STATION SYSTEMS
KEY TELEPHONE SYSTEM NO. 1A2
CO OR PBX LINE CIRCUIT

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SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 These line circuits, when installed as appropriate in the 1A2 key telephone system, provide the means for (a) signaling subscriber stations on a central office or PBX line; (b) holding this line; (c) indicating by visual signals that the line is being called, held, or is busy; (d) originating and holding outgoing calls, and (e) time-out of locked in signals after incoming calls are abandoned.

1.02 The 400A and 400B line circuits (FS1) have been discontinued and are included here only for reference. The 400B differs from the 400A only by the addition of diode CR4, which protects the system against false ringup due to power supply transients.

1.03 The 400C (FS2), which is a modification of the 400B, has also been discontinued. This line circuit is used where the transverse (between T and R) or longitudinal (between either T or R and ground) induced voltage may exceed 12 volts rms and cause the 400A and 400B circuits to ring up falsely. The 400C will not ring up falsely when the transverse/longitudinal voltage is less than 0/90, 12/70, 17/40, and 24/0 volts rms.

1.04 The 400D (FS3) is an improved line circuit which replaces the 400B and 400C circuits. It can be used for any 1A2 key telephone system CO or PBX line circuit application.

SECTION II - DETAILED DESCRIPTION

1. 400A AND 400B* LINE CIRCUITS (FS1)

A. Incoming Signal

1.01 When an idle circuit condition exists, all relays are in an unoperated condition and transistor Q1 is in a nonconducting state. Direct current is supplied to the base of transistor Q2 through resistors R10, R11, and R12. This current maintains the transistor in the conducting state. When ringing current is applied to the connecting line, the ac component flows through either capacitor C3 and resistor R3 or capacitor C4 and resistor R4 to the EBM5 contact of relay C to varistor RV1. The voltage limiting action of the varistor limits the peak signal voltage to approximately 10 volts. Diode CR3 rectifies the ac signal voltage, passing the positive cycles to the lead of capacitor C5. Base circuit current normally maintains this point at approximately -4 to -6 volts. The positive pulses cause the capacitor to increase in charge to a point where it becomes sufficiently positive to shunt the base current of transistor Q2. Capacitor C2 increases the switching time of the transistor so that it does not stop conducting immediately. This delay added to the time required to charge capacitor C5 as previously mentioned provides protection against false operation of the ringup circuit on disconnect or other transients. The collector of transistor Q2 will become negative when conduction ceases.

1.02 This potential is applied to the base of transistor Q1 through diodes CR2 and CR1. Diode CR1 is a zener-type diode that breaks down on approximately 6.2 volts. When transistor Q1 conducts, relay B operates. 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 signaling control. Ground is connected through resistor R5 to the winding of relay C, but the resulting current flow is insufficient to cause the relay to operate. Transistor Q2 will remain nonconducting and transistor Q1 conducting until the call is answered or timed out. Capacitor C6 bypasses higher frequency voltages induced into the line or which result from ac ground potential. It offers protection against false operation of the ringup circuit to 12 volts at 60 Hz. Resistor R6 forms a voltage divider with varistor RV1. The purpose is to maintain terminal 1 of diode CR3 negative in respect to terminal 2 so that the diode is back-biased. This arrangement isolates the base circuit bias of transistor Q2 from ground through varistor RV1.

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

1.03 The potential across capacitor C5, just before transistor Q1 conducts, is approximately 24 volts. The collector of the transistor will change from -24 volts to approximately ground when conduction begins. The - lead of capacitor C5 is also grounded, since it is connected to the same point. The potential across the capacitor remains 24 volts at this time. The difference is that the + side of the capacitor becomes +24 volts when the - side is grounded. The capacitor will discharge through resistors R11 and R10. Transistor Q2 will remain in the nonconducting state (as described in 1.01 and 1.02) until the capacitor discharges to a level that will permit sufficient current to flow in the base circuit to cause the transistor to conduct. Where an incoming call is signaled with a single ring, the time required

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*As described in CD-69476-01, Key Telephone System No. 1A2, 500-Type Key Service Unit.

to discharge to this level is approximately 26 seconds. Any additional ring received before this level is reached will reset this time to approximately 16 seconds. When the capacitor has sufficiently discharged, transistor Q2 will conduct. The collector will change from -24 volts to approximately ground. This removes the negative bias from the base circuit of transistor Q1 causing it to turn off. Relay B will release and the circuit is returned to the idle circuit condition.

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

1.04 This arrangement functions in a manner similar to the arrangement described in 1.03. The difference is that resistor R10 is shorted, lowering the resistance of the discharge circuit of capacitor C5. This results in shorter discharge times. On incoming calls where one ring is received, the discharge interval is approximately 15 seconds. The discharge time will reset to approximately 9 seconds on any additional ring received before the discharge cycle has been completed. Any incoming call, for example, which is signaled with machine ring will time out in approximately 9 seconds after the call is abandoned.

D. Answering an Incoming Call

1.05 An incoming call is answered by operating the pickup key associated with the line being rung and removing the handset from its mounting. Operation of the set switch hook connects ground through the pickup key to the A lead operating relay A. Relay A operated (a) prepares the talking path to the central office or PBX, (b) connects ground to the base circuit of transistor Q1 causing it to turn off and release relay B, and (c) connects ground to the winding of relay C causing it to operate. Relay C operated (a) completes the talking path, (b) connects the lamp lead to the lamp supply for visual signaling, (c) opens the RC lead to discontinue local audible signaling, and (d) provides a discharge circuit for capacitor C5 by connecting its + lead to the negative voltage through resistor R6.

OUTGOING CALL

1.01 The procedure for making an outgoing call is the same as that for answering an incoming call, except that transistor Q1 will be in a nonconducting state and relay B will be in the unoperated position.

HOLDING

1.07 An incoming or outgoing call can be held by operating the hold key in a telephone set that is associated with the line to be held. The operated hold key contact opens ground from the A lead, causing the release of relay A. Relay A released (a) connects the holding bridge (resistors R1 and R2) across the connecting line, (b) connects the station R lead to the base circuit of transistor Q1, (c) opens ground from the base lead of transistor Q1, and (d) removes ground from the L terminal of relay C. Relay C is slow to release as a result of the RC circuit shunted across its winding. A negative voltage, existing between resistors R1 and R2, supplies base current to transistor Q1 through the station shunt. The transistor will conduct and relay B will operate. Relay B operated (a) provides a hold path for relay C, (b) connects the LG lead to the ST lead to start or continue the signal interrupter operation, (c) connects the L lead to the LW lead (Y option) or to the lamp supply (X option) for visual signaling, and (d) connects the base circuit of transistor Q1 to the center of the hold bridge. The circuit will remain in this condition until a station connects to the line or the line is opened.

A. Release of the Holding Bridge by a Station

1.08 Any station of the key telephone system that seizes the line by operating the associated pickup key, with its handset off the hook, will cause relay A to operate over its grounded A lead. Relay A operated (a) removes the holding bridge from the line, (b) connects the station T and R leads to the line, and (c) connects ground to the winding of relay C and to the base of transistor Q1. The circuit is thus restored to a busy condition.

B. Release of the Holding Bridge from the Central Office or PBX

1.09 A permanent signal, caused by the hold circuit not being released by a station, can be released from the central office or PBX by opening the line momentarily to remove the negative bias from the base circuit of transistor Q1. This will cause the circuit to return to an idle circuit condition.

DISCONNECTION

1.10 Ground will be removed from the A lead when the station disconnects from the line, causing relay A to release. The release of relay A opens the holding circuit of relay C, causing it to release. The circuit is returned to an idle circuit condition in this manner.

OPERATION WITH LOCAL POWER FAILURE

1.11 Outgoing calls can be originated during periods when the local dc supply is inoperative. The station is connected to the line by break contacts of relays A and C when the receiver is removed from its mounting. Resistor R1 is in series with the station during power failure operation but does not affect the talk circuit. Incoming calls can be signaled by line ringers in the usual

manner. Common audible and separate audible signals will be inoperative, since relay B cannot operate.

2. 400C LINE CIRCUIT (FS2)

SIGNALING

A. Incoming Signal

2.01 In the idle circuit condition all relays are in the unoperated state, and transistors Q1, Q3, and Q4 are nonconducting. Transistor Q2 is conducting as a result of direct current supplied to the base of the transistor through resistors R10, R11, and R12.

2.02 When ringing voltage is applied to, for example, the ring side of the line R(CO) with tip, T(CO), grounded, the ac component flows through the portion of the bridge consisting of resistor R3, capacitor C3, resistor 15, and through varistor RV1. The voltage-limiting action of the varistor RV1 limits the peak signal voltage between the center of the bridge and ground to approximately 15 volts. When the potential across resistors R14 and R15 exceeds about 1.3 volts, transistor Q4 will conduct and provide a low-impedance path through the emitter-collector junction for positive ringing cycles. Positive current pulses will flow through Q4 to the EBM5 contact of relay C and through diode CR3 to the + side of capacitor C5. Base circuit current of Q2 normally maintains the + side of C5 at approximately -4 to -6 volts. The positive incoming pulses cause the capacitor to increase in charge to a point where it becomes sufficiently positive to shunt the base current of transistor Q2 causing it to cease conduction. Because of symmetry, the circuit operation will be similar when ringing voltage is applied to the tip side, TCO of the line with RCO grounded. In this case, Q3 will provide the path for ringing current.

2.03 Capacitor C2 increases the switching time of transistor Q2 so that it does not stop conducting immediately. This delay added to the time required to charge capacitor C5 provides protection against false operation of the ringup circuit on disconnect or from other transients. The collector of transistor Q2 will become negative when conduction ceases. This potential is applied to the base of transistor Q1 through diodes CR2 and CR1. (Diode CR1 is a zener-type diode that breaks down at approximately 6 volts.) Transistor Q1 will conduct, causing relay B to operate. Relay B operated connects ground to the ST lead, the L lead to the LF lead, and the interrupted (option W) or steady (option T) ringing current or ground (option V) to the RC lead, for audible signaling control. Ground is connected through resistor R5 to the winding of relay C, but the resulting current flow is insufficient to cause the relay to operate. Transistor Q2 will remain nonconducting and transistor Q1 conducting until the call is answered or timed out. Capacitor C6 across the bridge bypasses unbalanced high frequency transients induced into the line.

2.04 Resistor R6 forms a voltage divider with varistor RV1 to hold the emitters and bases of transistor Q3 and Q4 at about -15 volts. Since the + lead of capacitor C5 is at about -5 volts, diode CR3 is back biased. This tends to prevent leakage current from flowing through Q3 and Q4 to the bias circuit of transistor Q2 during the idle circuit condition. Resistor R16 assists by drawing off leakage current from Q3 and Q4, preventing this current from charging C5. Owing to the symmetry of the detector bridge, balanced inductive pickup appearing between tip and ground and between ring and ground will produce approximately equal and opposing voltages across resistors R14 and R15. As a result, the base-emitter voltage of transistors Q3 and Q4 will be close to zero and Q3 and Q4 will remain in the off condition, thereby preventing false ringup. The back-biasing effect of varistors RV3, RV4, RV5, and RV6 and the large ratio of R4 to R14 and of R3 to R15 permit the inductive pickup to be as large as 70 volts rms, and unbalanced by as much as 12 volts rms before sufficient bias is established to cause Q3 or Q4 to conduct.

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

2.05 Same as in 1.03.

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

2.06 Same as in 1.04.

D. Answering an Incoming Call

2.07 Same as in 1.05.

OUTGOING CALL

2.08 Same as in 1.06.

HOLDING

2.09 Same as in 1.07.

A. Release of the Holding Bridge by a Station

2.10 Same as in 1.08.

B. Release of the Holding Bridge from the Central Office or PBX

2.11 Same as in 1.09.

DISCONNECTION

2.12 Same as in 1.10.

OPERATION WITH LOCAL POWER FAILURE

2.13 Same as in 1.11.

3. 400D LINE CIRCUIT (FS3)

SIGNALING

A. Incoming Signal

3.01 In the idle circuit condition, all relays are in the unoperated state, and transistors Q2 and Q3 are off. Transistor Q1 is held on by current supplied to its base through the resistor network formed by RT1, RT2, R4, R8, R16, R11, and the B and C relay coils.

3.02 Ringing voltage is usually applied across the line with the tip side grounded. Ringing current then flows through the series connected primary and secondary of relay L, resistor R2, and capacitor C3, causing relay L to operate on each half Hz of ringing current. Ringing current also flows through C2 and R18 to terminal 2 of zener diode CR8. The - side of CT is normally maintained at about -16 volts. Negative half Hz of ringing cause CR8 to conduct in the forward direction so that terminal 2 of CR6 is at about -24.5 volts. CR6 is thus forward biased and the - end of CT charges through R3 toward -24 volts.

3.03 Positive Hz of ringing cause CR8 to break down so that terminal 2 of CR6 is at about 0 volt. The - end of CT is somewhere between -16 and -18 volts, so CR6 is reverse biased and CT does not charge. However, CT does discharge through the resistor network formed by RT1, RT2, R8, R11, R16, and the B and C relay coils. The charge lost by CT in this interval is much less than that gained during the negative half Hz. After about 0.3 second, a sufficient number of cycles of ringing will have charged CT to about -18 volts, the base potential of Q1, and Q1 thereby turns off. Because of the symmetry of the detector circuit, its operation will be the same when ringing voltage is applied across the line with the ring side grounded. In this case, ringing current flows to terminal 2 of CR8 through C5 and R17.

3.04 When Q1 turns off, its collector voltage rises and Q2 turns on; zener diode CR7 breaks down and Q3 turns on operating relay B. Relay C does not operate at this time since resistor R11 limits the current through its winding to less than its operate 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. Transistor Q1 remains off and Q2 and Q3 on until the call is answered or timed out.

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

3.05 At the instant Q1 turns off, the voltage at the - end of CT is about -18 volts. When the B relay operates, the voltage divider formed by resistors R14 and R15 is switched into the circuit, and the voltage at the + end of CT drops from 0 volt to about -6 volts. Consequently, the - end of CT drops from -18 to about -24 volts. On subsequent positive half Hz of ringing, CR6 will be reverse biased as before. Operation of relay B caused terminal 1 of CR5 to be connected back to -24 volts through resistor R8, transistor Q3, and diode CR4. Terminal 2 of CR5 is connected to the base of Q1, which is at about -24 volts so CR5 does not conduct. The discharge path for CT is thus only through resistors RT1 and RT2 to ground. On negative half Hz of ringing, CR6 will conduct slightly to restore the charge lost by CT during the previous positive half Hz. In this way, the charge on CT which determines the duration of the time-out remains constant once the circuit has operated regardless of the duration of the ringing burst.

3.06 When the first burst of ringing has ceased, the - end of CT begins to discharge towards ground through RT1 and RT2. Transistor Q1 remains off until the voltage at the - end of CT reaches -18 volts, at which time Q1 turns on and its collector voltage drops. This causes Q2, CR7, and Q3 to turn off and relay B to release, and the circuit is returned to the idle condition. The time required for the B relay to release after completion of a burst of ringing is approximately 30 seconds.

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

3.07 This arrangement functions in a manner similar to that described in 3.05 and 3.06 with the exception that RT2 is short circuited, thereby lowering the resistance through which capacitor CT discharges. This results in a shorter time-out. On incoming calls where one burst of ringing is received, the time-out is approximately 11 seconds. Subsequent bursts of ringing received before the B relay releases reset the time-out circuit to approximately 10 seconds. Any incoming call, for example, which is signaled with machine ringing will time out in approximately 10 seconds after the call is abandoned.

D. Provision for Reduced Time-Out

3.08 In cases where a shorter time-out than that obtained with the Z option is desired, this 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 the table below. Where the duration of machine ringing is 1 second, the time-out

shall not be reduced below 50 percent of the original time-out.

Time-Out Desired	R, megohm
3/4 TO	1.2
2/3 TO	0.75
1/2 TO	0.39
1/3 TO	0.20

E. Answering an Incoming Call - Busy State

3.09 An incoming call is answered by operating the pickup key associated with the line being rung and going off-hook. The station 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 switch hook and key contacts to the A lead, operating relay A, which shunts terminals 1 and 3 of relay L preventing it from operating on line current and connects -24 volts to the winding of relay C causing it to operate. Relay C operated disconnects the - end of CT from the base circuit of Q1 and connects resistor R6 across CT causing it to discharge. Transistor Q1 turns on immediately causing Q2 and Q3 to turn off and release relay B. Relay C also removes the center tap of the ringup bridge from the rest of the circuit, thereby preventing the introduction of noise into the talking path. It also disconnects the secondary of relay L and eliminates the shunting effect on the line of the secondary winding in series with R2 and C3. Relays A and C operated (a) establish the talking path, (b) connect the L lead to ±10 volts, and (c) open the RC lead to discontinue local audible signaling.

OUTGOING CALL - BUSY STATE

3.10 The procedure for making an outgoing call is the same as that for answering an incoming call except that transistors Q2 and Q3 are normally off and relay B is released.

HOLDING

3.11 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. The A contact shunting the L relay primary opens and, since the station has not yet been disconnected from the line, the L relay operates on line current. Operation of the L relay causes the base circuit of Q1 to be connected through resistor R3, diode CR6, and the operated C relay contact to -24 volts. The voltage at terminal 2 of the L relay contact drops to nearly -24 volts, causing Q1 to turn off and transistors Q2 and Q3 thereby turn on. Q3 will have turned on about 2 ms after relay A releases, and a hold path is thereby provided for relay C through R11, Q3, and CR4, to -24 volts. Finally, relay B operates through Q3. Relays B and C operated (a) connect the hold resistor R1 in series with the primary of relay L across the CO line, (b) connect the LG lead to the ST lead, and (c) connect the L lead to the LW lead (Y option) or to ±10 volts (X option). When the hold key is released, the station is disconnected from the line. Line current through the L relay and R1 maintains the circuit in the hold state.

A. Release of the Holding Bridge by a Station

3.12 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 of the L relay, which thereby releases. Transistor Q1 then turns on and Q2 and Q3 turn off releasing relay B. Relay C is held by operation of the A relay. The circuit is thus restored to the busy state.

B. Release of the Holding Bridge from Central Office or PBX - Open Circuit Line (ZC or ZD Option)

3.13 In the event a held party abandons, the line circuit can be released from the connecting switching equipment by providing an interruption of the line current of at least 20 ms (no option provided), 50 ms (ZD option), 500 ms (ZC option). This causes the L relay to release. Transistor Q1 thereby turns on, Q2 and Q3 turn off, and relays B and C release restoring the circuit to the idle state. The above times are valid with short time-out only.

C. Release of the Holding Bridge from the Central Office or PBX - Battery Reversal ZB Option Not Provided

3.14 If the voltage across the line is reversed when the line is in the hold state, the line circuit hold will be retired. Reversal of the line current causes the L relay to release and then immediately reoperate. When the L relay releases, Q1 turns on, Q2 and Q3 turn off, and relays B and C begin to release. The voltage at the collector of Q3 rises to nearly 0 volt, and CR5 conducts providing current to the base of Q1 through R8. After about 2 ms , the L relay reoperates and current is diverted from the base of Q1 through R4, R3, CR6, and the operated C relay contact to -24 volts. However, there is still sufficient current supplied through R8 to keep Q1 on so that Q2 and Q3 remain off and relays B and C therefore ultimately release restoring the circuit to the idle state.

DISCONNECTION

3.15 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

3.16 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 of the L relay are connected in series with R2 and C3 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.

4. 400D LINE CIRCUIT (FS4)

SIGNALING

A. Incoming Signal

4.01 In the idle circuit condition, all relays are in the unoperated state and transistors Q2 and Q3 are off. Transistor Q1 is held on by current supplied to its base through the resistor network formed by RT1, RT2, R4, R10, R9, and the B and C relay coils.

4.02 Ringing voltage applied across the line causes a current flow through the series connected primary and secondary of relay L, resistor R2, and capacitor C3, causing relay L to operate on each half Hz of ringing current. Relay L in operating on each half Hz of ringing current charges the negative end of capacitor CT through resistor R3 and diode CR4 toward -24 volts.

4.03 During the intervals when the L relay is released capacitor CT discharges through the resistor network formed by RT1, RT2, R10, R9, and the B and C relay coils. However, the charge lost by CT during these intervals is much less than that gained when the L relay is operated. After about 0.3 second, a sufficient number of cycles will have charged CT to the base potential of Q1, and Q1 turns off.

4.04 When Q1 turns off, its collecter voltage rises and Q2 turns on; zener diode CR7 breaks down and Q3 turns on operating relay B. Relay C does not operate at this time since resister R9 limits the current through its winding to less than its operate 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. Transistor Q1 remains off and Q2 and Q3 on until the call is answered or timed out.

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

4.05 At the instant Q1 turns off, the voltage at the negative end of CT is at the base potential of Q1. When the B relay operates, the voltage divider formed by resistors R14 and R11 is switched into the circuit, and the voltage at the positive end of CT drops from 0 volt to -6 volts. Consequently, the negative end of CT drops 6 volts to about -24 volts. Terminal 1 of CR5 is connected to -24 volts through transistor Q3 and diode CR4. Terminal 2 of CR5 is connected to the base of transistor Q1 through resistors R10 and R4 and since the base of Q1 is at about -24 volts CR5 does not conduct. Thus, the discharge path for CT is only through resistors RT1 and RT2 to ground. Continuous operation of the L relay restores the charge lost by CT when relay L is released. In this way, the charge on CT which determines the duration of the time-out remains constant once the circuit has operated regardless of the duration of the ringing burst.

4.06 When the first burst of ringing has ceased, the negative end of CT begins to discharge towards ground through RT1 and RT2. Transistor Q1 remains off until the voltage at the negative end of CT reaches the base potential of transistor Q1, at which time Q1 turns on and its collector voltage drops. This causes Q2, CR7, and Q3 to turn off and relay B to release, and the circuit is returned to the idle condition. The time required for the B relay to release after completion of a burst of ringing is approximately 30 seconds.

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

4.07 This arrangement functions in a a manner similar to that described in 4.05 and 4.06 with the exception that RT2 is short-circuited, thereby lowering the resistance through which capacitor CT discharges. This results in a shorter time-out. On incoming calls where one burst of ringing is received, the time-out is approximately 11 seconds. Subsequent bursts of ringing received before the B relay releases reset the time-out circuit to approximately 10 seconds. Any incoming call, for example, which is signaled with machine ringing will time out in approximately 10 seconds after the call is abandoned.

D. Provision for Reduced Time-Out

4.08 If a shorter time-out than that obtained with the Z option is desired, resistor RT1 is shunted 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 the table below. Where the duration of machine ringing is 1 second, the time-out shall not be reduced below 50 percent of the original time-out.

Time-Out Desired	R, Megohm
3/4 TO	1.2
2/3 TO	0.75
1/2 TO	0.39
1/3 TO	0.20

E. Answering an Incoming Call - Busy State

4.09 An incoming call is answered by operating the pickup key associated with the line being rung and going off-hook. The station 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, operating relay A which shunts terminals 1 and 3 of relay L preventing it from operating on line current and connects -24 volts to the winding of relay C causing it to operate. Relay C operated disconnects the negative end of CT from the base circuit of Q1 and connects resistor R6 across CT causing it to discharge. Transistor Q1 turns on immediately causing Q2 and Q3 to turn off and release relay B. Relay C disconnects the secondary of relay L and eliminates the shunting effect on the line of the secondary winding in series with R2 and C1. Relays A and C operated (a) establish the talking path, (b) connect the L lead to ±10 volts, and (c) open the RC lead to discontinue local audible signaling.

OUTGOING CALL - BUSY STATE

4.10 Same as in 3.10.

HOLDING

4.11 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. The A contact shunting the L relay primary opens and, since the station has not yet been disconnected from the line, the L relay operates on line current. Operation of the L relay cause the base circuit of Q1 to be connected through resistor R3 and diode CR4 to -24 volts. The voltage at terminal 5 of the L relay contact drops to nearly -24 volts, causing Q1 to turn off and transistors Q2 and Q3 to turn on. Q3 will have turned on about 2 ms after relay A releases, providing a hold path for relay C through R9, Q3, and CR4 to -24 volts. Relay B operates through Q3. Relays B and C operated (a) connect the hold resistor R1 in series with the primary of relay L across the CO line, (b) connect the LG lead to the ST lead, and (c) connect the L lead to the LW lead (Y option) or to ±10 volts (X option). When the hold key is released, the station is disconnected form the line. Line current through the L relay and R1 maintains the circuit in the hold state.

A. Release of the Holding Bridge by a Station

4.12 Same as in 3.12.

B. Release of the Holding Bridge from Central Office or PBX - Open Circuit Line (ZC or ZJ Option)

4.13 Same as in 3.13.

DISCONNECTION

4.14 Same as in 3.15.

OPERATION WITH LOCAL POWER FAILURE

4.15 Same as in 3.16.

SECTION III - REFERENCE DATA

1. WORKING LIMITS (400D LINE CIRCUIT)

1.01 Ringing Ranges

Maximum No. Ringers			0	1	2	3
App Fig. No.	Minimum RMS Ringing Voltage	Minimum Leakage Resistance (K)	Maximum Ringing Range (ohms)			
2	72	15	4446	1788	1119	814
	80	15	6062	2438	1526	1110
	84	15	6871	2763	1729	1258
	84	10	5140	2434	1594	1185
3	72	15	4060	1722	1093	800
	80	15	5537	2349	1490	1091
	84	15	6275	2662	1689	1237
	84	10	4799	2354	1560	1166
4	72	15	2408	1334	922	705
	80	15	3284	1819	1258	961
	84	15	3722	2062	1426	1090
	84	10	3148	1873	1333	1034

1.02 When a non-A lead control station bridged across the line dials into a CO or PBX, the resulting dial pulses may cause the line circuit to ring up falsely if there is a longitudinal voltage in excess of 35 volts rms present.

1.03 The maximum dc current drain at 20 volts is 53 mA and occurs during the busy state.

1.04 The station conductor loop resistance shall not exceed 50 ohms.

2. FUNCTIONAL DESIGNATIONS

None.

3. FUNCTIONS

None.

4. CONNECTING CIRCUITS

None.

5. MANUFACTURING TESTING REQUIREMENTS (400D LINE CIRCUIT)

5.01 These requirements are set forth in drawing A-835700.

SECTION IV - REASONS FOR REISSUE

B. Changes in Apparatus

B.1	Removed	Replaced By
	FS3	FS4

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D. Description of Changes

D.1 This change is made to provide two operational improvements:

(a) To eliminate the influence of ground impedances on the response of the line circuit to ringing signals.

(b) To protect against false ringup response due to sudden power supply voltage variations.

This change is also being made to provide a cost reduction.