407B or 424A KTU) of the KTS No. 1A2 Dial Selective Intercommunicating Line Circuit. The channel relays also provide an output corresponding to the eleventh and twelfth buttons of the TT station set. When two of the channel relays (one of the low group and one of the high group) are operated, a continuity path exists

between the input to the translation network and the proper output leads.

5.02 A ground input to the translation network is provided by the selector circuit on the RS1 lead. This ground is seen at the output of the translation network on the CG lead when the TT adapter is in the idle condition. When a TT station goes off-hook, ground is provided by the selector circuit on the TTG lead to power the TT adapter.

OUTPUT WITH A SINGLE-DIGIT DIAL CODE

5.03 When a TT signal corresponding to one of the digits 1 through 0 is received and associated channel relays operate, the ground output from the translation network is:

- (a) Removed from the CG lead.
- (b) Connected to the RH lead to inhibit operation of relay R in the selector circuit.
- (c) Connected to the output leads Y1 through Y5 according to Table A.

The relays in the selector circuit associated with these output leads operate to establish part of a ringing path to the selected station. When the TT signal is removed, the ground output of the translation network is:

- (a) Returned to the CG lead to hold the selected relays Y1 through Y5 in the selector circuit operated.
- (b) Removed from the RH lead.
- (c) Removed from the output leads Y1 through Y5.

Relay R in the selector circuit operates to complete a ringing path to the selected station and removes ground from the TTG lead. The TT adapter is inoperative for the duration of the call.

TABLE A

Digit	Output Lead(s)	Digit	Output Lead(s)
1	Y2	6	Y3, Y4, Y5
2	Y1	7	Y2, Y4, Y5
3	Y3, Y4	8	Y1, Y5
4	Y2, Y4	9	Y3, Y5
5	Y1, Y4, Y5	0	Y2, Y5

5.04 When a TT signal corresponding to the eleventh or twelfth button of a TT station set is received, the ground output of the translation network is removed from the CG lead and connected to the RH lead. It is also connected to the XY lead (via operated H1 and L4 contacts) or PP lead (via operated H3 and L4 contacts). When the TT signal is removed, the ground output of the translation

network is returned to the CG lead and removed from the RH lead and the XY or PP lead.

OUTPUT WITH A 2-DIGIT DIAL CODE

5.05 When a TT signal corresponding to the digit selected as the transfer digit (digits 1 through 0) is received, the operation of the TT adapter is the same as described in 5.03 up to the point where relay R in the selector circuit operates. After that point relay R in the selector circuit is prevented from operating by conditions within the selector, the signal leads are transferred to the 2-digit station signal leads, and relays Y release. When a TT signal corresponding to the second digit (digits 1 through 0) of a 2-digit code is received, the operation of the TT adapter is the same as described in 5.03. A ringing path is established in the selector circuit to the selected 2-digit station.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.01 The maximum station conductor loop resistance of the TT adapter circuit is 50 ohms.

1.02 When operating with the long line circuit (420A KTU), the maximum non-repeated station conductor loop is 500 ohms or 4-dB insertion loss (at 1000 Hz), whichever is limiting.

1.03 The power supply used with this circuit must maintain a voltage between a minimum of -26 volts and a maximum of -18 volts. The TT adapter battery shall be from the talk supply.

1.04 Current Drain: 0.16 ampere at -18 volts worst circuit condition.

2. FUNCTIONAL DESIGNATIONS

2.01 Leads

Designation	Meaning
CG	Counter Ground
HB	High Group Bias
HI	High Group Input
HFT	High Frequency Test
LB	Low Group Bias
LFT	Low Frequency Test
LI	Low Group Input
PP	PICTUREPHONE® Identification

RH	R Relay Hold
RS1	Reset
TTG	TOUCH-TONE Ground
XY	Unassigned
Y1, ...Y5	Counter Relay Selection

2.02 Relays

<u>Designation</u>	<u>Meaning</u>
H1,2,3	High Channel 1, 2, 3
L1,2,3,4	Low Channel 1, 2, 3, 4

3. FUNCTIONS

3.01 Receives multifrequency signals from a TT telephone set and converts the received tone signals into relay closures.

3.02 Provides translation from the two-out-of-seven TT signaling code to a one-, two-, or three-out-of-five code to provide the proper signaling input to the 407E or 424A KTU in the KTS No. 1A2 Dial Selective Intercommunicating Line Circuit.

3.03 Provides protection against false operation on speech or noise by the following means:

- (a) Limiter guard action.
- (b) Control of channel bandwidth.
- (c) Translation and logic which require the simultaneous closure of a low- and high-group contact for proper operation.

3.04 Provides a sufficiently high input impedance so that it may be bridged across a telephone loop without adversely affecting

the transmission or reception of dial pulses or other signals.

3.05 Meets signaling requirements and responds to TT signals under the following conditions:

- (a) A minimum signal amplitude across tip and ring of -10.3 dB (relative to 0.949 volt) at 697 Hz.
- (b) A maximum signal amplitude across tip and ring of +4.3 dB (relative to 0.949 volt) at 1477 Hz.
- (c) Variation in ambient temperature from 32°F to 130°F.

4. CONNECTING CIRCUITS

4.01 When this circuit is listed on a keysheet, the connecting information thereon is to be followed.

- (a) Key Telephone System No. 1A2 - Dial Selective Intercommunicating Line Circuit - SD-69567-01.

5. MANUFACTURING TESTING REQUIREMENTS

5.01 Manufacturing testing requirements are shown on a separate manufacturing drawing, A-314907.

6. TRANSMISSION INFORMATION

6.01 The maximum station conductor loop resistance of the TT adapter circuit is 50 ohms.

6.02 When operating with the long line circuit (420A KTU), the maximum non-repeated station conductor loop is 500 ohms or 4-dB insertion loss (at 1000 Hz), whichever is limiting.

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