STATION SYSTEMS
KEY TELEPHONE SYSTEM NO. 1A2
CO OR PBX LINE CIRCUIT
(INTEGRATED CIRCUIT TYPE)

TABLE OF CONTENTS PAGE

SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 This line circuit, when installed as appropriate in the 1A2 Key Telephone System, provides the means for:

(a) Signaling the subscriber station on a CO or PBX line.

(b) Holding the line.

(c) Indicating by visual signals that the line is being called, held, or is busy.

(d) Originating and holding outgoing calls.

(e) Time-out of locked in signals after incoming calls are abandoned.

1.02 The 400E (FS1) is an improved line circuit which replaces the 400D circuit (see SD-69513-01 for information on all other line circuits 400A, 400B, 400C, and 400D).

1.03 Transistor Q7 provides a constant voltage at terminal 13 to control the timing functions associated with capacitors C2, C4, and CT. Q7 also provides a constant current through reference diodes CR1 and CR2. Transistor Q8 is provided to improve the breakdown characteristics of the output transistor pair Q5 and Q6.

SECTION II - DETAILED DESCRIPTION

1. 400E LINE CIRCUIT - FS1

SIGNALING

A. Incoming Signal

1.01 In the idle circuit condition, all relays are in the unoperated state and transistors Q3, Q4, Q5, Q6, and Q8 are off. Transistors Q1 and Q2 are held on by current supplied to the base of Q1 through resistors RT1, RT2 (Z option not provided), and R4.

1.02 Ringing voltage is applied across the line with either side grounded. A bridged ringing detector is used and it does not require a ground return circuit to the CO or PBX. Ringing current flows through the series connected primary and secondary windings of relay L, resistor R2, and capacitor C1, causing relay L to operate on each half cycle of ringing current. The base of transistor Q1 is connected to -24 volts through R4, L relay contact 2-5, resistor R17, and diode CR10. Transistor Q1 is delayed from turning off by capacitor C3 for approximately 150 ms.

1.03 When transistors Q1 and Q2 turn off, the collector voltage of Q2 rises and Q3 turns on, diode CR3 breaks down, and transistors Q4, Q5, and Q6 turn on, operating relay B. Relay C does not operate at this time

since resistor R3 limits the current through its winding to less than its nonoperate value. Relay B operated connects ground to the ST lead, the L lead to the LF lead, and interrupted (option W) or steady (option T) ringing current or ground (option V) to the RC lead for audible signal control. Transistors Q1 and Q2 remain off and transistors Q3, Q4, Q5, and Q6 remain on until the call is answered or the circuit times out.

B. Time-Out of Ringup Circuit - Z Option Not Provided

1.04 When relay B operates, the negative end of charged capacitor CT is connected to resistor RT1 and through R4 to the base of Q1, holding Q1 off. During the interval that ringing is not present, capacitor CT discharges towards ground through resistors RT1 and RT2, driving the base of Q1 in a direction to turn Q1 on. If the L relay operates again before transistor Q1 turns on, capacitor CT charges again through the made B1 contact, the L contact, and resistor R17. If the L relay does not operate again, capacitor CT discharges to a point sufficient to turn on transistor Q1. The time it takes capacitor CT to discharge is approximately 20 seconds.

C. Time-Out of Ringup Circuit - Z Option Provided

1.05 This arrangement functions in a manner similar to that described in 1.04 with the exception that RT2 is short-circuited, thereby lowering the resistance through which capacitor CT discharges. This action results in a shorter time-out. The time-out period is approximately 6 seconds.

D. Provision for Reduced Time-Out

1.06 Shorter time-out can be obtained by shunting the RT1 resistor with an appropriate resistor R. The time-out desired as a fraction of the original time-out, TO, can be obtained by using the appropriate resistor R selected from Table A.

TABLE A

Time-Out Desired	R, Megohm
0.8	0.68
0.7	0.39
0.6	0.27
0.5	0.16
0.4	0.12

Adding resistance across resistor RT1 also reduces delayed hold release time (see 1.11). Resistance should be added across resistor RT1 only when the delayed hold release feature is not required.

E. Answering an Incoming Call - Busy State

1.07 An incoming call is answered by operating the pickup key associated with the line being rung and going off-hook. The station shunt is then connected across the line through the switchhook and key contacts, and ringing is tripped at the CO. Ground is also connected through the switchhook and key contacts to the A lead, causing relay A to operate. Relay A operated shunts terminals 1 and 3 of relay L, preventing it from operating on line current, connects the base of Q1 to terminal 12, and connects -24 volts through CR10 to the winding of relay C causing it to operate. Relay C operated removes capacitor C3 from the base of Q1 and connects resistor R16 across C3 causing it to discharge. Relay C operated also disconnects the negative end of CT and connects resistor R14 across CT causing it to discharge, opens the RC lead to discontinue local audible signaling. Due to base current through R15 and R4, transistor Q1 turns on immediately causing transistors Q3, Q4, Q5, and Q6 to turn off releasing relay B. Relay C also disconnects the ringup bridge from the line to remove the shunting impedance of R2 and C1 from the transmission circuit. Relays A and C operated maintains a talking path and connects the L lead to ±10 volts.

F. Outgoing Call - Busy State

1.08 The procedure for making an outgoing call is the same as that for answering an incoming call except that transistors Q3, Q4, Q5, and Q6 are normally off and relay B is unoperated.

HOLDING

1.09 A busy line can be placed on hold by operating the hold key on the telephone set. When the hold key is depressed, ground is disconnected from the A lead causing relay A to release. Relay A opens the base current path established when the relay operated; the base current path through resistors RT1 and R4 maintains transistor Q1 in the on state. The A contact that is shunting the L relay primary opens and, since the station shunt has not yet been disconnected from the line, the L relay operates on line current in series with the station shunt. Operation of the L relay contact causes the base circuit of Q1 to be connected through resistor R4 and diode CR10 to -24 volts. The voltage at the base of Q1 drops below the threshold voltage, Q1 and Q2 turn off, and transistors Q3, Q4, Q5, and Q6 turn on. Q5 and Q6 will have turned on about 0.5 ms after relay A releases, and a hold path is momentarily provided for relay C through R3, B6 break contact, Q5 and Q6, and CR10 to -24 volts.

Finally, relay B operates through Q5 and Q6. Relay B operated transfers resistor R3 to diode CR10 to provide hold current for relay C. Relays B and C operated (a) connect resistor R1 in series with the primary of relay L across the CO line to provide a holding path for the CO, (b) connect the LG lead to the ST lead, and (c) connect the L lead to the LW lead (Y option) or to ±10V (X option). When the hold key is released, the station shunt is disconnected from the line. Line current through the primary winding of relay L and R1 maintains the circuit in the hold state.

A. Release of the Holding Bridge by a Station

1.10 Any station of the key telephone system that seizes the line by operating the associated pickup key and going off-hook will cause the A relay to operate and shunt the primary winding of the L relay, which thereby releases. Relay A operated provides current through resistor R15 to immediately turn on transistors Q1 and Q2. Transistors Q3, Q4, Q5, and Q6 turn off releasing relay B. Relay C is held by operation of the Q relay. The circuit is thus restored to the busy state.

B. Release of the Holding Bridge from the CO or PBX

1.11 When in the hold state the circuit will bridge line current open for a period of (a) less than 20 ms or (b) less than 500 ms (R or Q option provided). The circuit will not release from the hold state when the line current is reversed. The duration of line current open required to release the circuit from the hold state is (a) greater than 90 ms, or (b) greater than 1 second (R or Q option provided). Interruption of the line current causes relay L to release. When relay L releases the negative end of charged capacitor C2 or C4 and C2 (R or Q option provided) is connected to resistor RT1, and through R4 to the base of Q1, holding Q1 off. During the line current open interval the capacitor discharges towards ground through resistors RT1 and RT2, driving the base of Q1 in a direction to turn Q1 on. If the L relay operates before transistor Q1 turns on the capacitors recharge and the circuit remains in the hold state. If transistors Q1 and Q2 turn on before the L relay operates, transistors Q3, Q4, Q5, and Q6 turn off and relay B releases. Relay B releasing restores the circuit to the idle state.

DISCONNECTION

1.12 When all stations go on-hook, the A lead is disconnected from ground causing relay A to release. Release of relay A opens the holding path for relay C which, in turn, releases. In this way, the circuit is restored to the idle state.

OPERATION WITH LOCAL POWER FAILURE

1.13 During periods when the local dc supply is inoperative, it is still possible to originate outgoing calls. When the station goes off-hook, connection to the line is metallic. The primary and secondary windings of the L relay are connected in series with R2 and C1 across the line, but this has a negligible effect on the talk circuit. Incoming calls are signaled by line ringers in the usual way, although visual and common audible signals are inoperative.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.01 The ringing ranges are shown in Table B.

TABLE B

Maximum Number of Ringers		Maximum Ringing Range (ohms)			
Minimum RMS Ring Voltage	Minimum Leakage Resistance	0	1	2	3
65	10	2250	1625	1150	850
72	10	3375	2250	1600	1250
80	10	4350	2750	2250	1625
84	10	5000	2875	2375	1850
84	20	6600	3750	2500	2100

1.02 The maximum dc current drain is 51 mA at 20V and 68 mA at 26V. The maximum drain occurs during the busy state.

2. FUNCTIONAL DESIGNATIONS

None.

3. FUNCTIONS

None.

4. CONNECTING CIRCUITS

4.01 All CO or PBX lines are connecting circuits.

5. MANUFACTURING TESTING REQUIREMENTS

5.01 These requirements are set forth in drawing A.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5335-AL-GES