STATION SYSTEMS
SWITCHING SYSTEM NO. 400
CABLING DIAGRAM

CHANGES

D. Description of Changes

D.1 On sheet A1, the sheet index is brought up to date.

D.2 On sheets A2 and A3 the lead index is brought up to date.

D.3 On sheet D-1 option ED for recorded telephone dictation trunk is added.

D.4 On sheets G4, 5 and G8-10 additional cross-reference information is added.

D.5 On sheet G7, lead DT required for recorded telephone dictation trunk, and cross-reference information are added.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 2120HW-RHO-WHK)
DEPT. 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
CABLING DIAGRAM

CHANGES

D. Description of Changes

D.1 All changes are made on a Class D - No Record basis per agreement with WECo for station make busy and TOUCH-TONE calling.

D.2 On sheet A1, the sheet index is brought up to date.

D.3 On sheet G4, G5 and G7 drafting errors are corrected on CAD's 4, 5, 6, 11 and 12.

D.4 On sheet G8, "E" option is added to TO straps on TS (PWR SUP) on CAD 15.

D.5 On sheet G9, CAD 16 is rated "Mfr Disc", CAD 17 is revised, and CAD 19 is added.

D.6 On sheet G10, CAD 18 is added.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7120HW-RHO-JGW)
DEPT 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
CABLING DIAGRAM

CHANGES

D. Description of Changes

D.1 CAD 2 is revised to redesignate lead "DT" as "DT(TT1 or LT2)".

D.2 CAD 17 is added for the application of TOUCH-TONE calling.

F. Changes in Sections

F.1 In SECTION III - CONNECTING CIRCUITS,

Add:

(ℓ) TOUCH-TONE Calling Receiver Applique Circuit - SD-66888-01.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-RAB-JGW)
DEPT 5337RAV

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
CABLING DIAGRAM

CHANGES

D. Description of Changes

D.1 On sheet A1, the sheet index is brought up to date.

D.2 On sheet A2, the MB lead is added to the lead index.

D.3 On sheet G2, portions of the leads are rated from A & M only to Mfr Disc on CAD 2.

D.4 On sheet G3, portions of the leads are rated from A & M only to Mfr Disc on CAD 3.

D.5 On sheet G4, "E" and "G" options are added to CAD 5; leads A0 to A17 and L are added to CAD 4; CAD 4 and 5 are rated from A & M only to Mfr Disc; a sheet note is added.

D.6 On sheet G5, T0 or MB0 to MB17 leads are added to CAD 6; "E" and "G" options are added; CAD 6 is rated from A & M only to Mfr Disc.

D.7 On sheet G6, portions of the leads are rated from A & M only to Mfr Disc on CAD 8; CAD 9 is rated from A & M only to Mfr Disc.

D.8 On sheet G7, A0 to A17 and L leads and "E" option are added to CAD 11; MB0 to MB17 and T0 leads and "E" and "G" options are added to CAD 12; a sheet note is added.

D.9 On sheet G8, "E" and "G" options and T0 and LW leads are added to CAD 15.

D.10 Sheet G10 is added and CAD 13 is relocated from sheet G7.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-PFD-JGW)
DEPT 5337-RAV

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
CABLING DIAGRAM

CHANGES

D. Description of Changes

D.1 CAD 1 is changed to rate wires to test post on slide 3 "Mfr. Disc." and to show new frame ground.

D.2 CAD 3 is changed to remove unused -48V FT lead and to show new frame ground.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-EWS-JGW)
DEPT 5337-RAV

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
CABLING DIAGRAM

SECTION I - GENERAL DESCRIPTION

1. GENERAL METHOD OF OPERATION

1.01 This cabling drawing shows the interconnection of each of the three equipment slides to (a) the other slides, (b) the Cabinet Crown cross-connecting terminal strips, and (c) the Call Progress Indicating Circuit.

SECTION II - DETAILED DESCRIPTION

None.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

None.

2. FUNCTIONAL DESIGNATIONS

None.

3. FUNCTIONS

None.

4. CONNECTING CIRCUITS

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

(a) Marker Circuit - SD-69468-01.

(b) Line, Link, and Connector Circuit - SD-69469-01.

(c) Dial Pulse Register Circuit - SD-69470-01.

(d) Alarm and Test Circuit - SD-69471-01.

(e) Junctor Circuit - SD-69464-01.

(f) Busy Tone Trunk Circuit - SD-69465-01.

(g) Key Telephone and Add-On Line Circuit - SD-69466-01.

(h) Auxiliary Relay Circuit for Direct Station Selection by Stations - SD-69467-01.

(i) Power Supply Circuit - SD-81577-01.

(j) Call Progress Indicating Circuit - SD-69472-01.

(k) TOUCH-TONE Calling Receiving Circuit - SD-67027-01.

SECTION IV - REASONS FOR REISSUE

D. Description of Changes

D.1 Add CAD 16 for the application of TOUCH-TONE calling.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5338-CRG-RVL

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
JUNCTOR CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. GENERAL METHOD OF OPERATION

1.1 The Junctor circuit is used to supply talking battery, and provide ringing and supervision on station-to-station and Dial Repeating Tie Trunk-to-station calls.

When the Marker is signaled by the register to set up a connection from a station or Incoming Dial Repeating Tie Trunk to another station it does so by connecting a link from the terminating end of the Junctor to the called station and another link from the calling station or Tie Trunk to the originating end of the Junctor.

When a register circuit signals the Marker to establish a connection using a junctor, it does so by connecting a link from the called station to the terminating end of a junctor and connecting the originating end of the Junctor to the link already connecting the calling station to the register.

Upon seizure the Junctor supplies a holding ground to hold the originating and terminating Hold Magnets as well as the originating and terminating Junctor Hold Magnets in the Link circuit. The Junctor also connects ringing current to the called line via the terminating link. When the called line answers, the Junctor trips the ringing and cuts through the transmission path. When the calling line disconnects the Junctor releases the originating link and calling Hold Magnet, and when the called line disconnects, the Junctor releases the terminating line and terminating Hold Magnet.

If the originating line disconnects but the terminating line fails to disconnect the Junctor will remain busy to the Marker even though the originating end of the connection is released. This feature is provided because the Marker tests the terminating end of the Junctor for a busy condition.

The Junctor furnishes reverse battery supervision in both directions.

SECTION II - DETAILED DESCRIPTION

1. SEIZURE

1.1 Operation of A Relay and Holding Connection

The Marker having received information from the register as to the called line number for a station-to-station or tie trunk-to-station call, proceeds to set up a connection to that line on a "Junctor Class" basis. A "Junctor Class" call requires a Junctor circuit to supply transmission battery to both parties.

The Marker tests the terminating hold magnets of the Junctors. Having found an idle Junctor the Marker SMT relay operates the terminating hold magnet for the Junctor and the hold magnet of the called line to connect them together over an idle link which has already been selected. Having established a connection to the called line, the Marker proceeds to operate the originating hold magnet of the Junctor which connects the Junctor to the same link used to connect the originating station or trunk to the Register. The Register then drops off the link. When the Junctor originating hold magnet operates to connect the calling line to the Junctor, the calling station loop is extended through crosspoints to the winding of relay A to battery and ground, and relay A operates. Relay A operates relay B. Relay B operated (1) closes ground through both sections of resistance A to the terminating link sleeve and to the originating link sleeve to hold the calling and called hold magnets and (2) closes holding ground to the originating and terminating Junctor hold magnets over leads OHM and THM respectively, to hold these operated after the Marker releases. Relay B is slow releasing in order to guard against momentary opens in the loop that would falsely drop the connection.

1.2 Start of Ringing

Ringing current, over Lead R1, through a make contact of A, through the primary winding and a break contact of tripping relay TP is applied to the ring conductor of the Junctor toward the called line. Ringing ground is connected and extended over lead Ring G through a break contact of Relay TP to the tip conductor of the Junctor toward the called line. Condenser A is providing to furnish audible ringing tone to the calling line.

2. RINGING TRIP AND CUT THROUGH

When the called party answers, the terminating loop operates relay TP. Relay TP operated, locks to ground through a make contact of B and transfers the terminating T and R leads from the ringing current supply to the windings of Relay D which operates. Relay D in operating reverses the originating and end T and R leads. This battery and ground reversal is of consequence on calls to local station lines from Tie Trunks, and on Key Telephone and Add-On Line Circuits, (See Paragraph 4) which require reversed battery type supervision. Relay D operated provides supplementary holding ground for the terminating link sleeve, the Junctor terminating hold magnet and relay TP. The Junctor supplies talking battery through relay A to the calling line or Tie Trunk, and through Relay D to the called line. The voice current path is complete through capacitors T and R.

3. RELEASE

3.1 Called Party Does Not Answer

When the calling line or tie trunk disconnects, Relay A releases. Relay A released, removes ringing current from the terminating T and R leads and releases Relay B. The release of Relay B removes ground from leads SO, ST, OHM and THM which releases the originating and terminating hold magnets of the Junctor and the hold magnets of the associated line.

3.2 Calling Party Disconnects First

Relays A and B release as described in Paragraph 3.1 but Relay D is held operated over the called station loop and only the originating end of the Junctor will release. This condition will prevail until the called party hangs up at which time, the release of Relay D releases Relay TP, opens up the terminating ST lead and also opens up the THM lead thereby releasing the terminating hold magnet, restoring the Junctor to normal.

3.3 Called Party Disconnects First

Relay D releases as described in Paragraph 3.2 but the Junctor terminating hold magnet, and Relay TP cannot release until the supplementary holding grounds supplied by operated Relay B are removed. When the calling party hangs up Relays A and B release and the Junctor restores to normal as described in Paragraph 3.1.

4. USE OF JUNCTOR WITH KEY TELEPHONE ADD-ON CIRCUIT

When a junctor is used on an incoming call from a central office line which was extended to a local station via a Key Telephone Add-On circuit, the called party hanging up releases the D relay causing a reversal of the battery and ground toward the Add-On circuit. This causes a relay in the Add-On circuit to function, releasing the circuit. When a junctor is used on an outgoing call from a station the calling party in hanging up releases the A relay which reverses battery and ground toward the Add-On circuit to release a relay and restore that circuit to normal.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.1 Maximum external circuit loop is 1410 ohms.

1.2 Voltage limits are: 45 to 52 volts dc.
75 to 110 volts ac.

2. FUNCTIONS

2.1 To respond to seizure and supply holding ground for the originating hold magnet and the terminating hold magnet under control of the calling station loop.

2.2 To supply ringing to the called station and audible ringing tone to the calling station.

2.3 To recognize that the called station has answered and to cut through the transmission path supplying transmission battery to both lines.

2.4 To reverse the battery and ground toward the calling end as an answered signal to Tie Trunks requiring reverse battery supervision.

2.5 To reverse the battery and ground toward the calling and called end to provide for the release of the Add-On circuit upon completion of a call.

2.6 To recognize when either party disconnects, and to hold itself busy to the Marker circuit until both parties hang up.

3. CONNECTING CIRCUITS

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

3.1 Marker SD-69468-01

3.2 Line, Link and Connector Circuit, SD-69469-01

3.3 Power Supply Circuit, SD-81577-01

4. MANUFACTURING TEST REQUIREMENTS

4.1 The Junctor Circuit shall be capable of performing all the service functions specified in this circuit description and meeting all the requirements in the Circuit Requirements tables.

5. TAKING EQUIPMENT OUT OF SERVICE

5.1 To make the Junctor busy, it is necessary to ground the (THM) lead toward the Marker Circuit. This can be accomplished as follows: Ascertain that no select magnet is operated and block the D relay operated.

6. ALARM INFORMATION

6.1 Fuse Alarm

An operated fuse supplying the Junctor circuit is indicated by an alarm at the Plant Service Center, if alarm transmitting features are provided and, in any case, by a visual signal locally. Replace the operated fuse to silence the alarm and extinguish the visual alarm signal.

SECTION IV - REASONS FOR REISSUE

CHANGES

B. CHANGES IN APPARATUS

B.1. Removed

D-Diode - KS-15724, L1

D. DESCRIPTION OF CIRCUIT CHANGES

D.1. The D diode is removed to correct an inoperative condition. The wiring around the T and R capacitors has also been changed.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 5332-PB-HFH-DDT

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
BUSY TONE TRUNK CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. GENERAL METHOD OF OPERATION

1.1 When a station line or trunk originates a call to another station line or trunk and the called station line or trunk is tested busy, the marker will route the call to the Busy Tone Trunk circuit.

When the Busy Tone Trunk is seized, it provides a ground to hold the station or trunk hold magnet and the Busy Tone Trunk hold magnet operated under control of the calling station loop or trunk.

SECTION II - DETAILED DESCRIPTION

1. SEIZURE

When a station line or trunk originates a call to another station line or trunk and the marker finds it busy, the marker will function to establish a connection between the falling station or trunk and the Busy Tone Trunk. When the marker completes this connection, the A relay in the Busy Tone Trunk circuit will operate over the loop from the station or trunk bridge. Operation of the A relay operates the RA relay, which connects ground to the link sleeve to hold the originating hold magnet operated, and provides direct ground to the Busy Tone Trunk hold magnet HM in the link circuit.

Relay RA is made slow to release to prevent the release of the connection should the calling station continue to dial. This release could occur if the calling station dialed a 2-way dial repeating tie trunk and assumed it was idle and, without listening for the dial tone, continued to dial. Since the RA is slow to release the station would only pulse the A relay.

The tone generator in the power supply circuit supplies busy tone over lead BT to condenser A of this trunk. Busy tone is passed through this condenser to the ring conductor of the trunk.

2. RELEASE OF BUSY TONE TRUNK

When the calling station line or trunk disconnects in response to the busy tone signal, the originating station loop or trunk bridge is opened and relay A releases. Relay A releasing causes relay RA to release which removes the locking ground from

the link sleeve to release the calling line hold magnet and removes ground from the Busy Tone Trunk magnet restoring the circuit to normal.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.1 Maximum external circuit loop is 2370 ohms.

1.2 Voltage limits are 45 to 52 volts.

2. FUNCTIONS

2.1 To respond to a seizure and provide a holding ground for the calling station or trunk hold magnet and the Busy Tone Trunk hold magnet.

2.2 To return Busy Tone to the calling station or trunk.

2.3 To release the calling station line or trunk line hold magnet and Busy Tone Trunk hold magnet when the calling line or trunk disconnects, and to return to normal.

3. CONNECTING CIRCUITS

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

3.1 Marker Circuit - SD-69468-01.

3.2 Line, Link, and Connector Circuit - SD-69469-01.

4. MANUFACTURING TEST INFORMATION

4.1 The Busy Tone Trunk shall be capable of performing all the functions specified in this circuit description and meeting all the requirements of the Circuit Requirements table.

5. TAKING EQUIPMENT OUT OF SERVICE

5.1 In order to take the Busy Tone Trunk out of service it is necessary to ground the HM lead toward the marker circuit. The following procedure shall be followed. Verify that no select magnet is operated than block relay RA operated.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 5332-PB-HFH-LF

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
KEY TELEPHONE LINE AND
ADD-ON CIRCUIT

CHANGES

D. Description of Changes

D.1 On sheet 1, the sheet index is brought up to date.

D.2 On sheet 2, circuit notes 102, 104, equipment note 202 and information note 305 are corrected.

D.3 On sheet 5 App. Fig. 7 M designation changed to M or MB.

D.4 On sheets 8 and 9, ratings on CAD's 1, 2, 6 and 7 are changed from "Mfr. Disc." to A&M Only.

D.5 On sheet 13, CAD 12, leads 1U and 1L to relay MB are reversed.

D.6 On sheet 14, CAD 14, leads S and S1 designations are assigned to leads from relays MB.

D.7 Above changes (D.2-D.6) are made on a class D - No Record basis per agreement with WECo.

D.8 On sheet 2, Information Note 308 is added.

D.9 On sheet 11, cross-reference information is added to CAD 9.

D.10 On sheet 12, option 7 on CAD 10 and sheet note 1 are added.

D.11 On sheet 13, cross-reference information is added on CAD 12.

D.12 On new sheet 15, CAD 15 is added for installer information.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 212OHW-RHO-WHK)
DEPT 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
CABLING DIAGRAM

CHANGES

D. Description of Changes

D.1 All changes are made on a Class D - No Record basis per agreement with WECo.

D.2 On sheet 2, Note 306 is revised and Notes 204 and 307 are added.

D.3 On sheet 5, App. Fig. 6 was part of App. Fig. 5 and App. Fig. 7 is added.

D.4 On sheets 4, 9 and 10 drafting errors are corrected.

D.5 On sheet 8, CAD's 1 and 2 are rated "Mfr Disc".

D.6 On sheet 9, CAD's 6 and 7 are rated "Mfr Disc".

D.7 On sheet 10, G-G1 cross-connect information is removed.

D.8 CAD's 8 through 13 are revised.

D.9 CAD 14 is added for station make busy cross-connect information.

D.10 Sheets 13 and 14 are added.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7120HW-RHO-JGW)
DEPT 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
KEY TELEPHONE LINE AND
ADD-ON CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 This add-on circuit with two line circuits provides a means of connecting a central office line to a local station at a key telephone set where the central office line appears.

1.02 Line circuits not required for association with add-on circuits can be used as part of a 1A1 key telephone system installation.

2. GENERAL METHOD OF OPERATION

2.01 An incoming call produces a 60-ipm flashing line lamp and audible signal at the key telephone set.

2.02 With the receiver off hook, operation of the pick-up key associated with the visual signal silences the audible signal and connects the key telephone station of the calling party. The line lamp is transferred from 60-ipm to steady.

2.03 A line circuit may be placed on hold by the operation of the HOLD key on the key telephone set. The line lamp is transferred from steady to 120-ipm wink.

2.04 A central office line and station line may be capacitive coupled via the add-on circuit by the operation of a transfer (TR) key on the key telephone set when one line circuit is on hold and ringing induction is heard or the called party has answered on the other line. A ringing local station is indicated by a 30-ipm flashing line lamp.

2.06 If an incoming call is not answered at a key telephone set, a time-out circuit will release the R relay in about 30 to 45 seconds. After time out, the R relay will follow incoming ringing.

SECTION II - DETAILED DESCRIPTION

1. INCOMING CENTRAL OFFICE OR STATION CALL TO KEY TELEPHONE SET

A. Ring-Up Circuit

Ground Ringing - V Option

1.01 Ringing current applied to the ring of the line flows through a break contact of relay AH, capacitor R, thermistor R and on one-half cycle through diode R to ground. The other half-cycle is blocked by diode R causing current to flow through the secondary of relay R to ground.

1.02 Contacts of relays A and AH shunt relay H and varistor H to bypass ringing current preventing the establishment of a false hold condition which might otherwise occur when a number of ringers are bridged across the station side of the line.

1.03 Thermistor R has a cold resistance of approximately 50,000 ohms to prevent false line signals from operating relay R. Ringing current heats thermistor R reducing its resistance to approximately 3,000 ohms in about 1/2 second. This permits a sufficient current flow to operate relay R on the half-wave rectified current.

1.04 Relay R operated:

(a) Locks operated on its primary winding under control of relay AH and the time-out circuit.

(b) Grounds lead TO starting time-out timing.

(c) Connects 60-ipm lamp supply to flash line lamp.

(d) Connects ringing supply to the common ringer of the key telephone set, if provided.

1.05 Varistor R1 protects diode R and thermistor R by providing a shunt path for transient currents.

Metallic Ringing - X Option

1.06 Operation of the circuit using metallic ringing return is the same as for grounded ringing except that ringing is returned to the tip of the line instead of to ground. This arrangement is designed to reduce noise due to cooling of thermistor R and/or potential differences.

B. Answering an Incoming Call

1.07 An incoming call is answered by operating the pickup key associated with the line being rung and removing the handset from its on-hook condition. The operated telephone switchhook and pickup key extends the A1 ground via lead A operating relay A.

1.08 Relay A operated:

(a) Operates relay AH.

(b) Transfers the line lamp from 60 ipm to steady.

(c) Opens the operating path of relay H.

(d) Prepares a path to operate relay W via lead SG if the line circuit is used as an add-on circuit adjunct.

1.09 Relay AH operated:

(a) Disconnects the ring-up circuit from the ring of the line.

(b) Releases relay R silencing audible ringing.

(c) Grounds lead CO operating relay TO to stop time-out timing.

(d) Prepares a path to transfer line lamp from steady to 120-ipm wink (H option).

1.10 With the handset off-hook and the pickup key operated, tip and ring connections between the key telephone station and the calling party are completed.

2. OUTGOING CALL FROM A KEY TELEPHONE STATION

2.01 Operation of a central office or station line pickup key and removing the handset from its on-hook condition extends the A1 ground to the associated line circuit via lead A operating relay A.

2.02 Relay A operated:

(a) Operates relay AH.

(b) Lights station line lamp steadily.

(c) Opens the operating path of hold relay H.

2.03 Relay AH operated:

(a) Operates relay TO preventing time-out timing.

(b) Opens the operating and locking path of relay R.

(c) Prepares a path to transfer line lamp from steady to 120-ipm wink.

2.04 With the handset off-hook, central office dial tone will be returned to the key telephone station with a central office line pickup key operated or switching system 400 dial tone with a station line pickup key operated.

3. HOLDING

A. Key Telephone Station Holds Call

3.01 An incoming or outgoing call may be held by operating the HOLD key in the telephone set. This removes the ground from lead A releasing relay A.

3.02 Relay A released:

(a) Inserts relay H in the ring side of the loop causing it to operate on line current.

(b) Removes battery from the slow releasing AH relay.

(c) Transfers line lamp from steady to 120-ipm wink (H option).

(d) Opens lead SG to add-on circuit, if provided.

3.03 Relay H operated:

(a) Reconnect battery to relay AH prior to its release.

(b) Places a holding bridge across the line.

3.04 Release of the HOLD key mechanically releases the operated pickup key. The key telephone station is disconnected from the held line.

3.05 Varistor H stabilizes the sensitivity of the H relay circuit when subjected to varying voltages.

B. Release of Holding Bridge

3.06 With the receiver off hook, re-operation of the line pickup key reoperates relay A.

3.07 Relay A operated:

(a) Transfers line lamp from 120-ipm wink to steady.

(b) Removes relay H from the ring of the line releasing it.

3.08 Relay H released removes the holding bridge from the line restoring the talking path.

4. DISCONNECTION

4.01 When a key telephone station disconnects on an incoming or outgoing call, relay A releases releasing relay AH which restores the circuit to normal.

5. OPERATION OF THE ADD-ON CIRCUIT

5.01 A talking connection can be established between the central office and a local station by a key telephone station when the central office and station line circuits are used as add-on circuit adjuncts.

5.02 After placing the central office line (or station line) on hold and operating the pickup key of the associated station line (or central office line), the desired number is dialed. Transfer may be completed immediately upon hearing ringing induction or after the called station answers.

A. Bridging the Station and Central Office Lines

5.03 Operation of the transfer (TR) key on the key telephone set grounds lead SG operating relay W via lead SG1 (with relay A of the line circuit used for dialing operated). The operated TR key provides a shunting ground for relay Z upon the operation of relay W.

5.04 Relay W operated:

(a) Locks operated on its secondary winding.

(b) Prepares its release path over the primary winding.

(c) Prepares an operating path for relay Z.

(d) Prepares a locking path for relay S1.

(e) Prepares a path to cut through the central office line tip and ring to the 1-2 winding of inductor TR upon the release of relay H (incoming).

(f) Cuts through the central office line tip and ring to the 1-2 winding of inductor TR and capacitors T and R (outgoing).

(g) Shunts central office line relay H releasing it (incoming).

(h) Transfers central office line lamp from 120-ipm wink to steady (incoming - option H).

(i) Provides an alternate lamp supply upon the release of central office line relay A (outgoing).

5.05 Central office line relay H released (incoming):

(a) Releases relay AH.

(b) Removes the central office line holding bridge cutting through the tip and ring to inductor TR and capacitors T and R.

5.06 The release of key TR removes the shunting ground from relay Z via lead SG1 permitting its operation.

5.07 Relay Z operated:

(a) Prepares a release path for relay W under control of the key telephone station.

(b) Cuts through the station line tip and ring to capacitors T and R (incoming).

(c) Prepares a path to cut through the station line tip and ring to capacitors T and R upon the release of relay H (outgoing).

(d) Shunts station line relay H releasing it (outgoing).

5.08 Station line relay H released (outgoing):

(a) Releases relay AH.

(b) Removes the station line holding bridge cutting through the tip and ring to capacitors T and R.

5.09 Upon cut through of the station line, relay S in series with diode T provides answer supervision and diode W in series with the 3-4 winding of inductor TR provides a holding bridge for the junctor.

Outgoing Call or Incoming: Local Station Answered

5.10 With relay Z and relays A and D in the junctor circuit operated, relay S operates on line current. Relay S operated operates relay S1.

5.11 Relay S1 operated:

(a) Removes the 3-4 winding of inductor TR from the circuit.

(b) Places the primary winding of relay W in series with diode W across the station side of the line for disconnect supervision.

(c) Locks operated under control of relay W.

(d) With relay Z operated, provides an alternate lamp supply upon disconnect of the key telephone station (incoming) or the release of station line relay AH (outgoing).

Incoming: Local Station Ringing

5.12 With the local station ringing, relays S and S1 are released. Relay S1 released flashes the station line lamp at 30 ipm upon the release of the key telephone station.

5.13 When the called station answers, junctor relay D operates. This reverses battery and ground, operating relay S. Relay S operated operates relay S1.

5.14 Relay S1 operated:

(a) Removes the 3-4 winding of inductor TR from the circuit.

(b) Places the primary winding of relay W in series with diode W across the station side of the line for disconnect supervision.

(c) Locks operated under control of relay W.

(d) With relay Z operated, transfers the station line lamp from 30-ipm flashing to steady if the key station has disconnected.

5.15 With relays Z and W operated and line relay H released, the central office and station line circuits are bridged by capacitors T and R establishing a talking path between the central office and local station parties.

B. Key Telephone Station Disconnects

5.16 The key station may disconnect after the release of the TR key. Upon disconnect, relay A of the line circuit used for dial tone releases releasing relay AH. Relay AH released will release relay TO if no other line circuit relay AH is operated.

C. Disconnection of Extended Call

Automatic Disconnect

5.17 When the local station hangs up, junctor relay A or D releases. This reverses battery and ground to the station side of the add-on circuit, releasing relay S. Diode W permits current to flow through the primary winding of relay W. This overcomes the secondary winding current effect releasing relay W.

5.18 Relay W released:

(a) Removes the 1-2 winding of inductor TR and capacitors T and R from the central office line circuit resulting in the release of the central office.

(b) Extinguishes the central office line lamp.

(c) Releases relay S1.

(d) Releases relay Z.

(e) Opens the paths through its primary and secondary windings.

5.19 Relay Z released:

(a) Opens the tip and ring towards the station line releasing any operated junctor circuit relays.

(b) Extinguishes the station line lamp.

5.20 The add-on circuit is now restored to normal. With relay W released, the central office line circuit is normal. Relay Z released restores the station line circuit to normal.

Key Station Forces Disconnection

5.21 Should it be necessary to disconnect the station line from the central office line, the key telephone station reenters via either line circuit and notifies the conversing parties that they are going to be disconnected and momentarily operates the TR key.

5.22 Ground on the SG1 lead via operated relay A and key TR shunts down relay W releasing it.

5.23 Relay W released:

(a) Opens the tip and ring toward the central office line circuit.

(b) Releases relay Z.

(c) Opens the locking path of relay S1.

5.24 Relay Z released opens the tip and ring toward the station line circuit releasing relay S. Relay S released releases relay S1.

5.25 Relay W released will release the central office or relay Z released will release the junctor circuit depending on which line circuit the key stations reentered to force the disconnect.

6. TIME OUT

6.01 The operation of relay R in any line circuit grounds lead TO to complete a path through the heater winding of relay TO to battery. If the call is abandoned or relay TO is not operated within 30 seconds the thermal contact opens, opening the locking path of relay R.

6.02 Relay AH of any line circuit operated operates relay TO. Relay TO operated removes battery from the heater winding preventing time out.

7. MISCELLANEOUS

A. Station Busy Lamp

7.01 Removing the handset from its on-hook condition grounds lead BL to light the remote station busy lamp. Diode LP prevents relay A from being held operated when the station busy lamp is connected to a 20 volt supply.

B. Station Make Busy

7.02 The operation of central office line relay R operates relay MB associated with the key telephone set having the primary appearance of the central office line.

7.03 Relay MB operated:

(a) Grounds lead TO starting time-out timing.

(b) Switches a local station associated with the key telephone set from assigned to unassigned causing it to appear busy to the marker.

(c) Lights the station lamp and its multiples if required.

7.04 Operation of the central office pick-up key holds the MB relay operated via lead A upon the release of relay R or operates relay MB on an outgoing call. The operation of relay AH stops the time-out timing.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.01 Lines

See 1A and 1A1 key telephone systems range charts.

1.02 Voltage Limits (from SS400 power supply circuit).

45-52V DC
75-105V AC
7-11V AC

2. FUNCTIONAL DESIGNATIONS

Designation	Meaning
A	Control
AH	Aux. Control
R	Ring Up
H	Hold
TO	Time Out
Z	Sta. Connect
W	Co. Connect
S	Station Answer
S1	Aux. Station Answer
MB	Make Busy

3. FUNCTIONS

3.01 This circuit provides for:

(a) Flashing visual signals on incoming calls.

(b) Common audible interrupted ringing at key telephone sets.

(c) Steady visual signals to indicate busy lines.

(d) Winking visual signals on held calls.

(e) Connecting outside central office lines with any local station.

(f) Key station forcing disconnect of connected station to central office call if desired.

(g) Making local stations busy when a central office line is seized if the local station and central office line appear on the same key telephone set.

(h) Removing the station busy condition when the central office line is to be connected to a local station.

4. CONNECTING CIRCUITS

4.01 Typical connecting circuits:

(a) Line, Link and Connector Circuit - SD-69469-01.

(b) Key Telephone System No. 1A1 - Key and Telephone Circuit - SD-69219-01.

(c) Power Supply Circuit - SD-81577-01 or SD-65943-01.

5. TAKING EQUIPMENT OUT OF SERVICE

5.01 Block (Z) and (W) relays down blocking tool if circuit is not assigned.

6. MANUFACTURING TEST REQUIREMENTS

6.01 This circuit shall be capable of performing all the service functions described herein and meet the requirements in the Circuit Requirement Tables.

7. ALARM INFORMATION

Fuse Alarm

7.01 An operated fuse supply the key telephone line and add-on circuit is indicated by a major alarm at the Plant Service Center if alarm transmitting features are provided and in any case a visual signal will be given locally.

7.02 The operated fuse must be replaced or removed to restore the alarm circuit to normal.

SECTION IV - REASONS FOR REISSUE

A. Changed and Added Functions

A.1 Making local stations busy when a central office line is seized if the local station and central office line appear on the same key telephone set.

A.2 Removing the station busy condition when the central office line is to be connected to a local station.

B. Changes in Apparatus

B.1 Added:

Relay (MB) 1/2 AK7 Fig. 5
Diode (MB) 446F E Option Fig. 5
Diode (M) 446F Fig. 6

D. Description of Changes

D.1 On sheet 2, notes 102 and 104 are revised and notes 202, 203, 304, 305, and 306 are added.

D.2 On sheet 4, wiring B is designated and rated Mfr. Disc. and options E and G are added to provide an isolated ground when relay R operates or a central office line pickup key is operated when the station make busy feature is provided. Diode MB isolates the central office line circuit A leads.

D.3 On sheet 4, minor corrections are made.

D.4 On sheet 5, App. Figs. 5 and 6 are added.

D.5 On sheet 6, Sequence Charts are revised, minor corrections are made and a sheet note is added.

D.6 On sheet 7, relay MB requirements are added to the Circuit Requirements Table.

D.7 On sheet 8, CADS 1 and 2 are revised.

D.8 On sheet 9, CAD 3 is revised.

D.9 Sheet 10, FS4 is added.

D.10 Sheet 11, CAD's 8, 9 and 10 are added.

D.11 Sheet 12, CAD's 11, 12, and 13 are added.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-AEK-JGW)
DEPT 5337-RAV

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
AUXILIARY RELAY CIRCUIT
FOR DIRECT STATION SELECTION
FROM STATIONS

CHANGES

D. Description of Changes

D.1 On sheet 1, the sheet index is brought up to date.

D.2 On sheet 2, CAD 3 is rated A & M Only.

D.3 On sheet 4, CAD 4 is rated A & M Only. Minor corrections are made on CAD's 8 and 9.

D.4 Sheet 5 and CAD's 10 and 11 (replacing CAD's 3 and 4 respectively) are added.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 2120HW-RHO-WHK)
DEPT 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
AUXILIARY RELAY CIRCUIT
FOR DIRECT STATION SELECTION
FROM STATIONS

CHANGES

B. Changes in Apparatus

	Superseded	Superseded by
B.1	HD- Resistor KS-13492,L1,1210	HD- Resistor KS-13492,L1,1200

D. Description of Changes

D.1 Minor drawing errors are corrected.

D.2 The value of resistor HD- is changed on a "No Record" basis to bring this drawing into agreement with manufacturing drawings.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-AELK-JGW)
DEPT 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
AUXILIARY RELAY CIRCUIT
FOR DIRECT STATION SELECTION
FROM STATIONS

CHANGES

B. CHANGES IN APPARATUS

B. 1 Added:

HD diode 400J - Appendix Fig. 6
HD resistor KS-13492, List 1 - Appendix Fig. 6

D. DESCRIPTION OF CHANGES

D. 1 On sheet 1, the supporting information table has been revised.

D. 2 On sheet 2, Note 104 reference to Fig. 6 has been added.

D. 3 On sheet 2, under Equipment Notes 201, a reference to option EA has been removed.

D. 4 On sheet 3, the addition of diode HD- and resistor HD- has been made in FS1 to provide a hold value of current to the supervisory relay in the connected junctor under the following conditions:

(a) The called party has answered.

(b) The calling party has a direct station selection key depressed.

This modification prevents false disconnection if a direct station selection key is held operated after the called party has answered or if this key is depressed accidentally when connected to a station.

D. 5 On sheet 3, Note 2 has been added under sheet notes relating to the use of relay contacts for mounting pigtail-type apparatus.

D. 6 Cabling Diagrams No. 8 and 9 have been revised to conform with station system practices.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-PB-HFH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
AUXILIARY RELAY CIRCUIT
FOR DIRECT STATION SELECTION
FROM STATIONS

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 This circuit is being reissued to change the 5 or 8 transfer contact on the K relay to 3 or 10 to eliminate an undesirable sparking condition.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 5332-AEG-HFH-MR

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
AUXILIARY RELAY CIRCUIT
FOR DIRECT STATION SELECTION
FROM STATIONS

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. GENERAL METHOD OF OPERATION

The purpose of this circuit is to provide a means whereby a station arranged for direct station selection may originate a call by lifting the handset, listening for dial tone, and momentarily operating a key corresponding to the number of the station or trunk being called.

Each line arranged for direct station selection will have associated with it a K and an SC relay. The telephone set in addition to the usual dial, will be equipped with a DSS key for each station or trunk it is desired to reach by this method. Each key will be wired, to reach a particular two digit directory number by appropriate connections of the T and U diodes. The switching equipment is arranged for direct station selection by stations by associating RC, PR, and DSC relays with each dial pulse register.

To originate a call by direct station selection the handset should be lifted from its cradle and the switching equipment will connect a dial pulse register to the line in the usual manner. After dial tone is heard, a DSS key should be operated. The key in operating will operate the K relay which in operating will signal the register over the tip conductor that a DSS call is being originated. The register will then operate the SC relay over the tip conductor. The SC relay in operating will connect thru the tens and units digit leads to the register. The tens and units digit leads corresponding to the operated key will be grounded and operate the appropriate tens and units digit register relays in the register. The SC relay in operating will also signal the register that the digit information is being passed and it should call the marker to complete the connection in the usual manner.

When the K relay operates, the RC relay associated with the connected register will release allowing the PR relay to operate which operates the SC relay over the tip conductor and DSC relay in local circuit. The PR and DSC relays for both registers are interwired so that only the PR and DSC relays associated with on register may be operated at one time. The purpose of this is to prevent interference between two simultaneous DSS calls.

SECTION II - DETAILED DESCRIPTION

1. ESTABLISHING A DIRECT STATION SELECTION CALL

When a station equipped for DSS removes the handset to originate a call, the station switchhook contacts complete the operate path of the associated line relay in the line circuit and the marker sets up a dial tone connection to the register.

When the Marker functions to operate the register hold magnets HM-8 and HM-9 and closes the crosspoints to the linkage, the station short through normal contacts of the K relay, normal contacts of the PR(0-1) relay, the winding of the RC(0-1) relay and the winding of the L relay in the register will operate both the L relay in the register and the RC(0-1) relay.

After hearing dial tone the associated DSS key for the called station will be depressed. This key in operating (1) grounds the associated T(-) and U(-) lead for the called station and (2) operates the K relay. The K relay in operating (1) transfers the winding of the L relay in the register to the tip side of the station telephone set to a make contact of the K relay to hold it operated, (2) removes the battery that operated the RC(0-1) relay releasing it and (3) prepares the operate path of the SC relay. With the RC(0-1) relay released and the ON in the Register operated, ON battery is extended through normal contacts of register relays and operates the PR(0-1) relay.

The (PR(0-1)) relay in operating (1) connects positive 48 volt battery to the tip side of the line which through a make contact of the K relay and the SC diode operates the SC relay, (2) further opens the operate path of the RC(0-1) relay, (3) extends register ground through its make contacts to operate the DSC(0-1) relay and (4) through a break contact opens the operate path of the PR(0-1) relay associated with the other register to prevent both DSC(0-1) relays from operating, so that if two stations originate a call at the same time only one can pass the tens and units information to the register. The SC relay in operating extends the ground on the tens and units leads to contacts of the DSC(0-1) relay.

The DSC(0-1) relay in operating (1) extends the ground on the T(-) and U(-) leads to the register to operate the associated TD(-) and UD(-) relays in the register and (2) extends ON ground from the register through its make contacts and shorted contacts of the SC relay to operate the UD relay of the register and (3) through its make contacts shunts the winding of the PR(0-1) relay associated with the other register to further prevent its operation.

The UD relay in the register operating (1) operates the DC relay in the register and (2) through a break contact opens the operating circuit of the PR(0-1) relay which releases. When the PR(0-1) relay releases, the associated DSC(0-1) and SC relays release which in turn remove the ground from the T(-) and U(-) leads to the register. When the PR(0-1) and DSC(0-1) relays release they prepare the operate path of the PR(0-1) relay in the other register. The PR(0-1) relay in releasing through a break contact restores the operate circuit for the RC(0-1) relay.

When the DC relay in the register operates, the Marker is called to complete the call in the regular manner.

2. MISCELLANEOUS

The contact configuration and wiring of the K relay is such that when it operates, the L relay in the register will be held by a ground from the K relay contact. The path for this holding ground is from the K relay over the ring conductor toward the telephone set, thru the telephone set and back over the tip conductor to the K relay. At the K relay the holding ground crosses over to the ring conductor towards the register. The purpose of this arrangement is to confine the unbalance on the tip and ring conductors to the line section between the K relay and the switching equipment and thereby minimize crosstalk possibilities.

Positive battery is used to control the SC relays to prevent stations from interfering with one another. For example, if the SC relay were permited to operate from negative battery, the accidental operation of a DSS key at a station connected to a junctor would cause the SC relay to operate from battery on the ring from the junctor. If another station were placing a legitimate DSS call at this moment, incorrect tens and units information would get recorded in the register and a wrong number would result.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.1 Lines

The maximum external loop resistance for satisfactory operation of (SC) relay - 125 ohms.

1.2 Voltage Limits

Minimum	Maximum
-45	-52
+40	+60

2. FUNCTIONAL DESIGNATIONS

The functional meaning for the relays of the auxiliary relay circuit are given in the following table.

Relay Designation	Functional Meaning
DSC (0-1)	Direct Station Connector
K	Key
PR(0-1)	Priority
RC(0-1)	Register Control
SC	Station Connector

3. FUNCTIONS

The auxiliary relay circuit is designed to perform the following functions:

3.01 To connect a calling station line to a dial pulse register and permit a station to complete a call by direct station selection.

3.02 To extend ground over the units dialed leads to operate the units dialed (UD) relay in the register.

3.03 To extend a ground on the tens and units leads to the register circuit to operate associated tens dialed and units digit dialed relays.

3.04 To give priority to a register and allow only one direct station selection type of call to be processed at one time.

3.05 To prevent interference between stations originating direct station selection calls simultaneously.

4. CONNECTING CIRCUITS

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

4.1 Line, Link and Connector Circuit - SD-69469-01.

4.2 Dial Pulse Register Circuit - SD-69470-01.

5. MANUFACTURING TEST REQUIREMENTS

The auxiliary relay circuit shall be capable of performing all the functions specified in this circuit description, and meeting all the requirements of the Circuit Requirement table.

6. ALARM INFORMATION

6.1 Fuse Alarm

An operated fuse supplying the auxiliary relay circuit is indicated by an alarm at the plant service center, if alarm transmitting features are provided, and in any case, by a visual signal locally. Replace the operated fuse to silence the alarm and extinguished the visual alarm signal.

SECTION IV - REASONS FOR REISSUE

CHANGES

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 The fuse for the +48 Volts as specified in Circuit Note 101 is changed from 1-1/3 AMP. to .180 AMP.

D.2 This is changed on a no record D basis as no units have been built.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 5332-PB-HFH-ML

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
MARKER CIRCUIT

CHANGES

D. Description of Changes

D.1 On sheets A3, B2 and G1, lead designations RC0 and RC1 are corrected to read RCG0 and RCG1 respectively.

D.2 Sequence charts SC1, SC2, and SC9 are revised.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-AELK-JGW)
DEPT 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
MARKER CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. GENERAL METHOD OF OPERATION

This circuit provides means for establishing dial tone connections for stations and trunks (associated with universal line circuits) to dial pulse registers, and talking connections between two stations, two trunks (associated with universal line circuits), or between a station and a trunk (associated with universal line circuits) through the crossbar switches.

The trunks are arranged so that they may be dial selected for outgoing calls by dialing a single digit code. Incoming calls on a tie trunk reach the dial pulse register and a connection to any station or another trunk may be established by dialing from the distant point.

Regular station lines may be arranged into one-way or 2-way hunting groups or in combinations of both types but with the restriction that all stations in a hunting group must be within the same tens group. The universal lines may also be arranged into similar hunting groups.

The removal of a handset from a station switchhook or an incoming seizure signal from a tie trunk will signal the marker to set up a dial tone connection to the station or trunk. The completion of dialing into a dial pulse register will signal the marker to set up a connection between the dialing station or trunk and the station or trunk corresponding to the dialed number.

The marker will only process one call at a time. To cope with simultaneous bids for its services a gating and preference arrangement is provided. When the marker is idle the gate is open. One call or a group of simultaneous calls for the marker will close the gate and the marker will proceed to process each register bid, one bid of a trunk or station in the universal line group, one station bid in the 20 to 29 tens group, and one bid in each of the higher numbered tens groups in ascending order until all groups have been accommodated.

Only the group in which a bid was admitted while the gate was open will be served. Once a group has registered a bid, however, individual bids within the groups which are originated before the group is served will be recognized. The station or trunk which is actually served is under control of a units sequence circuit in the marker. When both registers are busy, the marker will stop serving the station and trunk groups and wait until a register has been served, thereby making the register available again before proceeding to serve the next lower line preference group.

The units sequence circuit in the marker also controls the order of preference in the selection of junctors and lines in a hunting group under call terminating conditions. Other sequence control circuits control and change the order of preference for the selection of link groups and links within a group. A register allotter circuit is also provided to equalize to some extent the use of the two registers.

The marker contains a timing circuit which starts functioning at the beginning of each marker usage. If a blockage occurs and a connection is not completed within an interval of time, the processing of the call is restored to its initial stages and a second trial is made. If the connection is not completed on second trial within another interval of time, the marker will attempt to provide a connection to the busy tone trunk to return busy tone to the calling end. If this cannot be completed in another time interval, the marker will trouble release and restore to normal. If the call blocks and the timing circuit itself fails, a secondary timing circuit utilizing the pickup (PU) and time-out (TMO) intervals in the PBX interrupter will initiate a trouble release in this circuit and indicate an alarm condition to the Alarm and Test Circuit.

Connections to a Call Progress Indicating Circuit are provided so that it may be used to assist in the analysis of marker operation for maintenance purposes.

2. GENERAL FUNCTIONS

2.1 Dial Tone Connection

When a PBX station lifts the receiver to make a call, the line relay in the line circuit operates. The line relay operated, passes the tens and units identity of the calling station to the marker. All calls desiring service compete for the marker. The tens selection circuit of the marker accepts the tens information and allows only one call at a time to be processed. Lines and registers are assigned a location in the tens preference chain and simultaneous calls are served according to that location. (When no more registers are available, the marker stops processing dial tone connections until it can serve a register, thus freeing it for another dial tone connection.)

When an originating line has been given preference, the tens connector for the group of lines in which that station is located, operates. The tens connector operated allows the units information from the line relay to be extended to the units selection circuit. All stations in the preferred group which are desiring service will pass units information to the units selection circuit. However, only that line which has the highest

units preference in the group will be served at this time. The line hunting circuit determines which line will be served.

The operation of the tens preference relay also signals the register control circuit to connect an idle dial pulse register. The register control circuit connects a register and directs the link test circuit to find an idle link.

When an idle link has been found, the select magnet control circuit operates the select magnets corresponding to that link and signals the register control circuit and the line hunting circuit to operate the hold magnets associated with the selected dial pulse register and with the calling station. The station is thereby connected to a dial pulse register.

The line hunting circuit functions to check that the register is holding the connection to the station, then signals the route control circuit to release the marker.

2.2 Call Terminating Connections

2.2.1 General

When the dial pulse register has received all the dialed information, it signals the marker for service. The tens selection circuit recognizes the register request for service and passes the information on to the tens preference circuit. The registers have the highest preference in the marker and will be served before any lines which may have originated calls at the same time a register requests service. Ordinarily, the marker will continue to serve lines which were waiting when the register called. However, if the marker should encounter an all-registers-busy condition, it will serve a waiting register first in order to free that register for another dial tone call

2.2.2 Station Line to Station Line

When the register has been given preference, the register preference relays operate and connect leads from the register to the sequence control circuit over which passes information that a junctor will be required. The sequence control circuit requests the line hunting circuit to find an idle junctor. When an idle junctor has been found, its identity is stored on the junctor register relays and the sequence control circuit advances to operate the register connector relays of the tens connector circuit to signal the link test circuit to find an idle link.

The register connector relay operated, allows the tens and units identity of the called station to be transmitted to the marker. The tens connector relay, corresponding to the tens digit of the station, is operated and the units relay of the units selection circuit, corresponding to the units digit of the called station, is operated. The line hunting circuit then tests the sleeve of the called line to see if it is idle.

When the link test circuit has found an idle link, it signals the select magnet control circuit to operate the select magnets corresponding to the selected link. The select magnet control circuit then signals the line hunting circuit to operate the hold magnet associated with the called station (assuming it is idle) and to operate the terminating hold magnet of the selected junctor.

The line hunting circuit functions to check that the junctor is holding the called line and then signals the sequence control circuit to advance from the terminating to the originating part of the call. The sequence control circuit, in advancing, restores the tens connector, the units selection, the line hunting, the link test, and the select magnet control circuits.

The sequence control circuit then signals the register control circuit to operate the select magnets corresponding to the link to which the calling line and the dial pulse register are connected. The sequence control circuit also signals the line hunting circuit to operate the originating hold magnet of the selected junctor. The line and trunk hunting circuit then checks that the junctor is holding the originating station, and signals the route control circuit to release the marker. The route control circuit signals the register control circuit to release the dial pulse register, and the route control circuit restores the marker to normal.

2.2.3 Station Line to Trunk

When a register calls for the marker and desires to connect the calling station to a trunk (connected to a universal line circuit), the tens preference relay connects leads from the register to the sequence control circuit over which passes information that a junctor will not be required. The sequence control circuit then operates the register connector relay in the tens connector circuit and signals the register control circuit to operate the select magnets associated with the line to which the calling station and the register are connected.

The register connector relay allows the identity of the called trunk group to be transmitted to the marker, operating the corresponding relay in the tens connector circuit. Units information is also transmitted

from the register to operate the units selection circuit. By means of the H terminal strapping in the units selection circuit, units relays corresponding to all the trunks in the desired group are operated. The units selection circuit then signals the line hunting circuit to select an idle universal line associated with the trunk.

When an idle trunk has been found, the line hunting circuit operates the hold magnet associated with universal line and checks that the trunk is holding the connection. Then the line hunting circuit signals the route control circuit to release the marker. The route control circuit signals the register control circuit to release the register, then restores the marker to normal.

2.2.4 Trunk to Station Line

When a register calls for the marker and desires to connect a calling trunk to a station line, the tens preference relay connects leads from the register to the sequence control circuit over which passes information that a junctor will not be required. The sequence control circuit then operates the register connector relay of the tens connector circuit and signals the register control circuit to operate the select magnets associated with the link to which the calling trunk and the register are connected.

The register connector relay operated, allows the tens and units identity of the called station to be transmitted to the marker thus operating the corresponding tens connector and the corresponding units relay of the units selection circuit. The units selection circuit then signals the line hunting circuit to test the sleeve of the called station to determine if it is idle.

The line hunting circuit then operates the hold magnet associated with the called station (if it is idle) and checks that the trunk is holding the connection. The line hunting circuit then signals the route control circuit to release the marker. The route control circuit signals the register control circuit to release the register, then restores the marker to normal.

2.2.5 Trunk to Trunk

When a register calls for a marker and desires to connect a calling trunk to another trunk, the operation is generally the same as when it connects a calling station to a trunk.

2.3 Called Station Line Busy

When the line hunting circuit tests a station line and finds it busy, the hunt connector relays of that circuit operate to test, in case the line is in a hunting group, if lines in the hunting group are idle. If a idle line is found, the marker proceeds to complete the call to that line. If all lines in the hunting group are busy or if the called line is not in a hunting group, the route control circuit functions with the line and trunk hunting circuit to verify that the called line is busy. If the line busy is verified, the marker connects the calling station to a busy tone trunk.

2.4 Paths Busy

2.4.1 All Links Busy

If all links are busy when the marker tries to connect a station line or a trunk to a dial pulse register, the link test circuit signals the units selections circuit to abandon the call. This marker action will be repeated on successive calls until a link becomes idle.

If all links are busy when the marker tries to complete a call from a dial pulse register, the link test circuit will signal the route control circuit to complete the call to a busy tone trunk. The link used for this connection is the same one that connects the calling station or trunk to the register.

2.4.2 All Trunks Busy

If all trunks in a desired group are busy, the line hunting circuit signals the route control circuit to complete the call to the busy tone trunk.

2.4.3 Busy Tone Trunk Busy

If the busy tone trunk is busy, the marker, through the line hunting circuit and the register control circuit, signals the register to return busy tone to the calling customer and releases.

2.5 Abandoned Calls

If a station line or a trunk starts to place a call, then disconnects before the marker can connect it to a dial pulse register, an abandoned call condition is presented to the marker. The marker proceeds normally up to units selection, but, since the calling party has already disconnected, no units information will be available. The units selection circuit recognizes this as an abandoned call and signals the route control circuit to release the marker.

If the abandonment occurs after the units information has been identified, the marker timing circuit must advance to "no connection" before the marker restores to normal via the abandoned call route.

2.6 Marker Time-Out

2.6.1 Second Trial

As soon as the marker is seized, the advance, time-out,and release circuit starts timing the marker. If the route control circuit has not released the marker within a short time, the advance, time-out, and release circuit functions to advance the marker to second trial. The marker is restored to its call start condition and the sequence circuits of the line and trunk hunting circuit and the select magnet control circuit are advanced.

2.6.2 No Connection

If the marker is unable to complete a connection on a second trial before the advance, time-out, and release circuit functions for the second time, the route control circuit is directed to complete the call to the busy tone trunk, and the marker is restored to normal.

2.6.3 Normal Trouble Release

If the marker is unable to complete the call to the busy tone trunk before the advance, time-out, and release circuit functions for the third time, the marker is released and the marker proceeds to serve the next lower preference tens group.

2.7 Time-Out Check

The time-out check circuit functions to exercise the advance, time-out, and release circuit every time the marker completes a call to the busy tone trunk. When the marker becomes idle after completing a busy tone call and having finished serving all calls within the gate, the time-out check circuit holds the marker busy and exercises and checks the advance, time-out,and release circuit. After it has completed its check, the time-out check circuit releases the marker and locks itself out of action until the busy tone trunk has been used again.

2.8 Permanent Signals

2.8.1 Before Dialing

A station handset removed from the switchhook by mistake, or crossed tip and ring leads will cause that station line to be connected to a dial pulse register. If no dialing, or only partial dialing is received by the register, the register will time out.

If the station line remains off-hook, it will be reconnected to a register and the register will again time out. This action continues until the line hangs up.

2.8.2 After Dialing

If a called station line or tie trunk remains off-hook after the calling end disconnects, the connection will release and the station or tie trunk will be connected to a dial pulse register. If a calling station line or tie trunk remains off-hook after the called station line or tie trunk disconnects, the line or trunk and junctor used in the call will remain busy to other calls.

2.9 Alarms

A back up trouble release arrangment has been provided in the Alarm and Test Circuit to release the marker, if it cannot release under a normal trouble release condition, due to trouble in the timing circuit. With the MTA and MTB relays operated, a circuit is prepared to operate a PU and TMO relay in the Alarm and Test Circuit under control of the interrupter in the Power Supply Circuit. If after 7.5 to 15 seconds the marker has not completed its function or not released, the TMO relay in the alarm circuit will operate and cause the RLS and RLSA relays in the marker circuit to operate and trouble release the marker, which restores it to normal. When the TMO relay operates it will also operate the alarm relay in the Alarm and Test Circuit to bring in an alarm lamp and, if provided, an alarm at the plant service center.

SECTION II - DETAILED DESCRIPTION

1. ESTABLISHING DIAL TONE CONNECTIONS

1.1 Station Dial Tone Connections

1.1.1 Station Requests Service

When a local station customer lifts a handset to make a call, the switchhook contact in the telephone set closes the loop to operate the associated line relay in the line circuit.

Assuming there are no other requests by lines or registers for marker service, the line relay, in operating, will operate a tens (T-) relay corresponding to the tens group in which the originating station is located.

The operation of any T- relay will operate the tens end (TE0 and TE1 relays). The TE relays, in operating, will: (a) provide a locking path for the operated T- relay, (b) open the operating paths of all other T- relays, (c) start the marker timing, and (d) close paths for operating the preference relays.

With the TE and one T- relay operated, the associated tens preference (TP-) relay will operate. Any TP- relay operated will operate the tens auxiliary connector (TAC) relay. The particular TP- relay operated will operate the associated tens connector (TC-), (TCA-) relays in the Line, Link and Connector Circuit. The TAC relay operated will: (a) operate the line units connector (LUC) relay and units lock (UL) relay to start units selection and (b) operate the register group (RG) relay to start link testing and selection. The LUC relay in operating also starts the abandoned call timing as described in 4. The TC- relay in the Line, Link and Connector Circuit in operating will operate the select magnet connector (SMC-) relay in the Line, Link and Connector Circuit associated with the crossbar switch in which the calling line is located. The RG relay will operate the SMC0 and SMC1 relays in the Line, Link and Connector Circuit which are associated with switches 0 and 1 in which the registers appear.

1.1.2 Units Selection

With the associated (TC-) relay in the Line, Link and Connector Circuit operated and the LUC relay operated, the units (U-) relay corresponding to each operated line relay in the tens group will operate and lock to the operated UL relay. With the TE0, TE1 relays and TAC relay operated, the operation of a U- relay will operate the units end (UE) relay. The operation of the UE relay will release the LUC relay which stops the abandoned call timing.

The operated U- and TCA- relays in the Line, Link and Connector Circuit connect the primary winding of the associated sleeve (S-) relay to the "S" lead of the associated line circuit. The -48 volt battery through the winding of the hold magnet (HM--) in the link circuit will operate the associated S- relay. In the case of a line in the universal group, the -48 volt battery through the winding of the in (IN-) relay in the line circuit will operate the S- relay.

With the UE relay operated, the operation of an S- relay will cause the sleeve end (SE) relay to operate to complete the units selection sequence.

1.1.3 Link Testing Selection

The operation of the RG relay will cause the link start (LS and LSA) relays to operate, which: (a) operates the link test connector (LTC) relay, (b) starts the link shift timing which controls the shifting of the link testing circuits from one group to the other, (c) pulses the link group sequence and link sequence control circuits, (d) prepares a locking path for the link test (LT)2 through LT9 relays.

The state of the transfer link relay (TRL) will determine which of the two link groups will be tested first. Assuming that the TRL relay is operated, the operation of the LS relay and the LTC relay will connect battery through L12 through L19 resistances, through the primary winding of LT2 through LT9 relays to ground. This will operate the LT2 through LT9 relays if the associated links are idle.

If the link is in use, battery through the 900-ohm HM (or an IN- relay) to ground on the sleeve circuit of a junctor or universal line circuit will result in ground on the "S-" lead and will prevent the LT- relay, associated with a busy link, from operating because the LT- relay will be shunted down.

Therefore, those LT2 through LT9 relays which are associated with idle links in the group being tested will operate and those associated with busy links will not operate. All LT2 through LT9 relays that operate will lock over the secondary winding, through an operated LSA relay, its own contacts and through the link end (LE) relay to ground. The operation of any LT2 through LT9 relay will: (a) operate the LE relay, (b) open the operating path for the link busy (LB) relay thus halting the link shift timing, and (c) with the TRL relay operated will prepare a path for operating select magnet (SM) on switches 0 and 1 and the switch in which the calling line appears.

The LE relay in operating will: (a) release the LS relay, (b) operate the select

magnet timing (SMT) relay, and (c) operate SM0 through SM9 on the appropriate switches.

If more than one link in the group tested is idle, the selection of the link which will be used is dependent upon the state of the link sequence control circuit and the position of the LT2 through LT9 relay contacts corresponding to the idle links in the group in the chain shown on FS11. Assuming that the link sequence control circuit is in the state whereby the W1L and ZL relays are operated and the LT2 relay is operated, the operation of the LE relay will cause SM2 on switches 0 and 1 and the switch in which the calling line appears to operate. With an LT2 through LT9 relay and the TRL relay operated, the operation of the LE relay will operate SM1 on switches 0 and 1 and the switch in which the calling line appears. Thus idle link 12 has been selected for the call and the appropriate select magnets operated.

1.1.4 Register Selection

The register selected for the call is dependent upon the state of the register allotter (RA0 and RA1) relays which are preset at the start of any marker operation.

1.1.5 Hold Magnet Operation

The operation of the SMT relay will operate the select magnet register (SMR)A relays which provide a locking path for any operated S- relays. With the SMT and SMRA relays operated, ground from contacts of the SMT relay will operate the HM-- of the calling station (or the IN-- relay which in turn operates the hold magnet) through the chain of S0 through S9 relay contacts in the line hunting circuit. If more than one station in the tens group is requesting marker service, the one that will be served is dependent upon the state of the ZU relay in the units sequence control circuit and the position of the corresponding S- relay in the line hunting preference chain.

At the same time that the hold magnet is being operated, a ground from the SMT relay will operate the register HM-8 and HM-9.

When the hold magnets operate, the crosspoints close and the selected link connects the "T," "R," and "S" leads of the calling station line circuit to the allotted register. The switchhook bridge in the calling station telephone set will operate the L and SR relays in the register circuit in that sequence. The SR relay in operating will connect a ground to the sleeve of the link to maintain the HM (or the IN- relay) operated and ground on the RHM- lead to maintain the register hold magnets operated.

1.1.6 Hold Magnet Checks

The operation of the SMT relay will close the operating path of the hold magnet timing (HMT)A relay which, when operated, will close the operating path for the HMT relay. When the HMT relay operates: (a) the original operating ground for the hold magnets is removed, (b) the hold magnet check (HMK) relay is connected to the HM or IN-- relay (over the path by which it originally operated), and (c) the register hold magnet check (RHK) relay is connected to the register hold magnets. If the holding ground is present at the line hold magnet, the HMK relay will operate and if the holding ground is present at register hold magnets, the RHK relay will operate.

1.1.7 Marker Release

The down check (DCK) relay in the marker is normally locked operated. The operation of the HMK and RHK relays will open the locking paths and the DCK relay will release. The release of the DCK relay will cause the release(RL and RLA)relays to operate. The RL and RLA relays in operating will: (a) release the marker timing (MT) relays which halts the marker timing, (b) open the operating paths for the relays in the TP chain causing the TP- relays to release, (c) operate the tens auxiliary TA- relay associated with the tens group just served which in turn releases the corresponding T- relay, (d) release the LE relay which in turn releases any operated LTS- relays and the operated select magnets and (e) release the SMT relay which in turn releases the HMT and HMTA relays and, in sequence, the SMR and SMRA, S-, and SE relays.

The release of the TP- relay causes the TAC,TACA,RG, TC-, and TCA- relays in the Line, Link and Connector Circuit to release.

The TAC relay in releasing causes the UL and UE relays to release. The release of the UL relay in turn releases any operated U- relays.

The TC- relay in the Line, Link and Connector Circuit, in releasing, releases the associated SMC- relay in the Line, Link and Connector Circuit. The release of the TCA- relay in the Line, Link and Connector Circuit releases the HMK relay.

The RG relay, in releasing, releases SMC0 and SMC1 in the Line, Link and Connector Circuit, the RHK, and LSA relays. The LSA relay, in releasing, advances the link group sequence and link sequence control circuits.

When the HMK, RHK, and HMT relays are all released, the DCK relay reoperates and

locks. The operation of the DCK relay releases the RL and RLA relays and the marker is ready to process another call.

If there are no other T- or R- relays operated at this time, the TEO and TE1 relays will also release releasing all operated TA- relays and restore the marker to normal.

1.2 Tie Trunk Dial Tone Connections

A tie trunk is terminated on a universal line circuit in the 6, 7, or 8 line group.

A seizure of the trunk by the distant end will operate the associated line (L-) relay in the universal line circuit. The L- relay will operate the T1 relay and the marker will process the call in the same manner as for a station in the 20 through 59 group.

2. CALL TERMINATING CONNECTIONS

2.1 Station to Station Call

2.1.1 General

When a station completes dialing a station code into a register, the register will originate a request for marker service. The marker in serving the register will connect the calling station to the called station via an idle junctor. The same link as was used for the dial tone connection will be reused for connecting the calling station to the originating side of the junctor and an idle link will be selected and used to connect the terminating side of junctor to the called station. If the called station is busy, the marker will look for an idle station in the hunting group and connect to it instead. If the called station and all other stations in the hunting group (if any) are busy, the marker will connect the calling station to the busy tone trunk using the same link as was used for the dial tone connection.

2.1.2 Register Requests Service

When a register has received all of the dialed digits, the dial completion (DC) relay in the register will operate, which (assuming there are no other requests for marker service) operates the associated register R- relay. The R- relay, in operating, will operate the TEO and TE1 relays which, in operating, will: (a) open the operating paths for the other R- relay, T1 through T5 relays, (b) start the marker timing, and (c) close paths in the preference relay chain causing the register preference (RP-) relay to operate. The RP- relay, in operating, operates the register preference auxiliary (RPA-) relay.

The RPA- relay in operating: (a) operates the register units connector (RUC) relay, and (b) closes the path for operating the junctor terminating (JTA and JTB) relays over the "JTA-" leads from the register. The register will have connected ground to these leads after determining from the dialed code that a junctor class type of call completion is required. The JTA and JTB relays, in operating, operate the JTAA relay.

2.1.3 Junctor Testing and Selection

The six junctors are associated with U- relays as follows: junctors 0, 1, 2, 3, 4, and 5 are associated with units relays U0, U1, U2, U5, U6, and U7, respectively. The operation of the JTA and JTB and the RUC relays operates the U0, U1, U2, U5, U6, and U7 relays thus connecting the primary windings of the corresponding S- relays to HM01, HM03, HM05, HM07, HM12, and HM14 respectively in the link circuit, which are associated with the terminating side of the junctors. The S- relays corresponding to the idle junctors will operate from battery through the terminating hold magnets. If a junctor is in use, the ground holding the hold magnet operated will prevent the corresponding S- relay from operating.

Any S- relay in operating will, with the UE relays operated, cause the SE relays to operate. The SE relay in operating releases the RUC relays which in turn release all operated U- relays. The U- relays, in releasing, release the UE relay.

The idle junctor selected for use in this call is dependent upon the state of the ZU relay. When the SE relay operates, battery through the contacts of the first operated S- relay in the chain on FS6, the contacts of the operated JTA and JTB and released UE relays will operate the junctor register (JR-) relay corresponding to the junctor selected. The JR- relay operated will: (a) operate the junctor register end (JRE) relay and (b) operate the SMC1 or SMC0 relay in the Line, Link and Connector Circuit whichever corresponds to the switch in which the selected junctor is located.

The operated JRE relay will release the JTA and JTB relays which, in turn, release the JTAA relay, and any of the relays S1, S2, S6, and S7 which are operated. The release of the JTAA relay releases the S0 and S5 relays, if operated. The release of all S- relays releases the SE relays, ending the junctor selection sequence.

The release of the SE relay at this time reoperates the RUC relay and operates the register cut-through RCT and RCTA relays. The operation of the RCT and RCTA relays will initiate the link testing and selection sequence and operate the register connector

RC and RCA relays in the register circuit. The operated RCA and RUC relays will initiate the called station selection and testing sequence.

2.1.4 Terminating Link Selection

The operation of the JRE and RCT relays will operate the LS and LSA relays and cause an idle link to be selected in the same manner as described in 1.1.3.

2.1.5 Called Station Selection and Testing

The operation of the RC- and RCA- relays in the register circuit will: (a) connect the "T-" leads from the appropriate register to the TC- relays and operate the TC- relays in the Line, Link and Connector Circuit corresponding to the tens digit of the called station number and (b) connect the "U-" leads from the appropriate register to the units relays and operate the U- relay corresponding to the units digit of the called station number.

The TC- relay in the Line, Link and Connector Circuit, in operating, will operate the SMC- relay in the Line, Link and Connector Circuit corresponding to the switch in which the called station is located.

The U- relay operated will operate the UE relay. With a U- relay and the TCA- relay in the Line, Link and Connector Circuit both operated, the primary winding of the corresponding S- relay will be connected to the HM-- of the called station. If the station is idle, battery through the LHM (or IN- relay in the universal line circuit) will operate the S- relay. If the station is busy, the ground maintaining the HM (or IN- relay) operated will prevent the S- relay from operating.

Assuming that the station is idle and the S- relay has operated, the SE relay will reoperate and release the RUC relay which in turn will release the U- relay. The U- relay, in releasing, will release the UE relay.

2.1.6 Connection of Called Station to Junctor

By the time that the LE relay has operated at the completion of the link testing the selection sequence, the SMC- relays in the Line, Link and Connector Circuit corresponding to the switches in which the called station and the selected junctor are located will have operated. The operation of the LE relay will: (a) operate the select magnets in the involved switches corresponding to the selected link and (b) operate the SMT relay.

The SMT relay in operating, will: (a) operate the SMR and SMRA relays, (b) close the path for operating the slow operate HMTA relay, and (c) operate the terminating hold magnet of the selected junctor through contacts of the operated JR- relay. The HMTA relay operates the HMT relay.

When the SMRA relay operates, ground from contacts of the SMT relay will operate the called station HM-- (or the IN- relay) through contacts of the SE relay, the operated S- relays, and the TCA- relay in the Line, Link and Connector Circuit. The SMR relay, in operating, furnishes a locking path to keep the S- relay operated over its secondary winding.

When the junctor terminating hold magnet and the called station hold magnet (or IN- relay) operate, the crosspoints associated with the selected link close and the called station is connected to the terminating side of the junctor.

When the HMT relay operates, the ground is removed from the SMT relay contacts which operated the called station hold magnet and the windings of the HMK relay are connected in its place. The ground from the SMT relay contacts which operated the junctor terminating hold magnet will maintain the called station hold magnet operated via the link sleeve and also operate the HMK relay after the HMT relay operates.

2.1.7 Connection of Calling Station to Junctor

The operation of the HMK relay, with the JRE and RCT relays operated, will operate the terminating route check TRK and TRKA relays. These relays in operating will: (a) lock to the operated SE relay and (b) release the HMK, SMT, and HMTA relays.

When the HMK and SMT relays release with the TRK relay operated, the terminating route complete TRCA relays operate.

The SMT relay, in releasing, also releases the following relays in sequence: SMRA, S-, and SE.

The TRC relay in operating: (a) provides a ground for holding the junctor terminating and called hold magnets when the SMT relay releases, (b) releases the RCTA relays, and (c) operates the select magnets on the switch in which the selected junctor is located. (The select magnets in the called line switch may also operate at this time if the associated SMC- relay in the Line, Link and Connector Circuit has not yet released, associated with the link used for the dial tone connection through the closed crosspoints of the register memory vertical.)

The release of the RCT relays releases the LSA and TRKA relays in this circuit and the RC- and RCA- relays in the register circuit. The release of the LSA relay: (a) releases the LE relay and any operated LT- relays causing the select magnets associated with the terminating link to release and (b) advances the link sequence and link group sequence control circuits. The RC-, RCA- relays in the register circuit, in releasing, release the TC- and TCA- relays in the Line, Link and Connector Circuit associated with the called stations. The TC- relay in the Line, Link and Connector Circuit, in releasing, will release the associated SMC- relay in the Line, Link and Connector Circuit.

When the TRKA relay releases, the SMT relay will reoperate, which will: (a) operate the originating hold magnet of the selected junctor and (b) close the operating path for the slow operate HMTA relay.

When the originating hold magnet of the selected junctor operates, the cross-points associated with its vertical, and the link used for the calling station's dial tone connection operate connecting the A relay of the junctor in parallel with the calling station's telephone set and the tip and ring of the register circuit. The A relay in the junctor operates, which in turn operates the B relay in the junctor. The B relay in the junctor, in operating, will provide: (a) a ground on the originating link sleeve to continue to hold the calling station hold magnet operated after the register subsequently releases, (b) a ground to hold the junctor's originating hold magnet operated, (c) a ground on the terminating link sleeve to continue to hold the called station hold magnet operated when the marker releases, and (d) a ground to hold the junctor's terminating hold magnet operated when the marker releases.

When the HMTA relay operates it will close the operating path for the slow operating HMT relay.

When the HMT relay operates, the original operating ground for the junctor's originating HM is removed and the HMK relay is connected to the junctor's originating HM through contacts of the operated TRCA, JR-, and HMT relay and the released sleeve operate SOA and TRK relays. If the B relay in the junctor has operated and is furnishing the ground for holding its originating hold magnet operated, the HMK relay will operate.

2.1.8 Marker and Register Release

The operation of the HMK relay at this point in the call sequence will release the DCK relay, which in turn will operate the RL and RLA relays.

The RL and RLA relays in operating: (a) release the MTA and B relays which halts the marker timing, (b) open the operate paths for the relays in the tens preference chain causing the RP- relays to release, (c) release the SMT relay which in turn releases the HMT and HMTA relays, and (d) operate the register release (RRL) relay in the register circuit.

The RP- relay, in releasing, releases the RPA- and JR- relays and the select magnets associated with the originating link on the switch in which the junctor used appears. The RPA- relay releases the TRCA relays and the release of the JR- relay releases the JRE and HMK relays and the SMC- relay in the Line, Link and Connector Circuit associated with the switch in which the junctor used appears.

The RRL relay in the register in operating: (a) locks to the ON relay in the register and (b) releases the L and DC relays in the register. The release of the L relay releases the SR relay in the register which, when released, will release the ON relay in the register and the register HM-8 and HM-9 in the link circuit. When the ON relay releases, the RRL relays release restoring the register to normal.

The DC relay in the register, in releasing, releases the R- relay in the marker which, if there are no other calls for the marker to serve, will cause the TE0, TE1, and TE2 relays to release.

When the HMT, TRC, and HMK relays are all released, the DCK relay will reoperate and release the RL and RLA relays restoring the marker to normal.

With the ON relay in the register released, the associated RA0 and RA1 relays in the marker will have reoperated if the register allotter circuit was in a certain state.

2.1.9 Called Station Busy - Station in Hunting Group Idle

If during the called station line testing sequence the S- relay corresponding to the called station does not operate, the ground applied to the S0 through S9 relay contact chain will pass through the break contacts of all of the S0 through S9 relays to operate the busy test (BY) relay.

The BY relay, in operating, locks to the operated RCT relay and operates the hunt connector (HC) relay. The HC relay, in operating, closes the operating path for the slow operate circuits busy (BSY)A relay and extends the ground on the "U-" lead from the register corresponding to the called station's units digit to the H terminal associated with the called station. This ground will be extended through the hunting

group straps or any properly poled H diodes to the H terminals associated with stations in the same hunting group and operate the U- relays corresponding to those stations. These U- relays, in operating, will connect the primary windings of the corresponding S- relays to the hold magnets in the Line, Link and Connector Circuit (or IN-- relays in the universal line circuit) of these stations. Battery through the hold magnets (or IN-- relays) of the idle stations will operate the associated S- relays. The operation of any S- relay will: (a) open the operating ground for the BSYA relay and (b) operate the SE relay.

The operation of the SE relays will permit the operated SMT relay to operate the HMTA, SMR, and SMRA relays and continue the sequence described in 2.1.5.

The calling station will be connected to the idle station in the hunting group corresponding to the first operated S- relay (relative to the state of the ZU relay) in the line hunting chain of S- relay contacts.

The BY relay will release when the RCT and RCTA relays release. If the BSYA relay has operated it will also release at this time.

2.1.10 Called Station and Stations in Hunting Group also Busy - Busy Tone Trunk Idle

If the called station is found to be busy, the BY and HC relays will operate as described in 2.1.9. If there are no stations in the hunting group idle (or the called station is not part of a hunting group), no S- relays will operate and the slow operate BSYA relay will operate from the SMT relay ground on the line hunting S- relay contact chain. The BSYA relay, in operating, will close the operating path for the slow operate BSY relay.

When the BSY relay operates: (a) the HC relay releases which, in turn, releases the U- relays associated with the station in the hunting group (if any) and (b) the SOA relay operates. With the SOA relay and the U- relay associated with the called station operated, the S- relay corresponding to the called station will operate over its secondary winding causing the SE relay to operate.

The SE relay in operating: (a) operates the SMR and SMRA relays and (b) releases the RUC relay which causes the operated U- and UE relays to release in sequence. The SMR relay in operating, provides a locking path for the operated S- relay.

With the SMRA and SOA relays and the S- relay corresponding to the called station operated, a path is completed between the hold magnet (or IN-- relay) of the called station and the HMK relay. The ground maintaining the called station's line hold magnet (or IN-- relay) operated will then operate the HMK relay. HMK will now operate the TRK and TRKA relays.

With the HMK, SE, SOA, and SMRA relays operated, the busy tone (BTT) relay will operate which, in turn, will: (a) release the SOA relay and the operated JR- relay, and (b) lock to the operated RPA- relay.

The JR- relay, in releasing, will: (a) release the JRE relay which will, in sequence, release the LSA and LE relays and the operated LT- relay, and (b) release the associated SMC- relay which in turn releases the select magnets on the junctor switches corresponding to the selected terminating link. The release of the LSA relay will advance the link group sequence and the link sequence control circuit and the release of the LT- or LE relay will release the select magnets corresponding to the selected terminating link on the switch in which the called station line appears.

The operation of the TRK and TRKA relays releases the SMT relay which, in turn, releases the SMR and SMRA relays. The SMR and SMRA relays, in releasing, release the operated S- relay in turn releasing the SE relay. The RUC relay reoperates upon release of the SE relay.

When the SMT relay and the HMK relay release, a path is closed through contacts of the operated TRK relay for operating the TRC and TRCA relays. The relays in operating will: (a) lock operated under control of the BTT and RPA- relays and (b) release the TRK and TRKA and RCT and RCTA relays.

The RCT and RCTA relays in releasing will: (a) release the RC- and RCA- relays in the register circuit which in turn release the TC- and TCA- relays in the Line, Link and Connector Circuit associated with the called station and (b) release the BY, BSY, and BSYA relays. The TC- relay in the Line, Link and Connector Circuit, in releasing, releases the associated SMC- relay in the Line, Link and Connector Circuit.

With the BTT and TRC relays operated and the TRK and TRKA relays released, the busy tone trunk connector (BTC) relay will operate, which: (a) in conjunction with the operated RUC relay operates the U7 relay, which in turn operates the UE relay, (b) operates the SMC1 relay in the Line, Link and Connector Circuit, (c) releases the time-out lock (TOL) relay to cock the time-out checking circuit as described in 9, and (d) with the U7 relay operated, closes a path between the S7 relay primary winding and the hold

magnet HM17, associated with the busy tone trunk, in the link circuit.

If the busy tone trunk is idle, the battery through the busy tone trunk hold magnet HM17 will operate the S7 relay over its primary winding. The S7 relay in operating will operate the SE relays.

The SMC1 relay in the Line, Link and Connector Circuit in operating will: (a) operate the SMT relay and (b) operate the select magnets corresponding to the link used for the dial tone connection from ground at the contacts of the operated TRCA relay through contacts of the operated RP0 and RP1 relays and the crosspoints of the register memory hold magnet HM-9.

The SE relays, in operating, will: (a) with the SMT relay operated, close paths for operating the slow operate HMTA relay and the SMR and SMRA relays and (b) release the RUC relay which releases the U7 and UE relays in that sequence. The SMR and SMRA relays provide a locking path for the operated S-relay.

At this point in the call, ground from contacts of the operated SMT relay passing through contacts of the released HMT, TRK, and SOA relays; the operated SE, S7, SMRA, and BTC relays; and the ZU relay either operated or released will operate the busy tone trunk hold magnet HM17. The hold magnet in operating will close the crosspoints in the vertical associated with the operated select magnets thereby connecting the "T", "R", and "S" leads of the busy tone trunk to the calling station line circuit in parallel with the register via the link used in the dial tone connection. The bridge on the "T" and "R" leads will operate the A relay in the busy tone trunk which will operate the RA relay. The RA relay in the busy tone trunk, in operating, will: (a) apply a ground on the link sleeve for holding the calling station hold magnet (or IN-- relay) operated after the register releases and (b) connect ground to the busy tone trunk hold magnet to keep it operated after the marker removes operating ground.

When the HMTA relay operates the operating path for the slow operate HMT relay is closed, and the operating ground for the busy tone trunk HM is removed. When the HMT relay eventually operates the HMK relay is connected to the busy tone trunk hold magnet to check for the presence of the holding ground. Assuming the holding ground is present it will operate the HMK relay which, in turn, will release the DCK relay. The DCK relay in releasing will operate the RL and RLA relays which release the marker.

The RL and RLA relays in operating, will: (a) release the MTA and MTB relays which halts the marker timing, (b) open the operate paths for the relays in the tens preference chain causing the RP- relays to release, (c) release the SMT relay, and (d) operate the RRL relay in the register circuit.

The release of the RP- relay releases the RPA- relay and the operated select magnets on switch 1. The RPA- relay in releasing releases the BTT relay which in turn releases the BTC TRC and TRCA relays. The BTC relay, in releasing, releases the SMC1 relay in the Line, Link and Connector Circuit.

The SMT relay, in releasing, releases the HMT relay and the SMR and SMRA relays which, in turn, release the S7 relay. With the release of the S7 relay, the HMK and SE relays release.

The operation of the RRL relay in the register causes the same release sequences to occur as described in 2.1.8.

When the TRC, HMT, and HMK relays release, the DCK relay will reoperate which, in turn, releases the RL and RLA relays thus restoring the marker to normal.

2.2 Called Line Unassigned

When a line is not assigned the strap between the "S" and "S1" leads will be omitted and the "S1" lead will be grounded. When the RUC relay operates in conjunction with the ground from the register units dialed lead the U- relay will operate placing the primary winding of the associated S- relay to ground on the "S1" lead. Since this ground prevents the S- relay from operating, the ground from the SMT contact will pass through the back contacts of the SO through S9 relay contact chain and operate the BY relay. This relay, in operating, locks to the operated RCT relay and operates the HC relay. The HC relay, in operating, closes the operating path for the slow operate BSYA relay and extends the ground on the "U-" lead from the register (corresponding to the called station's units digit) to the H terminal associated with the called station. Since the station dialed is unassigned there will be no strapping of the "H" leads. Therefore, no other U or S relay may operate and the slow operate BSYA relay will operate from the SMT relay ground on the line hunting relay contact chain. The BSYA relay in operating will close the operating path for the slow operate BSY relay.

The operation of the BSY relay causes the same action as described in 2.1.10. The end result is busy tone either from the busy tone trunk or if it is busy, from the register.

2.3 Call to Unequipped Tens Group Option (4 or 5) or Unassigned Universal Line Circuit

A call to an unequipped tens group (option 4 or 5) or an unassigned universal trunk circuit is recognized by the register

circuit and does not involve the marker, once the dial tone connection has been completed. The register, upon recognizing that an unassigned code has been dialed, will return busy tone to the calling party.

3. LOCKOUT AND TENS PREFERENCE CONTROL

3.1 Lockout Control

The operation of any station relay T1 through T5 will operate the tens end TE0 and TE1 relays. Also competing with these station groups for service are two registers. Their associated relays R0 and R1 perform the same functions as the T1 through T5 relays. The TE0 and TE1 relays function as a gate in this circuit such that once the gate is closed, all calls outside the gate are denied access to the marker until those within the gate are served. This function is ensured by opening the operate path of the T1 through T5, and R0 and R1 relays with break contacts on the TE relays. Furthermore, the TE0 and TE1 relays will lock operated to any operated T1 through T5 and R0 and R1 relays.

The marker proceeds to serve each group within the gate only once. This is ensured by the release of the T1 through T5 or R0 and R1 relay at the end of each marker usage. In the case of T1 through T5 relays, this is done by the operation of an associated TA1 through TA5 relay. In the case of R0 and R1 this is done by the release of the DC relay in the register which opens the operate path of the R0 and R1 relays.

The release of all of the T1 through T5, or R0 and R1 relays allows the TE0 and TE1 relays to release. This opens up the gate allowing new calls waiting for service to enter and the cycle to be repeated.

3.2 Tens Preference Control

The R0 and R1 and T1 through T5 relays are associated with the following respective relays in the preference circuit: RP0 and RP1, and TP1 through TP5. These relays are arranged in a transfer chain circuit such that one and only one relay can remain operated if more than one R0 and R1, or T1 through T5 relays are operated. The register circuits have the highest preference, the station lines have the lowest preference. The exact preference order is as follows: R0, RP1, TP1, TP2, TP3, TP4, TP5.

The preference relays have two independent operating paths, one through their primary windings and one through their secondary windings.

4. ABANDONED CALLS

When a station or trunk originates a call, the marker will try to establish a dial tone connection. When the TAC and LUC relays operate during the units selection sequence, the operating path for the slow operate abandon call (AC) relay is closed. If the station or trunk abandons the call before the LUC relay releases (indicating that a U- relay and the UE relays have operated), the AC relay will eventually operate.

The AC relay in operating will release the DCK relay which in turn operates the RL and RLA relays and release the marker to serve the next call.

If the abandonment occurs after the LUC relay has released (the AC relay never operated), the station or trunk will be connected to a register in normal fashion but the connection will fall down for lack of a holding bridge on the "T" and "R" leads.

If a station line or a trunk dials a call into a register and then disconnects after the register is seized, the marker never knows of this abandonment and proceeds to set the call up in the normal fashion. After the marker releases, the connection set up by the marker will also drop off because of the lack of a holding ground which is provided from the originating end.

5. ALLOTTING AND SEQUENCE CONTROL

5.1 Register Allotter

Relays RA0 and RA1 associated with register 0 and 1, respectively, operate when the associated register becomes idle. However, the operate path of the RA0 relay is through break contacts of the RA1 relays. Consequently, once released, the RA0 cannot reoperate until a call is served by register 1. The RA1 relays can operate any time that register 1 becomes idle. If both register 0 and register 1 are idle and their allotter relays are operated, the marker will prefer register 0.

If both registers are idle and the marker experiences trouble in connecting to register 0, the marker will progress to second trial and the second trial (ST) relay will operate and release the RA1 relay. When the marker attempts to complete the call on the second trial, it will again prefer register 0. However if the marker initially prefers register 1, the operation of the ST relay will release the RA1 relay and, assuming that register 0 is idle, the RA0 relay will operate. In this case the marker will prefer register 0 on the second trial attempt.

In either case, if the marker cannot complete the connection on a second trial the marker will progress to the no connection sequence and the NA relay operates. This relay in operating will operate the BTT relay which in turn causes the TRK and TRKA relays to operate. The TRKA relay in operating releases

the SMT relay which in turn operates the TRC and TRCA relays. These relays in operating will release the BTT and TRK and TRKA relays and close the operating path for the slow operate AC relay. When this relay finally operates, the RA1 relay will operate (if not already operated) and the RAO relay will release. On the next marker usage register 1 will be preferred.

5.2 Link Group Sequence Control

The link group which is tested first in a marker operation is dependent upon the state of the TRL relay. When this relay is released, the link testing and selection circuits are associated with links 02 through 09 and, when operated, the association is with links 12 through 19.

The state of the TRL relay is dependent in turn upon the state of the link sequence (ZLG) relay. The ZLG relay functions in combination with the link sequence (WLG) and W auxiliary (WLGA) relays.

Assuming that all of these relays are released, the operation of the LSA relay will operate the WLG relay. When the LSA relay releases, the ZLG relay operates in series with the WLG relay. The ZLG relay, in operating, will operate the TRL relay.

On the next operation of the LSA relay, the WLGA relay will operate which in turn will release the WLG relay. The ZLG relay however will be held operated by battery through the WLGA resistance. The subsequent release of the LSA relay will release the WLGA, ZLG, and TRL relays restoring the control circuit to normal.

The LB relay can also step the WLG, ZLG, WLGA relay combination by interrupting the operating grounds from the contacts of the operated LSA relay. As explained in 7, the LB relay will operate after an interval if all links in the first group tested are busy. The operation of the LB relay will thereby cause the TRL relay to change state and shift the link testing and selection circuitry to the alternate group of links.

5.3 Link Sequence Control

The selection of a particular idle link in a link group being tested is governed by the state of the WL, ZL, WIL, and ZIL relays. If during link selection the ZL and WIL relays are operated, the link preference order will be -2 through -9. When the ZL relay is released and the ZIL relay operated, the preference order is -4 through -9, -2, -3. With the ZL relay operated and WIL relay released the preference order is -6 through -9, -2 through -5. Finally with both the ZL and ZIL relays released the preference order is -8, -9, -2 through -7.

The preference is changed on every marker operation involving link selection. Also if the marker operation involving link selection progresses to second trial the preference order will change twice during the marker operation.

Assuming that the WL, ZL, WIL, and ZIL relays are initially released, the LSA relay in operating will operate the WL relay. With the LSA and WL relays operated the ZL relay is shunted down. The WL relay in operating will also operate the WIL relay. With the WL and WIL relays operated, the ZIL relay is shunted down. Thus on this first marker operation, the link preference order will be that associated with the ZL and ZIL relays both released. The release of the LSA relay removes the shunt from the ZL relay which will then operate.

The next operation of the LSA relay will shunt down the WL relay but maintain the ZL relay operated. The release of the WL relay will remove the shunt from the ZIL relay allowing it to operate. Thus on this second marker operation involving link selection, the link preference order will be that associated with the ZL and WIL relays operated. When the LSA relays release, the ZL relay releases.

The third operation of the LSA relay will reoperate the WL relay which in turn will shunt down the WIL relay. The ZIL relay however will remain operated. Thus on this third marker operation, the link preference order will be that associated with the ZL relay released and the ZIL relay operated. The release of the LTA relay at this time will remove the shunt from the ZL relay permitting it to operate.

The fourth operation of the LSA relay will shunt down the WL relay but maintain the ZL relay operated. The WL relay in releasing will release the ZIL relay. Thus on the fourth marker operation, the link preference order will be that associated with the ZL relay operated and the WIL relay released. When the LSA relay releases the ZL relay will release.

At the end of the fourth marker operation involving link selection the link sequence control circuit will be restored to the state it was in prior to the first marker operation.

If during any marker operation involving link selection the marker progresses to second trial, the ST relay will operate followed after a short interval by the operation of the SA relay. The operation of these relays interrupts the ground from the contacts of the operated LSA relay to the WL and ZL relays which will advance the link sequence control circuit in the same manner

as if the LSA relay were released and re-operated.

5.4 Units Sequence Control

The state of the ZU relay will determine: (a) the preferential order with which stations within a tens group will be selected for dial tone calls, (b) the preferential order with which stations within a hunting group will be selected for the completion of calls to them, (c) the preferential order with which the junctors will be selected for the completion of station to station calls. The above preference orders change whenever the marker is seized for a dial tone call or whenever the marker progresses to second trial on any type of call.

The preference order of stations in a tens group is related to the units digit of a station and when the ZU is operated the order is 5 through 9, 0 through 4. When the ZU relay is normal, the preference order is 0 through 9. The universal lines take their preference order in the same manner from the units digit of their number assignment.

The preference order of junctor selection when the ZU relay is operated is 3, 4, 5, 0, 1, and 2 and when the ZU relay is released the order changes to 0, 1, 2, 3, 4 and 5.

Assuming the WU and ZU relays to be normal, the operation of the TACA relay in the Line, Link and Connector Circuit on a dial tone call will: (a) operate the WU relay which locks to its own contacts and (b) shunt the winding of the ZU relay to prevent it from operating. When the TACA relay in the Line, Link and Connector Circuit releases, the shunt is removed from the ZU relay and it operates from ground at the contacts of the operated WU relay.

On the next operation of the TACA relay in the Line, Link and Connector Circuit on a subsequent marker usage, the WU relay will be shunted down but the ZU relay will remain operated over a path to ground through a break contact of the released WU relay. When the TACA relay in the Line, Link and Connector Circuit releases, the ZU relay releases restoring the circuit to the state it was in prior to the operation of the first TACA relay in the Line, Link and Connector Circuit.

If the marker progresses to second trial while it is processing a dial tone call, the ground from the contacts of the operated TACA relay of the Line, Link and Connector Circuit will be interrupted by the operation of the ST relays and reapplied an interval later when the SA relay operates, thus changing the state of the ZU relay and changing the units sequences. If the marker progresses to second trial while it is processing other than a dial tone call, the TACA relay in the Line, Link and Connector Circuit will be normal and the operation of the ST relay and subsequent operation of the SA relay will apply and release ground from break contacts of the TACA relay in the Line, Link and Connector Circuit and thus change the state of the ZU relay.

6. PATHS BUSY

6.1 All Registers Busy

If all registers are busy when a line tries to make a call, the marker will hold that call and serve the first register wanting to complete a call before the station line or trunk will be served.

When the RL and RLA relays operate to release the marker after the marker has set up a call to a register, and both registers are then busy, relay TP- will release and release relays TAC and TACA in the Line, Link and Connector Circuit. The TAC and TACA relays in the Line, Link and Connector Circuit release relays RAO and RA1 which were involved in the call just served.

With relay RL operated and relays RAO and RA1 released, the all registers busy (ARB) relay (FS1) will operate. The ARB relay locks through its own contacts independently of the RL relay, closes an operating path for relays RO and R1 independent of the TEO and TE1 relays, and opens the operating circuit of the TP- relays.

When a register becomes idle again, its associated RAO and RA1 relays operate which in turn releases the ARB relay. The marker will again continue to serve station calls within the gate.

6.2 All Links Busy

6.2.1 Station to Station Call - SC13

If during the link testing sequences of the marker while setting up a station to station call as described in 2.1.4, all links in the first group of links tested are found to be busy the marker will shift the link testing circuitry to the second group of links (see 7) and look for an idle link in that group. If there are no idle links in the second group tested the all links busy (ALB) relay will operate.

The ALB relay in operating will operate the BTT relay which will: (a) operate the TRK and TRKA relays, (b) lock operated to the operated RPA- relays, and (c) release the JR- relay corresponding to the junctor selected. The release of the JR- relay will release the JRE relay. The JRE relay in releasing will release the LS and LSA relays which in turn cause the release of the LB, LTC, and

ALB relays. The LSH relay will also release after the LB releases.

After the TRK and TRKA relays operate the marker will function to complete the call to a busy tone trunk as described in 2.1.10 using the link used for the dial tone connection.

6.2.2 Dial Tone Call

If while the marker is processing a dial tone call, it finds all links busy, the ALB relay will operate. Since on this type of call the TAC and TACA relays in the Line, Link and Connector Circuit are operated, the operation of the ALB relay will close paths for operating the slow operate AC relay.

When the AC relay operates the DCK relay releases which causes the RL and RLA relays to operate releasing the marker.

When the marker is released, it will continue to try to complete calls required of it even though all links are still busy.

6.3 All Junctors Busy

When the marker is trying to complete a call requiring a junctor and all junctors are busy, the call will be routed to a busy tone trunk.

When the U- relays operate during the junctor selection sequence no S- relays will operate since all junctors are busy and the ground from the contacts of the JTAA relay will operate the BY relay. This will operate the HC relay which will then provide a path for operating the BSYA and BSY relay which in operating will operate the SOA relay and release the HC relay. The SOA relay, in operating, will operate the S0 through S2 and S5 through S7 relays which in turn operate the SE relay. These relays in operating at this time operate the SMR and SMRA relays and release the RUC relay.

With the SMRA, SE, SOA, S0, and JTA relays operated, the HMK relay is connected to the hold magnet of junctor 0 and the ground at that point will operate the HMK relay. Meanwhile the RUC relay in releasing will cause a sequence releasing the U0 through U2, U5 through U7, UE, BY, BSYA, and BSY relays.

With the SOA, SMRA, and HMK relays operated the BTT relay will operate and lock to the operated RPA- relays. The BTT relay operated will: (a) operate the TRKA relays, (b) release the JTA and JTB relays which in turn release the JTAA, SMRA, S0 through S2, S5 through S7, and SE relays in that sequence, and (c) release the SOA relay which in turn releases the HMK relay.

With the TRK relay operated and the HMK relay released, the TRCA relays will operate.

The release of the SE relays will: (a) release the TRK and TRKA relays and (b) reoperate the RUC relay.

With the BTT and TRC relays operated and the TRKA relay released, the BTC relay operates which in turn operates the SMC1 relay in the Line, Link and Connector Circuit and releases the TOL relay. The SMC1 relay in the Line, Link and Connector Circuit in operating will: (a) provide a path for operating the select magnets on switch 1 used for the dial tone connection from grounds at the contacts of the operated TRCA relay passing through the RP- relay and the register memory hold magnet HM-9, and (b) operate the SMT relay.

With the BTC and RUC relays operated, the U7 relay will operate which, in turn, will operate the UE relay. If the busy tone trunk is idle, battery through its trunk hold magnet HM17 will operate the S7 relay which in turn will operate the SE relay.

Beyond this point in the sequence, the marker will function to connect the calling station to the idle busy tone trunk and release itself and the register in the same manner as described previously.

6.4 Busy Tone Trunk Busy

When the marker reaches the point in a sequence where it starts to set up the call to the busy tone trunk as described in previous paragraphs, it will first make a busy test on the busy tone trunk by connecting the S7 relay primary winding to the HM of the trunk. If the trunk is busy the ground at the HM will prevent the S7 relay from operating and when the SMT relay is operated by the SMC1 relay in the Line, Link and Connector Circuit, ground from the contacts of the SMT relay will pass through the break contact chain of the unoperated S0 through S9 relays and operate the BY relay.

The BY relay in operating will: (a) release the DCK relay which in turn will operate the RL and RLA relays and start the sequence to release the marker, (b) operate the HC relay which has no function at this time, (c) lock operated to the operated UE relay, and (d) ground the "BY-" leads to the register through contacts of the operated BTC and RPA- relays which will operate the BY relay in the register.

The BY relay in the register, in operating, will: (a) lock operated to the ON relay in the register, (b) release the DC relay in the register, (c) open the "RRO"

and "RR1" leads from the register to the marker to prevent the release of the register when the marker releases, and (d) apply busy tone over the tip and ring conductors to the calling station or trunk.

The release of the DC relay in the register will release the R- relay in the marker. The operation of the RLA or R- relays will: (a) release the RP- relay which in turn will release the RPA- relay and the operated select magnets on switch 1, and (b) release the MTA and MTB relay which stops the marker timing.

The release of the RPA- relay releases the BTT and RUC relays. The BTT relays in releasing will release the TRC TRCA and BTC relays and the release of the RUC relays will cause the release of UO, UE, BY, and HC relays in sequence. The release of the BTC relay will release the SMC1 and SMT relays in sequence.

With the TRC relay released and the RLA relays operated, the DCK relay will reoperate causing the RL and RLA relays to release restoring the marker to normal.

The register will continue to furnish busy tone to the calling station or trunk until it times out and releases.

7. LINK SHIFT TIMING

7.1 General

Whenever the marker is processing a call requiring link selection the LS relay will operate at the start of the link hunting sequence which will close the operating path of the slow operate LB relay to the chain of break contacts of LT2 through LT9 relays. If an LT- relay does not operate before the LB relay operates the link group sequence control circuit will advance as explained in 5.2, and change the state of the TRL relay. The TRL relay in operating or releasing will shift the link testing circuitry from one group of links to the other.

7.2 Link Shift Timing

The operation of the LS relay will connect ground to one side of the winding of the slow operate LB relay. The other side of the winding is connected through break contacts of the released LSH relay to the break contact chain of LT2 through LT9 contacts to battery. If no LT- relays operate within approximately 50 msec indicating that all links are busy in the first group tested, the LB relay will operate.

The LB relay in operating will: (a) lock operated to its own contact under control of the LS relay, (b) advance the link group sequence control circuit as described in 5.2, (c) open the operating path for the LE relay to prevent it from operating prematurely should an LT- relay have operated just prior to the operation of the LB relay, (d) release the LTC relay to open the circuit to the LT2 through LT9 relays to prevent them from operating or release any that may have operated during the link shifting operation, and (e) operate the LSH relay.

The LSH relay is also slow in operating and will operate in approximately 29 msec. This relay in operating will: (a) reoperate the LTC relay, (b) restore the operating paths for the LE relay, and (c) connect the ALB relay to the chain of LT2 through LT9 relay break contacts to start the all links busy timing sequence.

The LB relay will release when the LT relay releases and the LB relay, in releasing, will release the LSH relay.

8. MARKER TIMING

8.1 General

Whenever the marker is seized to process a call, a relay timing circuit begins to function. The circuit is arranged to recycle three times, timing three distinct intervals. The timing will be stopped and the circuit restored to its starting condition whenever the marker has completed its functions and released in the normal manner.

If the marker has not released before the timing circuit has run through its initial cycle, the marker will restore the call sequence to an earlier state and initiate a second trial. If the marker has not been able to complete the call and release in the normal manner on the second trial before the timing circuit has completed its second cycle it is assumed a "no connection" condition exists and the marker will attempt to complete the call to the busy tone trunk. If the marker has not disposed of the call by the time the timing circuit has recycled for the third time, the marker will "trouble release."

8.2 Second Trial

When the marker is seized for any type of call the MTA and MTB relays will operate as described in previous paragraphs to start the marker timing. The MTA and MTB relays in operating will operate the TM relay which in turn will operate the TO relay. The TO relay in operating operates the slow operating TA relays.

When the TA relay operates, the slow releasing TM relay releases and when the TM relay releases, the slow-releasing TO relay releases.

With the TO relay released and the TA relay operated, the ST and second trial register (STR) relay will operate and lock to the operated MTA and MTB relays. The release of the TO relay will also release the TA relay which will: (a) reoperate the TM relay to start the timing circuit on its second cycle and (b) operate the SA relay which locks to the operated MTA and MTB relays and releases the STR relays.

The approximate time interval between the operation of the MTA and MTB and the ST and STR relay is 600 msec. The approximate time interval between the operation of the ST and SA relays is 70 msec.

The operation of the STR relay will release the SMT relay and also release the RPA- relay, if operated. The ST relay in operating will: (a) release any operated JR- relay and (b) release the RA1 relay if operated. The subsequent operation of the SA relay will: (a) release the STR relay which will restore the operating path for the SMT relay and (b) restore the locking path for the JR0 through JR5 relays. The sequential operation of the ST and SA relays will also advance the link and units sequence control circuits.

On a dial tone call the release of the SMT relay will cause the release of the SMR and SMRA, HMT, and HMTA relays. The advance in the link sequence control circuit will cause a new link to be selected (if another link is idle in the same group). If on the first trial the marker preferred register 1, the release of the RA1 relay will cause the marker to attempt to connect to register 0 (if idle) on the second trial. If the marker preferred register 0 on the first trial, the release of the RA1 relay will cause the marker to prefer register 0 again on the second trial. The advance of the units sequence control circuit will change the state of the ZU relay and when the SMT relay reoperates the grounds from their contacts will pass through the S- relay contact chain by the alternate route.

If the marker is processing a terminating call, the release of the RPA-, JR-, and SMT relays will cause the release of most of the relays involved in processing the call on the first trial and,on the second trial, the marker will make new link and junctor selections.

8.3 No Connection

While the marker is processing a call on a second trial, the timing circuit will recycle. If the call has not been completely processed and the marker released before the TO relay releases on the second cycle the NC relay will operate and release the JTA and JTB, and TRCA relays, if operated. When the TA relay releases the TM relay will operate to start the timing circuit on its next cycle and operate the NA relay. The NA relay in operating will: (a) release the RCTA relays if operated, (b) restore the operating path for the TRCA relays, and (c) operate the BTT relay through contacts of the released TRCA relay.

The BTT relay in operating with the TRC relay released will operate the TRKA relays which in turn release the SMT and SMRA relays in sequence. With the HMK relay released, the TRCA relays will reoperate when the SMT relay releases. When the TRC relay operates the TRKA relay will release and, since the BTT relay is operated, the BTC relay will operate.

When the BTC relay operates, the marker will attempt to complete the connection to the busy tone trunk in a manner similar to that described in 2.1.10, 2.2, or 6.3.

8.4 Trouble Release

If the marker is unable to complete processing the call to the busy tone trunk on a "no connection" basis before the TO releases on the third cycle of the timing circuit, the TR relay will operate over a path through contacts of the released TO relay and the operated TA and MTA and MTB relays.

The TR relay in operating will: (a) lock to the operated MTA and MTB relays, (b) release the normally operated release check (RCK) relays and (c) release the TA relay which in turn reoperates the TM relay.

The release of the RCK relay will operate the trouble release RLS and RLSA relays from ground at make contacts of the operated TR relay.

The trouble release relays in operating will: (a) release the TEO and TE1 relays, (b) release any operated RP-, TP-, TACA in the Line, Link and Connector Circuit, SE, LE, and SMT relays, (c) operate the RRL relay in a register if a register is connected, and (d) release the MTA and MTB relays.

The release of the MTA and MTB relays releases the ST, SA, NC, NA, TM, and the slow release TR relays. When the TR relay releases the RLS and RLSA relays release and the slow operate RCK relay reoperates.

When the RLS and RLSA relays operate, the TA-relay corresponding to the operated TP- relay will operate and lock to the released RCK relay. The released RCK relay will also maintain the locking path for any other operated TA- relay when the TEO relay releases. The release of the TP-, TAC and TACA in the Line, Link and Connector Circuit, SE, LE, and SMT relay will otherwise restore the marker to normal.

The release of the TE1 relay will reopen the gate circuits and admit new requests

for the services of the marker in those tens groups whose corresponding TA- relay is not locked operated. When the RLSA relays release, any operated T- or R- relay will reoperate the TE0 and TE1 relays which will maintain the locking path for any operated TA- relays when the RCK relay releases.

The marker will then process the calls in the preferential order omitting those tens groups which had been served before the trouble release.

9. TIME-OUT CHECK

The time-out check circuit is provided to exercise the marker timing circuit. When the marker is functioning normally, the timing circuit will never run through its full sequence. The time-out check circuit is designed to run the timing circuit through its full sequence whenever the normally operated TOL relay releases due to a power failure or the BTC relay operating when the marker connects a call to the busy tone trunk.

When the TOL relay operates, a path is prepared for operating the time-out check (TOK) relay when the marker has finished processing all of the calls in the tens preference chain and the TE1 relays release.

The TOK relay in operating will: (a) operate the MTA and MTB relays which will start the timing circuit functioning as described in 8, (b) lock operated under control of the RLS relay, (c) open the operating path for the TE0 and TE1 relays and the tens preference chain and (d) reoperate the TOL relay.

When the marker timing circuit has completed its third cycle the RLS and RLSA relays will operate releasing the TOK relay returning the marker to normal.

10. STATION AND TRUNK HUNTING GROUPS

10.1 General

Any number of stations within the same tens group may be formed into a hunting group. Each station has a corresponding H-- terminal and a hunting group is formed by connecting between pairs of terminals until the pattern desired is established. A variety of patterns can be created but in general they can be classified as 2-way hunting groups, one-way hunting groups, combined 2-way and one-way hunting groups or one-way sequential hunting groups.

A grouping of the universal lines can be established by strapping or connecting diodes between the associated H terminals as desired.

As described in previous paragraphs, the marker in completing a call to a station will first attempt to connect to the station corresponding to the dialed number. Only if this station is busy will the marker attempt to complete the call to an idle station in the same hunting groups.

10.2 The 2-Way Station Hunting Group

The 2-way station hunting groups are created by connecting straps between the H-- terminals corresponding to the stations to be included in the group. If the station dialed is busy, the marker will progress to the station hunting sequence and operate all of the U- relays corresponding to stations in the hunting group and the S- relays corresponding to the idle stations in the group will operate. The marker will then connect to the station associated with the first operated S- relay in the line hunting chain circuit. It should be noted that if the ZU relay is operated the preference order of selection is S5 through S9, S0 through S4. If the ZU relay is released the preference order is S0 through S9.

10.3 One-Way Station Hunting Group

A one-way station hunting group is created by connecting an H diode between pairs of H-- terminals corresponding to stations to be included in the hunting group, being careful to pole the diodes such that the arrow direction corresponds to the hunting direction desired. In this case when the marker progresses to the hunting sequence, only the U- relays corresponding to the stations beyond the dialed station in the H-- terminal strapping order will operate. The marker will connect the call to an idle station corresponding to the operated U- relays in a preference determined by the state of the ZU relay and the position of the S- relays corresponding to the operated U- relays in the line hunting chain.

10.4 Combined 2-Way and One-Way Station Hunting Group

A combined station hunting group is created by using straps between pairs of H-- terminals and diodes between other pairs to accomplish a desired result. For example, if it is desired that calls to station 30 or 36 be routed to the other station when the dialed station is busy, a strap will be connected between terminals H30 and H36. If it is further desired that calls to station 37 be routed to either station 30 or 36 when station 37 is busy, a diode will be provided between terminals H37 and H36 (or H30) with the diode arrow pointing in the direction of punching H36 (or H30).

In this case if the marker is processing a call to station 37 but finds it busy, it will progress to the hunting sequence and operate the U0 and U6 relays and if both stations 30 and 36 are idle, the S0 and S6 relays will operate. The marker will then

complete the call to either station 30 or 36 depending upon the station of the ZU relay. However, if the marker is processing a call to station 36 and finds it busy, the marker, after progressing to its hunting sequence, will operate only the U0 relay and if station 30 is idle the S0 relay will also operate. The marker will then complete the call to station 30.

10.5 One-Way Sequential Station Hunting Group

A one-way sequential hunting group may only involve stations within the same subgroup of five stations in a tens group. Such a group may be formed by connecting a diode between pairs of H-- terminals corresponding to the stations involved with the diode arrows always pointed in the direction of the higher numbered H-- terminal. For example, assume that stations 20, 22, and 24 are to be arranged in a hunting pattern such that calls to a busy station 20 will be routed to station 22 unless that station is also busy in which case it will be routed to station 24. Furthermore, calls to a busy station 22 will be routed to station 24, but calls to a busy station 24 will not be routed to any other station. To create this pattern a diode should be provided between terminal H20 and H22 and between H22 and H24 with the diode arrow pointed towards the higher numbered terminals in each case.

In this case, if the marker is processing a call to station 20 but finds it busy, it will progress to the hunting sequence and operate the U2 and U4 relays which in turn will cause the S2 and S4 relays to operate if stations 22 and 24 are idle. Regardless of the state of the ZU relay the S2 relay will be ahead of the S4 relay in the line hunting chain and the marker will always connect the call to station 22, if idle. If station 22 is also busy the S2 relay will not be operated and the call will be connected to station 24.

If the marker is processing a call to station 22, but finds it busy, it will progress to the hunting sequence and operate the U4 relay through the H diode between terminals H22 and H24. The U0 relay will not operate since the H diode between terminal H20 and H22 is poled in the wrong direction to pass the ground on terminal H22. If station 24 is idle, the S4 relay will operate and the call will be completed to that station.

If the marker is processing a call to station 24, but finds it busy, it will progress to the hunting sequence but no U-relays will operate (other than the U4 relay which is already operated) since the H diodes between terminals H20, H22, and H24 are poled in the wrong direction to operate the U0 and U2 relays from ground on terminal H24. The marker will therefore attempt to connect the call to the busy tone trunk.

11. TROUBLE TIME-OUT

When the marker is seized to process a call the MTA and MTB relays operate to start timing of the call. Under normal conditions if a trouble is encountered in establishing a call the marker will finally release itself and attempt to process another call. However, if a trouble is encountered in the timing circuit this function is unavailable. An alarm circuit is provided which under these conditions will release the marker.

When the MTA and MTB relays operate they prepare a path to operate the PU relay in the alarm circuit under control of a ground from the power supply interrupter circuit. In 0 through 7.5 seconds a ground on the "MTPU" lead will operate PU relay in the alarm circuit. The PU in operating locks up through its own make contact a break contact of the TMO relay in the alarm circuit, and make contacts of the MTA and MTB relays, which extended ground on the "MT" lead from the marker circuit to the alarm circuit. In approximately 7.5 seconds a ground from the interrupter circuit will be placed on the "TMO" lead to the alarm circuit operating the TMO relay. When TMO relay operates (a) relay PU releases, (b) completes its own locking path to ground from the marker on the "MT" lead, (c) operates the AL relay in the alarm circuit,and (d) operates the trouble release relays RLS, RLSA in the marker, restoring the marker to normal and allowing it to attempt to process another call. The marker in releasing restores the alarm circuit timing relays to normal. The alarm indication will remain until released by the alarm release (AR) key.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.1 Voltage Limits

Minimum	Maximum
-45	-52

2. FUNCTIONAL DESIGNATIONS

The functional meanings for the relays of the marker circuit are given in the following table:

Relay Designation	Functional Meaning
AC	Abandoned call
AlB	All links busy
ARB	All registers busy
BSY, BSYA	Circuits busy
BTC	Busy tone trunk connector
BTT	Busy tone
BY	Busy test
DCK	Down check
HC	Hunt connector
HMK	Hold magnet check
HMT, HMTA	Hold magnet timing
JR(0-5)	Junctor register
JRE	Junctor register end
JTA, JTAA, JTB	Junctor terminating
LB	Link busy
LE	Link end
LSH	Link shift
LT(2-9)	Link test
LS, LSA	Link start
LTC	Link test connector
LUC	Lines units connector
MTA, MTB	Marker timing
NA	No connection auxiliary
NC	No connection
RO, R1	Register
RAO, RA1	Register allotter
RCK	Release check
RCT, RCTA	Register cut through
RG	Register group
RHK	Register hold magnet check
RL, RLA	Release
RLS, RLSA	Trouble release
RPO, RP1	Register preference
RPAO, RPA1	Register preference auxiliary
RUC	Register units connector
S(0-9)	Sleeve
SA	Second trial auxiliary
SE	Sleeve end
SMR, SMRA	Select magnet register
SMT	Select magnet timing
SO	Sleeve operate
SOA	
ST	Second trial
STR	Second trial register
T(1-5)	Line tens
TA(1-5)	Line tens auxiliary
TA	Timeout auxiliary
TAC	Tens auxiliary connector
TE(0-1)	Tens end
TM	Timing
TO	Time-out
TOK	Time-out check
TOL	Time-out lock
TP(1-5)	Tens preference
TR	Trouble
TRC, TRCA	Terminating route complete
TRK, TRKA	Terminating route check
TRL	Transfer links
U(0-9)	Units
UE	Units end
UL	Units lock
WIL, WL	Link sequence W-Z
ZIL, ZL	Link sequence
WLG, ZLG	Link sequence
WU, ZU	Units sequence W-Z
WLGA	W auxiliary

3. FUNCTIONS

The marker circuit is designed to perform the following functions:

(a) To connect a calling station line or trunk (associated with a universal line) to a dial pulse register.

(b) To connect a station line to a station line through a junctor.

(c) To connect a trunk (associated with a universal line) to a station line.

(d) To connect a trunk to a trunk (both associated with universal lines).

(e) To connect a station line or trunk (associated with a universal line) to the busy tone trunk if the called line or trunk group is busy.

(f) To set the dial pulse register to return busy tone if the busy tone trunk is busy.

(g) To release and abandon a call under the following conditions:

(1) The calling party disconnects before receiving dial tone.

(2) The calling party disconnects after the dial pulse register seizes the marker and before the call is completed.

(3) The calling station line or trunk (associated with a universal line) does not test idle.

(h) To serve calls from register lines in a predetermined order and to prevent calls from interfering with each other.

(i) To select an idle link for a call.

(j) To allot an idle dial pulse register for a call.

(k) To select an idle trunk (associated with a universal line) from the group desired.

(l) To hunt over lines strapped in a hunting group.

(m) To recognize an all registers busy condition and block until a busy register has been served and becomes idle.

(n) To release the dial pulse register when a call has been completed.

(o) To go to second trial if a call is not completed in a predetermined length of time.

(p) To connect the calling party to the busy tone trunk if the call is not completed on a second trial in a predetermined length of time.

(q) To release if the call cannot be completed to the busy tone trunk in a predetermined length of time.

(r) To check the time-out circuits every time the busy tone trunk is used.

(s) To release and give an alarm if a call cannot be disposed of by the marker and the marker timing circuit fails.

4. CONNECTING CIRCUITS

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

(a) Dial Pulse Register Circuit - SD-69470-01.

(b) Alarm and Test Circuit - SD-69471-01.

(c) Junctor Circuit - SD-69464-01.

(d) Line, Link and Connector Circuit - SD-69469-01.

(e) Power Supply Circuit - SD-81577-01.

(f) Busy Tone Trunk Circuit - SD-69465-01.

(g) Call Progress Indicating Circuit - SD-69472-01.

5. MANUFACTURING TESTING REQUIREMENTS

The marker circuit shall be capable of performing all the functions specified in this circuit description, and meeting all the requirements of the Circuit Requirements Table.

6. TAKING EQUIPMENT OUT OF SERVICE

6.1 Marker

There is no way in which the marker can be taken out of service without disrupting all traffic through the system.

7. ALARM INFORMATION

7.1 Fuse Alarm

An operated fuse supplying the marker circuit is indicated by a major alarm at the plant service center if alarm transmitting features are provided and in any case a visual signal will be given locally.

The operated fuse must be replaced or removed to restore the alarm circuit to normal.

7.2 Trouble Release Alarm

A major alarm will be indicated at the plant service center and/or locally if the marker trouble releases on a time-out basis. This alarm indication is locked in and can be removed by operating the alarm release key in the Alarm and Test Circuit.

SECTION IV - REASONS FOR REISSUE

D. DESCRIPTION OF CHANGES

D.1 Miscellaneous changes are made in the circuit description and sequence charts.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-GA-HFH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
LINE, LINK, AND CONNECTOR CIRCUIT

CHANGES

D. Description of Changes

D.1 All changes are made on a Class D - No Record basis per agreement with WECo.

D.2 On sheet A1, the sheet index is brought up to date.

D.3 On sheet B3, drafting error on lead R is corrected.

D.4 On sheet D1, Note 202 is added.

D.5 On sheets G2, 3, 4 and 5, CAD's 2, 3, 4 and 5 are revised and equipment option EB is added to leads S and S1 to provide for the station make-busy feature.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7120HW-RHO-JGW)
DEPT 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
LINE, LINK, AND CONNECTOR CIRCUIT

CHANGES

D. Description of Changes

D.1 On sheets B3, 4 and 5, leads S20-59, S120-59, S6-8 and S16-8 to the telephone line and add-on circuit are added to provide for the station make busy feature.

D.2 On sheet B4, connecting information for the interface trunk circuit is added.

D.3 On sheet D1 note 102 is revised.

D.4 On sheet D2 note 307 is added.

D.5 On sheets G2, 3, 4 and 5, CADS 2, 3, 4 and 5 are revised.

F. Changes in CD Sections

F.1 In SECTION III, CONNECTING CIRCUITS, add:

4.9 Interface Trunk Circuit - SD-66926-01.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-AEK-JGW)
DEPT 5337-RAV

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
LINE, LINK, AND CONNECTOR CIRCUIT

CHANGES

D. Description of Changes

D.1 On sheet B2, location B&C-3, relay contacts LTS9, LEA and LTS2 (in marker circuit) have been corrected to read LT9, LE and LT2 respectively. Also on sheet B2 at location C-7, relay contact LTS2-9 (marker circuit) has been corrected to read LT2-9.

D.2 On sheet 33, location C-0, E-0, and G-0, relay contact descriptions U-0 and S-0 have been corrected to read U-5, S-5, U-6, S-6, U-9, and S-9 respectively.

D.3 On sheet B6, location G and H-6, leads T1, T2, T3, T4, and T5 from the marker circuit have been added.

D.4 On sheet E1, location E7, U-3 lead designation has been changed to read U-9.

D.5 On sheet G6, CAD 6 and 7 is added.

D.6 On sheets G3, 4, and 5, options R and S are added.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-GR-HFH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
LINE, LINK, AND CONNECTOR CIRCUIT

CHANGES

D. DESCRIPTION OF CHANGES

D. 1 References to the term PBX have been removed and replaced by SW SYS.

D. 2 On sheet B3, the fixed side of relay $\begin{matrix}TC2,\ 3\\TC4,\ 5\end{matrix}$ was shown reversed and has been changed to agree with manufacturing information.

D. 3 On sheets B4 and G2, several typographical errors were corrected.

D. 4 On sheet G2, CAD 6 is rated A&M Only and reference to CAD 13 is added.

D. 5 On sheets G3, G4, and G5, CAD 5 is rated A&M Only and reference to CAD 12 is added.

D. 6 On sheet G5, references to options "T" and "Y" were added.

All other headings, no change

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-PB-HFH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
LINE, LINK AND CONNECTOR CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. GENERAL METHOD OF OPERATION

1.1 General

The link circuit provides terminations for the 20-29 and 30-29 groups of station lines and, if apparatus options "4" & "5" are provided for the 40-49 and 50-59 groups of station lines. Terminations are also provided for three universal line circuits, which may be used with a loud speaker paging trunk, recorded telephone dictation trunk, 2-way tie trunk, 3A Code Call Circuit or a station line. Terminations are also provided for one busy tone trunk, two dial pulse registers and both ends of six junctors.

The crossbar switching network consists of six 10 x 10 - 6 point crossbar switches. The horizontals are arranged so that a total of sixteen 3-wire links are available. The 16 links are realized by using eight 6-wire horizontals (levels 2 through 9) and choosing either the left or right half of the crosspoints by operating the crosspoints of either the zero or one levels in combination with those of one of the two through nine levels. The line circuits, busy tone trunk, junctor circuits, and the dial pulse registers are terminated on the switch verticals. Each dial pulse register is assigned two verticals. One of these verticals is used as a temporary memory device to record the link number used in the dial tone connection. The crosspoints of the register memory verticals are not multipled to the crosspoints of other verticals and therefore do not form part of the links. The junctors have two vertical appearances each, one for the originating side and the other for the terminating side.

Only one link is used for establishing dial tone connections, station to trunk connections, and trunk to trunk connections. Station to station connections are established through a junctor and thus use two links per connection. Station to trunk connections are established using only one link but tie trunk to station connections are established through a junctor and so employ two links.

The link system also includes the select magnets, which determine the selection of the link to be used on a call and are under control of the link testing and selection circuit in the marker. After the marker has determined the link to be used and operated the associated select magnets, the operation of a hold magnet causes the associated crosspoints to close down on the link and extend the T, R and S leads of the associated circuit to be bridged to the link wiring to the originating or terminating circuit to which a connection is being completed. All hold magnets are wired in the sleeve circuit so that the operating path is from the marker and the holding path is completed by a ground from the various circuits over the sleeve of the link circuit.

1.2 Station Line

When the telephone set is removed from the switchhook the line is shorted and the associated L- relay operates. The L- relay in operating grounds the tens and units leads corresponding to the line number to the marker as a seizure signal. The marker in processing the call operates the crossbar switch hold magnet in the link corresponding to the vertical appearance of the line which in turn operates the hold magnet off-normal springs. The hold magnet off-normal springs in operating releases the L- relay and removes the seizure signal to the marker.

A call is terminated to a line by dialing the two digit line number. The L- relay is not operated on a terminating call and the line circuit is not involved.

1.3 Universal Line

The universal line circuit may be connected as a station line or to a two way tie trunk, recorded telephone dictation trunk, loud speaker paging trunk, or 3A Code Call Circuit. The universal line circuit is reached by dialing the single digit 6, 7, 8, 9, or 0 depending upon the strapping provided in the dial pulse register circuit. Strapping in the dial pulse register circuit will also determine whether calls are completed to a universal line circuit with or without a junctor. The "H" and "S" punchings corresponding to the universal line circuits are shown on the marker circuit.

When a universal line circuit is assigned as a station line or connected to a two way tie trunk, an originating call will operate the L- relay which grounds the T1 lead and the appropriate U- lead to the marker as a seizure signal. The marker in processing the call will operate the (IN-) relay which in turn operates the line hold magnet in the link. When the hold magnet operates, the operating off-normal springs cause the L- relay to release. The IN- relay will lock operated to the ground on the link sleeve.

When a call is terminated to a universal line circuit assigned as a station line or connected to the answering end of the 3A Code Call Circuit, the marker circuit will operate the IN- relay which operates the line hold magnet in the link. The IN- relay will lock operated to the ground on the link sleeve. When a call is terminated to a universal line circuit

connected to a two way tie trunk, recorded telephone dictation trunk, loud speaker paging trunk, or to the calling end of the 3A Code Call Circuit, the marker will operate the OT- relay which operates the line hold magnet in the link. The OT- relay will lock operated to ground on the S2 lead from the connected circuit. In this case the SL- relay will also operate and lock to the S2 lead.

1.4 Station Hunting Groups

Stations may be arranged into one way or two way hunting groups or in combinations of both types but with the restriction that all stations in a hunting group must be within the same tens group.

SECTION II - DETAILED DESCRIPTION

1. OPERATION OF HOLD MAGNETS

1.1 Originating Call

Since all the hold magnets are associated with their own sleeve lead and a common line and trunk hunting circuit in the marker the explanation of the operation of one hold magnet as to another will only vary as to what sleeve lead is completed by the tens connector relays, junctor terminating relays or the busy tone connector relay.

Assuming a call is being originated by a station in the 20-29 group, the associated tens connector auxiliary relay will operate and prepare the operate path for all the hold magnets in that group. As the marker progresses with the call and assuming station 27 is the originating station, the U7 relay in the marker operates and places the primary winding of the S7 relay in the marker in series with hold magnet HM27 through contacts of the TCA2 relay in the marker. Since the winding of the S7 relay is 5000 ohms and the winding of the HM27 hold magnet is 900 ohms the current flow will be such that only the S relay will operate at this time. As the marker continues to progress with the connection, the SMT relay in the marker operates and (1) extends ground on the sleeve leads to make contacts of the S7 relay, (2) operates the register hold magnets HM(-)8 and HM(-)9 under control of the register allotter relay in the marker, (3) operates the SMRA relay in the marker which in operating extends the ground from the SMT relay through its make contacts operating the HM27 hold magnet, which closes its crosspoints to the link to complete the connection to the dial pulse register. When the register is seized its L relay operates operating the register SR relay which places a ground on the link sleeve lead to hold the originating hold magnet operated, and ground to hold its own hold magnets operated. The hold magnet HM27 in operating opens the operate path of the line L27 relay in the line circuit which releases.

1.2 Terminating Call

When the register has received the dialed number it requests the marker to complete the call to the called station. The testing and operation of the station hold magnet is accomplished as in the originating call as explained in Paragraph 1.1. In this case, however, the hold magnet of the called station could be operated due to another call. Under this condition the associated S relay in the marker cannot operate because ground holding the hold magnet operated rather than battery will be on the sleeve lead through the TCA- relay and operated U-relay through the winding of the S- relay to ground. The marker then functions as is explained in the marker circuit description.

2. OPERATION OF SELECT MAGNETS

When a station or trunk originates a call, a junctor register relay operates, or the busy tone connector relay operates the marker select magnet connector relay associated with the crossbar switch that the circuit involved appears on. The select magnet connectors in the marker prepare the operate paths for the select magnets. During link testing by the marker, all LTS relays in the marker associated with idle links will operate. Assuming that the LTS4 relay in the marker is operated and the link sequence control is such that when the LEA relay in the marker operates ground is extended through contacts of all operated SMC(-) relays operating the SM4 select magnet in all switches whose corresponding SMC relay is operated. Whether horizontal 0 or 1 will be used for the connection is dependent on the state of the transfer link relay in the marker. Assuming the TRL relay is operated, the operation of the LTS4 relay in the marker extends a ground to a make contact of the TRL relay in the marker. When the LE relay in the marker operates this ground is further extended through contacts of the operated SMC(-) relays operating all select magnets associated with vertical 1. In this example the select magnets associated with link 14 were operated. Had the TRL relay been released the select magnets associated with link 04 would have operated.

3. OPERATION OF SELECT MAGNETS THROUGH THE REGISTER MEMORY VERTICAL

When the register memory hold magnet operates during the dial tone connection it performs no actual function, however, it serves to remember the link of the originating call and enables the marker to reuse the link when the call is eventually terminated. The memory vertical is not multipled to crosspoints of other verticals but closes down on link memory leads associated with vertical 0 and 1 and link memory leads associated with horizontals 02-09 to 12-19.

On a junctor type of call when the marker terminating route complete (TRCA) relay operates, ground is extended through make contacts of the register preference RP(0-1) relay in the marker over the LM00 or LM10 and LM01 or LM11 leads depending upon which RP- relay is operated. Since the crosspoints of the memory vertical are in the same position as the work vertical the ground will be extended over the proper LM leads to operate the select magnets of the switch in which the SMC is operated and cause the crosspoints involved in the terminating connection to close down on the previous used link.

On a trunk type of call the junctor register end JRE relay will not operate but on subsequent action in the marker the register cut through RCT relay will operate. With the JRE relay nonoperated and the RCT relay operated ground is extended on the LM leads as previously explained in this paragraph.

4. STATION LINE CIRCUIT

The removal of a handset from a station switchhook will cause the station's L- relay to operate. The L- relay in operating (1) operates the associated tens relay in the marker circuit which signals the marker to set up a dial tone connection to the station and (2) grounds the associated U- lead to the marker circuit. The marker in processing the call, will place the winding of the station hold magnet in the sleeve circuit and operate it. When the hold magnet operates it will release the associated L- relay. When connected to the line, the dial pulse register will place a ground on the sleeve linkage to hold the hold magnet operated after the marker releases.

After a station or trunk completes dialing a station code into the register circuit, the register will request the marker to complete the call. During the process of completing the call the marker will test the condition of the called station's hold magnet. If it is idle there will be negative forty eight volts on the hold magnet winding. Having found the station idle the marker will operate the station's hold magnet which opens the operate path of the L- relay.

If the called station is busy when the marker tests the hold magnet, the holding ground will cause the marker to check if the station is in a hunting group. If the station is in a hunting group in which there is an idle station, the marker will complete the call to that station. If there are no idle circuits in the hunting group or the called station is not in a hunting group, busy tone will be returned to the calling station.

5. UNIVERSAL LINE CIRCUIT

5.1 Station Line - (Option Z)

When a line circuit is assigned to a station line "Z" option is provided. Calls to and from the station line are processed by the marker in the same manner as described in Paragraph 4 above, except that the S lead from the marker operates the IN- relay instead of the hold magnet directly. The hold magnet is operated by the IN- relay. The ground on the sleeve of a connected link will hold the IN- relay operated after the marker completes its functions and leaves the connection.

5.2 Two-Way Tie Trunk - (Option X)

When a line circuit is assigned to a 2-way tie trunk, the T1, R1, T2, R2 and S2 leads are connected to the trunk, and "X" option is used. With some trunks the S1 lead may also be required.

When the circuit is seized for an incoming call a bridge on the tip and ring or a ground on the ring in the trunk will operate the L- relay over the T1 and R1 leads and the marker will process the call as if it were a station. The L- relay in operating will close a path between the S lead to the marker and the winding of the IN- relay. This path is maintained by make contacts of the IN- relay after the marker operates the IN- relay over the S lead. The IN- relay operated operates the hold magnet in the link circuit which causes the L- relay to release.

After the connection has been established, the IN- relay is held operated by the ground on the sleeve of the link. This ground will in some cases also cause a relay to operate in the trunk (over the S1 lead) which will return ground to the line circuit over the S2 lead operating the SL- relay. In other trunks the ground on the S2 lead is present immediately upon seizure. The T thermistor in series with the SL- relay delays the operation of this relay by approximately 250 milliseconds. The purpose of this delay is explained below. The IN- relay in operating opens the operate path for the OT- relay and places a ground on the S lead to the marker as a busy indication. When the SL- relay operates, this make busy function is performed by its contacts.

When the marker seizures the circuit for an outgoing call by grounding the S lead, the OT- relay operates. The OT- relay in operating (1) operates the hold magnet thus closing the crossbar switch crosspoints, (2) transfers the link tip and ring leads from their normal connection to the incoming leads of the trunk (T1 and R1 leads) to the outgoing leads of the trunk (T2 and R2 leads), (3) disconnects the link sleeve from its normal connection to the S1 lead of the trunk and connects a ground to it, (4) prepares a path for locking itself to the S2 lead of the trunk, and (5) starts the operation of SL- relay. If the trunk is of the type that requires a forward ground on the S2 lead for seizure on an outgoing call, this requirement is satisfied by the operation of the OT- relay since the ground from the marker which operates it is extended to the S2 lead when the relay operates.

The calling party's bridge on the tip and ring of the link will operate a relay in the trunk causing it to return a ground over the S2 lead to keep the OT- relay operated

when the marker removes ground from the S lead. This ground on the S2 lead also operates checking relays in the marker and completes the operation of the SL- relay. The SL- relay in operating opens the operate path for the OT- relay and grounds the S lead to the marker as a busy indication. The SL- relay is made slow in operating to allow sufficient time for the trunk to return locking ground on the S2 lead to hold the OT- operated before the operating path for the OT- relay is opened. When the SL- relay operates, the T- thermistor is short-circuited by contacts of the SL- relay to allow it to start cooling immediately thus insuring that the SL- relay will operate in approximately the same time interval on subsequent operations.

5.3 Recorded Telephone Dictation Trunk (Option X)

When a line circuit is assigned to a recorded telephone dictation trunk the T2, R2, and S2 leads are connected to the trunk, and "X" option is used.

The marker will connect a calling station to the recorded telephone dictation trunk in the same manner as when setting up a call to a two-way tie trunk. The trunk will return ground over the S2 lead to complete operating the SL- relay and lock the OT- relay operated.

When the calling station hangs up, the trunk normally removes the ground on the S2 lead causing the OT- and SL- relays to release. The OT- relay in releasing releases the hold magnet restoring the circuit to normal. If the trunk is taken out of service for maintenance of the trunk or the associated dictation machine, the S2 lead will be grounded which will operate the SL- relay and connect a busying ground on the S lead.

5.4 Loud Speaker Paging Trunk (Option X)

When a line circuit is assigned to the loud speaker paging trunk, "X" option is used and the T2, R2 and S2 leads are connected to the trunk.

A calling station or trunk is connected to the loud speaker paging trunk by the marker in the same manner as when a calling station or trunk dials the recorded telephone dictation trunk.

5.5 3A Code Call Circuit (Options "W", "V")

Two line circuits are required to connect to one channel of the 3A Code Call Circuit; one circuit is required for association with the calling end and the second circuit for association with the answering end. The line circuit assigned to the calling end should be provided with "W" option and the T2, R2, and S2 leads connected to the code call circuit. The line circuit assigned to the answering end should be provided with "V" option and the T1, R1, S and S1A leads connected to the code call circuit. It is also required that the HM, IT, and S2 leads be interconnected between the two line circuits and that the hold magnet contacts in the line circuit assigned to the answering end be permanently insulated with a blocking tool to isolate the associated L- relay windings from the circuit. This must be done to prevent the answering end line circuit from being seized by the relay bridging the tip and ring conductors in the 3A Code Call Circuit when the code call circuit is seized at its calling end.

A calling party will originate a call to the 3A Code Call Circuit by dialing the number in the 6-0 series corresponding to the line circuit to which the calling end is assigned. Assuming that the answering end line circuit is idle, the marker will process the call in the same manner as when connecting a call to a two-way tie trunk. The ground on the S lead originating in the marker will operate the OT- relay in the calling end line circuit through break contacts of the SL- and IN- relays in the answering end line circuit and break contacts of the L- and IN- relays in the calling end line circuit. When the OT- relay operates operating the hold magnet, the calling party's bridge on the tip and ring of the link will function relays in the code call circuit causing it to return a holding ground for the OT- relay on the S2 lead. Ground on this lead will also operate the SL- relays in the line circuit associated with both the calling and answering ends, however, only the SL- relay associated with the answering end performs a useful function in this application. The answering end SL- relay in operating will connect ground to the IT lead which is extended to calling end line circuit's S lead as an indication to the marker that the calling end is busy.

When the code call circuit is idle the S lead to the answering end line circuit will be grounded. Consequently a station dialing the line number corresponding to the answering end will receive busy tone. However, when a calling party has seized the calling end, a relay in the code call circuit will close a path between the S and S1A leads and remove the ground thus making the answering end line circuit available for seizure by the marker. Also, when the SL- relay operates in the answering end line circuit due to a seizure of the calling end of the code call circuit, the tip and ring conductors from the answering end of the code call circuit will be extended to the crossbar switch crosspoints prepared for connection to the answering call.

A called party responding to the code signal broadcasted by the code call circuit will originate a call to the answering end of the code call circuit from any station in

the PBX. The called party will dial the number in the 6-0 series corresponding to the line circuit assigned to the answering end of the code call circuit. The marker will process this call as a station-to-station call using a junctor in the connection. When the marker grounds the S lead of the answering end line circuit, the IN- relay will operate. The IN- relay in operating will operate the hold magnet cutting through the tip and ring conductors of the answering end of the code call circuit to the terminating end of the junctor via the connected link. The IN- relay will lock over the sleeve lead of the ground in the junctor. The operation of the IN- relay will prepare a path for connecting ground to the IT and S lead associated with the calling end line circuit if the answering end SL- relay should release before the IN- relay.

When a calling party is connected to the code call circuit to the answering party for conversation, the S lead to the marker in the answering end line circuit will be grounded by the same ground holding the IN- relay operated. Thus if a station tries to dial the number of the answering end line circuit during this period it will receive a busy indication.

If the calling party disconnects first, the removal of the station bridge from the calling end of the code call circuit will cause ground to be removed from the S2 lead. This will release the OT- relay in the calling end line circuit and release the SL- relay in the answering end line circuit. The OT- relay in releasing will release the hold magnet restoring the calling end line circuit to normal except that the operate path of the OT relay is held open and ground is maintained on the IT and S lead by the operated IN- relay in the answering end line circuit. In the answering end line circuit the IN- relay is held operated by the junctor which is under control of the answering party. The answering end SL- relay in releasing opens the code call circuit bridge on the tip and ring conductors at the answering end releasing a relay in the terminating end of the junctor.

When the answering party finally connects the junctor removes the ground on the sleeve lead of the link releasing the IN relay. The IN relay in releasing releases the hold magnet in the answering end line circuit restoring that circuit to normal and in the calling end line circuit removes the ground from the IT and S lead and closes the operating path of the OT- relay thus restoring that circuit to normal and making the code call circuit available for another call.

If the answering party should disconnect first, the removal of the bridge at the originating end of a junctor will release only the link between the originating end of the junctor and the party responding to the code call signal. The remainder of the connection will remain intact under control of the calling party. When the calling party finally disconnects, the code call circuit will remove ground from the S2 lead to the calling end line circuit releasing the OT- relay in that line circuit and the SL relay in the answering end line circuit. The OT relay in releasing will release its associated hold magnet. The answering end SL- relay in releasing will remove the bridge towards the terminating end of the junctor allowing the junctor to release. The junctor in releasing will release the IN- relay in the answering end line circuit which releases the associated hold magnet. Thus both line circuits are restored to normal and the code call circuit is available for another call.

When the code call circuit is made busy for maintenance reasons at the code call equipment, the ground will be connected to the S2 lead. This ground will operate the SL- relay in the answering end line circuit which will ground the IT and S lead to the marker at the calling end line circuit as a busy indication.

6. STATION HUNTING GROUPS

6.1 General

Any number of stations within the same tens group may be formed into a hunting group. Each station has a corresponding H terminal and a hunting group is formed by connecting pairs of terminals until the pattern desired is established. A variety of patterns can be created but in general they can be classified as two way hunting groups, one way hunting groups, combined two way and one way hunting groups or one way sequential hunting groups.

The marker in completing a call to a station will first attempt to connect to the station corresponding to the dialed number. Only if this station is busy will the marker attempt to complete the call to an idle station in the same hunting group.

6.2 Two Way Station Hunting Group

Two way station hunting groups are created by connecting straps between the H terminals corresponding to the stations to be included in the group. If the station dialed is busy, the marker will progress to the station hunting sequence and operate all of the U- relays corresponding to stations in the hunting group and the S- relay corresponding to the idle stations in the group will operate. The marker will then connect to the station associated with the first operated S- relay in the line hunting chain circuit. It should be noted that if the ZU relay is operated the preference order of selection is S5-S9, S0-S4. If the

ZU relay is released the preference order is SO-S9.

6.3 One Way Station Hunting Group

A one way station hunting group is created by connecting the H diode between pairs of H terminals corresponding to stations to be included in the hunting group being careful to pole the diodes so that the arrow direction corresponds to the hunting direction desired. In this case when the marker progresses to the hunting sequence, only the U- relays corresponding to the stations beyond the dialed station in the H terminal strapping order will operate. The marker will connect the call to an idle station corresponding to the operated U- relays in a preference determined by the state of the ZU relay and the position of the S- relays corresponding to the operated U- relays in the line hunting chain.

6.4 Combined Two Way and One Way Station Hunting Group

A combined station hunting group is created by using straps between some pairs of H terminals and H diodes between other pairs to accomplish a desired result. For example, if it is desired that a call to station 40 or 46 be routed to the other station if the dialed station is busy, a strap will be connected between terminals H40 and H46. If it is further desired that calls to station 47 be routed to either station 40 or 46 when station 47 is busy, an H diode will be provided between terminals H47 and H46 (or H40) with the diode arrow pointing in the direction of punching H46 (or H40).

In this case if the marker is processing a call to station 47 but finds it busy, it will progress to the hunting sequence and operate the U0 and U6 relays and if both stations 40 and 46 are idle, the S0 and S6 relays will operate. The marker will then complete the call to either station 40 or 46 depending upon the state of the ZU relay. However, if the marker is processing a call to station 46 and finds it busy, the marker after progressing to its hunting sequence will operate only the U0 relay and if station 40 is idle the S0 relay will also operate. The marker will then complete the call to station 40.

6.5 One Way Sequential Station Hunting Group

A one way sequential hunting group may only involve stations within the same subgroup of five stations in a tens group. Such a group may be formed by connecting H diodes between pairs of H terminals corresponding to the stations involved with the diode arrows always pointed in the direction of the higher numbered H terminal. For example, assume that stations 20, 22 and 24 are to be arranged in a hunting pattern such that calls to a busy station 20 will be routed to station 22 unless that station is also busy in which case it will be routed to station 24. Furthermore, calls to a busy station 22 will be routed to station 24, but calls to a busy station 24 will not be routed to any other station. To create this pattern an H diode should be provided between terminal H20 and H22 and between H22 and H24 with the diode arrow pointed towards the higher numbered terminals in each case.

In this case, if the marker is processing a call to station 20 but finds it busy, it will progress to the hunting sequence and operate the U2 and U4 relays which in turn will cause the S2 and S4 relays to operate if stations 22 and 24 are idle. Regardless of the station of the ZU relay the S2 relay will be ahead of the S4 relay in the line hunting chain and the marker will always connect the call to station 22 if idle. If station 22 is also busy the S2 relay will not be operated and the call will be connected to station 24.

If the marker is processing a call to station 22 but finds it busy, it will progress to the hunting sequence and operate the U4 relay through the H diode between terminals H22 and H24. The U0 relay will not operate since the H diode between terminal H20 and H22 is poled in the wrong direction to pass the ground on terminal H22. If station 24 is idle, the S4 relay will operate and the call will be completed to that station.

If the marker is processing a call to station 24 but finds it busy, it will progress to the hunting sequence but no U-relays will operate (other than the U4 relay which is already operated) since the H diodes between terminals H20, H22 and H24 are poled in the wrong direction to operate the U0 and U2 relays from ground on the H24 terminal. The marker will therefore attempt to connect the call to the busy tone trunk.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.1 Lines

Maximum external circuit loop resistance	1,500 ohms
Minimum insulation resistance	10,000 ohms

1.2 Voltage Limits

Minimum	Maximum
-45	-52

2. FUNCTIONAL DESIGNATIONS

The functional meaning for all the relays of the line circuit are given in the following table:

Relay Designation	Functional Meaning
IN-	In
L-	Line
OT-	Out
SL-	Sleeve
HM 20-59	Hold Magnet (station lines)
HM 10,15,16	Hold Magnet (universal trunks)
HM 00, 02, 04, 06, 11, 13	Hold Magnet (junctor originating)
HM 01, 03, 05, 07, 12, 14	Hold Magnet (junctor terminating)
HM 08,09	Hold Magnet (register, 0)
HM 18, 19	Hold Magnet (register, 1)
HM 17	Hold Magnet (busy tone trunk)
SM 00-59	Select Magnet

3. FUNCTIONS

3.1 The link circuit is designed to perform the following functions:-

3.11 To operate any of the various hold magnets and close the T, R and S leads to the link wiring for completion of a circuit.

3.12 To provide connections to the marker for selecting, under control of the link sequence circuit, an idle link.

3.13 To remember and reuse the original link circuit through contacts of the register memory vertical when required.

3.2 The line circuits are designed to perform the following functions:-

3.21 To recognize a seizure signal from a station or trunk and in turn signal the marker to set up a dial tone connection.

3.22 To indicate a busy condition over the S lead to the marker when the circuit is in use.

3.23 When connected to a trunk, to indicate a busy condition over the S lead to the marker when the trunk is placed out of service.

3.24 When connected to a trunk, to return a 100 ohm ground over the link sleeve on terminated calls.

3.25 In the universal line circuit to operate the associated line hold magnet when seized by the marker for an originating or terminating call.

3.26 When connected to the answering end of a 3A Code Call Circuit, to cut through the tip and ring conductors to the link appearance when the calling end of the code call circuit is seized.

3.27 When connected to the answering end of a code call circuit, to indicate a busy condition to the marker until the calling end of the code call circuit is seized.

3.28 When connected to the answering end of a code call circuit, to cause a busy indication to be given to the line circuit associated with the calling end after a connection is established while a called party remains on the connection after the calling party has disconnected.

4. CONNECTING CIRCUITS

When this circuit is listed on a keysheet the connecting information thereon is to be followed:

4.1 Marker Circuit - SD-69468-01.

4.2 Register Circuit - SD-69470-01.

4.3 Junctor Circuit - SD-69464-01.

4.4 Busy Tone Trunk - SD-69465-01.

4.5 Dial Repeating Type Tie Trunks - SD-65718-01,* SD-65755-01.*

*Typical Circuits

4.6 Recorded Telephone Dictation Trunk - SD-65788-01.

4.7 Loud Speaker Paging Trunk - SD-65747-01.

4.8 3A Code Call Circuit - SD-66610-01.

5. MANUFACTURING TEST REQUIREMENTS

The line and link circuits shall be capable of performing all the functions specified in this circuit description and meeting all the requirements of the Circuit Requirements table.

6. TAKING EQUIPMENT OUT OF SERVICE

6.1 Links

A link may be removed from service to insulating the contacts of the LTC relay in the marker which connects battery through the L resistance to the S lead of the link.

6.2 Station Lines

A station line may be removed from service by removing the S to S1 lead from the S term and wiring from the S1 term to the G term. All calls directed to that station will receive busy tone. If that station line attempts to make a call it will be routed to the busy tone trunk and receive busy tone.

7. ALARM INFORMATION

7.1 Fuse Alarm

An operated fuse supplying the line or link circuit is indicated by an alarm in the plant service center, if alarm transmitting features are provided, and in any case, by a visual signal locally. Replace the operated fuse to silence the alarm and extinguish the visual alarm signal.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 5332-PB-HFH-JW

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
DIAL PULSE REGISTER CIRCUIT

CHANGES

D. Description of Changes

D.1 All changes are made on a Class D - No Record basis per agreement with WECo.

D.2 On sheet A1, the sheet index is brought up to date.

D.3 On sheet B6, fuse designations are corrected.

D.4 On sheet G1, options A, B and cable K1 are removed and CAD 1 is rated (Mfr Disc).

D.5 Sheet G2, showing CAD's 6, 7, 8 and 9 is added.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7120HW-RHO-JGW)
DEPT 5337-RAV

SWITCHING SYSTEMS
SWITCHING SYSTEMS NO. 400
DIAL PULSE REGISTER CIRCUIT

CHANGES

B. Changes in Apparatus

B.1 Superseded

OT Relay AJ-12 - Fig. 1 ZD Option	OT Relay AJ-516 - Fig. 1 ZE Option
OT6, OT7, OT8 Diode - Fig. 1 ZD Option	ZE Wiring Option
L6 Diode - Fig. 1 Z Option	ZC Wiring Option
L7 Diode - Fig. 1 Y Option	ZB Wiring Option
L8 Diode - Fig. 1 X Option	ZA Wiring Option

D. Description of Changes

D.1 Notes 102 and 104 are revised.

D.2 On sheet B3, diodes OT6, OT7, and OT8 covered by option ZD are rated Mfg. Disc. and superseded by option ZE.

D.3 On sheet B3, diodes L6, L7, and L8 covered by options Z, Y, and X, respectively, are rated Mfr. Disc. and superseded by options ZA, ZB, and ZC.

D.4 On sheet B3, option ZF is rated Mfr. Disc. and superseded by option ZG to prevent premature operation of relay STR and registration of a double unit digit.

D.5 CAD's 4 and 5 are rated Mfr. Disc. and CAD 1 is revised.

F. Changes in CD Sections

F.1 Under SECTION II, change 2.17 to read:

2.17 If a universal line circuit is connected to a trunk or the calling end of a 3A code call circuit, the corresponding ZA, ZB, or ZC option should be provided.

F.2 Under SECTION II, change the second sentence in 2.18 to read:

If the Z- option is provided, relay TR will operate upon operation of relay OT.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-RLS-JGW)
DEPT 5337-RAV

STATION SYSTEMS
SWITCHING SYSTEMS NO. 400
DIAL PULSE REGISTER CIRCUIT

CHANGES

A. Changed and Added Functions

A.1 To provide dial tone for TOUCH-TONE calling.

A.2 To provide for operation with the TOUCH-TONE calling receiver type A3.

B. Changes in Apparatus

A.1 Removed:

DT resistor KS-13490,L1, 3000 ohms, M option

D. Description of Changes

D.1 Various indexes and Notes 102 and 104 are revised and Note 106 is rated Mfr. Disc.

D.2 On sheet B1, option J is designated and option F is added to provide dial tone for TOUCH-TONE calling using a 404C tone generator via lead DT (TT1).

D.3 On sheets B1, B2 and B3, options K and M are rated Mfr. Disc. and option E is added to provide wiring and apparatus which was previously part of option M. This removes resistor DT.

D.4 On sheets B1, B3 and B6, option B is added to provide wiring and apparatus for TOUCH-TONE calling with a type C1 receiver. This wiring and apparatus was previously part of option M.

D.5 On sheets B1, B3 and B6, option A adds leads A, B, D0-9, P, STR, T and R connecting to the TOUCH-TONE calling receiver applique circuit to provide for TOUCH-TONE calling with a type A3 receiver.

D.6 On sheet B6, FS7 is added.

D.7 On sheet G1, CAD 1 is revised.

F. Changes in CD Sections

F.1 In SECTION III, CONNECTING CIRCUITS, add:

4.01 (h) TOUCH-TONE Calling Receiver Applique Circuit - SD-66888-01.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-AELK-JGW)
DEPT 5337-RAV

STATION SYSTEMS

SWITCHING SYSTEM NO. 400

DIAL PULSE REGISTER CIRCUIT

CHANGES

D. Description of Changes

D.1 CAD 2 is rated "Mfr. Disc." and replaced by CAD 4.

D.2 CAD 3 is rated "Mfr. Disc." and replaced by CAD 5.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760-EWS-JGW)
DEPT 5337-RAV

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
DIAL PULSE REGISTER CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. GENERAL FUNCTIONS

1.01 The dial pulse register functions as a dial pulse counter and digit store on all calls passing within the switching system.

1.02 When either a station or a trunk originates a call into the switching system, the marker selects and connects an idle dial pulse register to it. The register transmits dial tone to the line or trunk. After dialing is completed, the register engages the marker to terminate the call and transmits the information needed to establish a connection to the called station or trunk to the marker. When the connection has been established, the marker releases the register.

1.03 If the marker finds the busy tone trunk busy when trying to complete a call to it, it notifies the register to return the busy tone to the calling line.

1.04 The register allows from 7.5 to 15 seconds in which dialing must be completed after seizure. If dialing is not completed in this time, the register will release.

1.05 The register is arranged to receive either dial pulses or tens and units information from a TOUCH-TONE calling receiver or a direct station selection by stations auxiliary relay circuit.

2. GENERAL METHOD OF OPERATION

2.01 When the receiver is lifted off-hook at a station, or a trunk circuit requests inward service, the associated tens relay in the marker operates. This sets off a train of events that result in the marker connecting the line through an idle link to an idle register.

2.02 When the register hold magnet closes the tip, ring, and sleeve of the line through to the register, the register off-normal relay operates. The off-normal relay furnishes holding battery and ground for most of the register and closes the dial tone path to the calling line. This connection is known as the dial tone connection and is an indication that dialing may proceed.

2.03 The dial pulse register is arranged to receive two digit codes for station lines and one digit codes for universal line circuits.

2.04 After the calling line dials the one or two digits required for identification of the called line, the register recognizes dial completion and engages the marker for termination of the call.

(a) The digit steering relays determine when the tens and units digits have been registered, the tens digit being stored in the TD register relays and the units digit in the pulse counter and the UD register relays.

(b) If an assigned one digit code is dialed, the register recognizes that only one digit will be dialed and engages the marker to complete the call. If the one digit code dialed is not assigned, the calling station will receive busy tone from the register.

(c) The number dialed determines the terminating class of call, which directs the marker in its method of call completion. There are two terminating classes of calls which are as follows.

(1) Junctor Class - Calls which require a junctor.

(2) Trunk Class - Calls which do not require a junctor.

2.05 When the digit registration is completed and the marker engaged, the register transmits the class information and the called number data to the marker.

2.06 When a dial tone call is established, the register memory hold magnet in the link circuit remembers which link was used for the connection from the calling line to the register so that the same link can be reused when the call is later terminated via a junctor or a trunk.

2.07 After the marker performs its functions in terminating the call, it transmits a release signal to the register. The register then opens the tip, ring, and sleeve connections to the link, restores to normal, makes itself available to the marker for reseizure, and releases the register work and memory hold magnets in the link circuit.

2.08 If the marker encounters a busy condition and the busy tone trunk is also busy, it signals the register to transmit a busy tone to the calling line.

SECTION II - DETAILED DESCRIPTION

1. REGISTER SEIZURE

REGISTER SELECTION

1.01 When a register is idle, ground is extended through break contacts of the ON and RT relays to hold the register allotter relays RA- of the marker operated. This establishes an operate path for the register hold magnets of the line link and connector circuit under control of the marker circuit. A holding path for these magnets is provided through a make contact of the SR relay of the register circuit.

REGISTRATION OF CLASS

1.02 The state of the TR relay determines whether the call will be a junctor or trunk-type class of call. If the TR relay operates it will operate the marker RCT relay and the marker will complete the call on a trunk class basis. If the TR relay does not operate the marker JT (A,B) relays will operate and the call will be completed on a junctor class basis.

DIAL TONE CONNECTION ESTABLISHED

1.03 When the tip and ring leads of the register are extended via a link to the calling station (or trunk), the calling station or trunk bridge causes the operation of the L relay through the windings of the tone coil. Relay L in operating operates relay SR which upon operating provides holding ground for HM-8 and HM-9, closes ground to the sleeve lead to hold the calling party hold magnet, prepares the operate path for the P1 relay in the pulse counting chain

rough a break contact of the L relay, and perates the ON relay. Relay ON supplies battery for the steering and timing relays, completes the dial tone supply through the tertiary winding of the tone coil transmitting dial tone to the line, opens the register allotter circuit in the marker which indicates a busy register and prepares paths for operating the PU, RA, RRL and the pulse counting relays.

2. DIAL PULSE COUNTING AND REGISTRATION

GENERAL

2.01 The dialing of a digit consists of 1 to 10 equally spaced momentary line openings generated by the calling line dial. The number of opens corresponds to the number dialed. Between the tens and units digit is an interdigital interval during which the line remains closed. The L relay responds to the dial pulses and the counting relays count the number of pulses in each digit. During the interdigital time interval the tens digit information is transferred to the tens digit register and the counting relays are released thus preparing the circuit for receipt of the units digit information. The units digit pulses are counted and registered by the pulse counter relays. Relay RA recognizes the beginning and ending of each digit.

PULSING RELAY

2.02 The L relay is a three winding magnetically biased polarized mercury contact relay. The primary winding is in series with the calling line dial contacts and is used as a line winding to operate the relay in response to the dial pulses. The secondary winding is used to aid the release of the relay. When the L relay operates, a make contact furnishes ground for the secondary circuit which is poled oppositely to the primary circuit. This opposition of ampere turns, when the relay is operated, tends to make L easier to release. The value of resistor L has been set at a value that will give the optimum benefit from this winding. The tertiary winding is a pulse aiding winding. The tertiary circuit consists of the pulse help capacitor, PH, and the winding. The side of PH that is connected to ground through the make contact is also connected to the winding of relay SR. When the L relay operates, the charging current through the PH capacitor is in the direction to hold the relay operated. As the capacitor becomes fully charged, the charging current becomes zero and the other windings regain full control. When the primary circuit opens, the relay releases, removing ground from the make contact. The PH capacitor then discharges through the SR relay winding. This discharge current through the tertiary winding is in such a direction as to hold the relay released. The tertiary winding and PH capacitor thus act to insure that once the L relay operates it will remain operated for a definite minimum time and that once it releases it will remain released for a definite minimum time. This pulse correcting action permits longer maximum loops to be used than would otherwise be possible.

2.03 The LW capacitor and resistor network connected to the line side of the primary winding of the L relay is for the purpose of preventing a premature release of the L, when working with station lines which have high capacity ringing bridges. On each open pulse on these lines the line current momentarily dips and then increases as the bridged capacitor charges in series with the inductive ringer. The LW capacitor holds the L relay over the dip in the line current. This network is also used to prevent a false momentary release of the L relay when a retard coil holding bridge is inserted into the loop after the dialing of each digit.

SUPERVISORY CONTROL

2.04 The supervisory relay, SR, operates from ground through the make contact of L. It holds over momentary opens of the make contact of L but will release when the register is dismissed by the marker or when the calling line disconnects before completion of dialing.

2.05 The register advance relay, RA operates during the first open of the dial pulse when the L relay releases and remains operated until the interdigital interval during which the L relay is held operated. The RA relay is fast operating but is made slow to release through the use of its secondary winding which is short circuited when the relay is operated. Thus, the RA relay is made to recognize the start and stop of pulse trains for each digit.

PULSE COUNTING

2.06 The pulse counting circuit consists of dial pulse counter relays P1 to P5 and P2A. The P2A relay removes dial tone from the line at the beginning of dialing. The P1 and P2 relays function as a pulse divider, each relay operating at half the speed of the L relay. When the L relay releases on the first break of the dial, P1 operates through the continuity transfer contact of P2. P1 locks through its own contact to ON ground. When relay L reoperates at the end of the first open pulse, the pulsing ground transfers to the make contact of the L relay and operates P2 through the operated make contact of P1. P2 operating locks itself through P1 operated to ON ground, opens its operate path and transfers the locking path of P1 from ON ground to the make contact of L. On the next release of L, P1 releases and closes ON ground through to operate P3 and P2A. When L reoperates on the second pulse P2 releases.

This cycle of P1-P2 combination repeats itself with P1 and P2 remaining operated at the end of odd numbered pulses and remaining normal at the end of even numbered pulses. Relay P4 operates when P2 operates at the end of the third open pulse and P5 operates when P2 releases at the end of the sixth open pulse. The sequence of operation of these relays is given in the following table.

Pulse	L	P1	P2	P3	P4	P5	P2A	P- Relays Remaining Operated
1 BK	R	O						
MK	O		O					P1, P2, P2A (Q Option)
2 BK	R	R		O			O	
MK	O		R				O	P2A, P3
3 BK	R	O					O	
MK	O		O		O		O	P1,P2,P2A,P3,P4
4 BK	R	R					O	
MK	O		R				O	P2A, P3, P4
5 BK	R	O					O	
MK	O		O				O	P1,P2,P2A,P4
6 BK	R	R					O	
MK	O		R			O	O	P2A, P4, P5
7 BK	R	O					O	
MK	O		O				O	P1,P2,P2A,P4,P5
8 BK	R	R		O			O	
MK	O		R				O	P2A,P3,P4,P5
9 BK	R	O					O	
MK	O		O		R		O	P1,P2,P2A,P3,P5
10 BK	R	R					O	
MK	O		R				O	P2A, P3, P5

DIGIT STEERING AND REGISTRATION

2.07 The digit steering circuit directs the output of the tens digit from the pulse counter relays to the TD tens register relays and then releases the pulse counter relays. When the units digit is dialed, the pulse is then steered to the UD units register relays.

2.08 When the dialing of the tens digit is completed, the respective P- relay combination for the digit dialed transmits operate ground to the proper TD relay when RA restores to normal. The SW relay operates when the RA relay releases after the tens digit has been dialed. A TD relay also operates at this time and locks to its own contact to ground, through a break contact of the normal RT relay. The SW relay in operating releases the P- relays and operates the STR relay, preparing the register for receipt of the units digit. Relay STR in operating transfers the output circuit of the pulse counter relay to the units digit register relays.

2.09 On the first open dial pulse of the units digit, the RA relay operates operating relay UD. Make contacts on the UD relay provide the necessary ground path to hold the pulse counter circuit operated after dialing is completed. The UD relay operating prepares the operate path for the DC relay.

TENS AND UNITS DIGIT REGISTERS

2.10 The TD and UD register relay units consist of five dry reed relays each enclosed in a sealed container. Each relay consists of an operating coil surrounding two dry reed switches. One of these switches performs the function of holding the relay operated and the other acts as a load contact. One side of each coil is wired internally to one side of its respective holding contact. The load contact pair, one side of the holding contact, and the winding pairs are all brought out on individual terminals which have appearances on both front and back sides of the container. For ease of wiring, three sets of these terminals are strapped internally.

PRELIMINARY PULSES

2.11 Since the tens group 10-19 is unassigned, single pulses due to accidental momentary line opens after seizure are prevented from causing wrong numbers in the following manner.

2.12 When Q option is provided, a single first pulse will be registered but being unassigned will cause the register to return busy tone to the calling station as described in 2.14 to 2.17.

2.13 When R option (Mfr Disc.) is provided, the pulsing circuit will refuse registration of the tens digit one. The P2A relay accomplishes this by keeping the ground for operating the TD- relays open until it operates. The P2A relay will not operate until the second pulse is received (L relay released with P1 and P2 relays operated). With the P2A relay not operated, the locking path for the P1 and P2 relays is open and the P1 and P2 relays release after the first pulse (L relay reoperated). The P2A relay remaining inoperative also maintains the dial tone output to the calling station.

UNASSIGNED LINES AND SINGLE DIGIT DIALING CODES

2.14 The universal line circuits in the switching system may be assigned single digit dialing codes 6, 7, 8, 9, and 0 by appropriate strapping of the cross-connection punchings provided in the register. Cross-connection punchings are also provided

for strapping to cause the register to return busy tone to a calling party dialing an unequipped tens group of an unused single digit code.

2.15 If the 40-49 station line group is equipped the 4 punching should be strapped to the T4 punching, otherwise it should be strapped to the BY punching. Likewise, if the 50-59 station line group is equipped the 5 punching should be strapped to the T5 punching, otherwise it should also be strapped to the BY punching.

2.16 Universal line circuits L6, L7, and L8 are assigned single digit dialing codes by strapping punchings L6, L7, and L8 to punchings 6, 7, 8, 9, or 0 as desired. Any of the punchings in the 6 through 0 group which are unused should be strapped to the BY punching.

2.17 If a universal line circuit is connected to a trunk or the calling end of a 3A code call circuit, the corresponding L6, L7, or L8 diode (Z, Y, or X option, respectively) should be equipped.

2.18 When an assigned single digit code is dialed, the corresponding TD relay will operate and extend the ground from a break contact of the normal RT relay to the L- punching to which the TD relay output is strapped and cause the OT relay to operate. If the L-diode is equipped the TR relay will also operate. The OT relay in operating (1) prepares a path for grounding the T1 lead to the marker when the RC relay operates, (2) extends the grounded output of the operated TD relay to the appropriate contacts of the RC relay in preparation for further extending it over a units lead to the marker when the RC relay operates, (3) operates the UD relay, and (4) locks operated under control of the operated ON relay. The TR relay in operating prepares a path for grounding the RCT lead to the marker instead of the JT lead as an indication the call is to be completed on a trunk class basis. Subsequent action is the same as described in 3.

2.19 If an unassigned tens group or single digit code is dialed, the operated TD relay will ground the BY punching and operate the BY relay. The BY relay in operating will (1) connect busy tone to the tone TN coil input, (2) open a link in the operating path of the DC relay to prevent the call from progressing any further, and (3) lock operated to the operated ON relay. The calling party will receive busy tone until either the call is abandoned or the register times out.

"TOUCH-TONE" CALLING (SC3, SC4)

2.20 The sequence of operation for establishing the dial tone connection is the same for all types of calls as described in 1.03. Since in TOUCH-TONE calling there will be no pulsing of the L relay, no pulse counting sequence will take place.

2.21 When a numbered button (0-9) is depressed at a TOUCH-TONE type telephone set, a definite frequency will be generated at the telephone set for each button depressed. This frequency will be picked up by a multifrequency receiver which will translate the signal and place a ground on the corresponding D- lead toward the steering circuit of the register.

2.22 The register recognizes that a TOUCH-TONE type of call is being processed in the following manner: When a button at a telephone set is depressed the multifrequency receiver will ground a D- lead to operate the TD- relay corresponding to that digit. The receiver will also ground the STR lead to operate the key pulsing register advance KRA relay. With the KRA relay operating, the P2A relay in the pulse counting circuit will operate and lock to ground through a make contact of the ON relay. The P2A relay in operating removes dial tone from the tertiary winding of the tone coil and prepares the operate circuit of the switching SW relay and extends ground over the A lead to prepare a locking path for the unit digit register relays. On the release of the button the ground is removed from the D- lead toward the TD- relay but that relay is locked under control of a contact of the RT relay. The button releasing causes the release of the KRA relay which in releasing will, through make contacts of the P2A, cause the SW relay to operate. The SW relay in operating will complete the operate path of the steering STR relay which in turn will set the register to receive the units information. On depressing the button for the units digit the multifrequency receiver will again place a ground on the D- lead and through operated contacts of the STR relay operate the corresponding UD- relay. The KRA relay will also reoperate and extend ground from a contact of the ON relay to the winding of the UD- relay causing it to operate. On release of the button the KRA will release, and the ground will be removed from the D- lead. With the UD- relay operated and the KRA relay released the dialing complete DC relay will operate. The DC relay in operating will request the marker to process the call to the called station. Subsequent action is the same as for any other type of call. The DT resistor reduces the dial tone to a level which will not interfere with the normal operation of the TOUCH-TONE Calling Receiving Circuit.

DIRECT STATION SELECTION

2.23 In this type of call dial tone completion by the marker is the same as any other call.

2.24 When dial tone is received by the station and a DSS key at a telephone set is depressed the K relay in the auxiliary

relay circuit operates which in turn operates the SC relay in that circuit extending a ground from the DSS key on the tens and units leads. When the DSC relay operates in the auxiliary relay circuit the ground on the tens and unit lead is extended into the dial pulse register circuit and the following sequence takes place. The associated tens digit TD- relay operates and prepares the tens lead to extend ground to the marker, and the unit digit UD- relay operates preparing the path for the ground on the units lead to the marker. With the ON relay operated ground is sent out over the UD1 lead to make contacts of the SC relay in the station auxiliary circuit, back on the UD2 lead to operate the units dialed UD relay in the register. When the UD relay operates the dialing complete DC relay operates which requests the marker to complete the call to the called station. Subsequent action is the same as for any other type of call.

3. REGISTER COMPLETION TO MARKER (SC-1)

DIAL COMPLETION

3.01 When RA restores to normal after completion of the units digit or when UD operates on single digit code calls, relay DC operates. The DC relay operating is an indication that the register is ready to transmit its stored data to the marker. DC operates the register relay, R(0-1), in the tens selection circuit in the marker, closes battery through for the class call information to the marker, opens the battery supply for the PU relay, opens the operate path for the SW relay, locks relay L through its tertiary winding and places a 200-ohm bridge across the tip and ring conductors. This 200-ohm bridge is required by the junctor in the establishment of junctor class calls.

TRANSFER OF REGISTER DIGITS AND CLASS INFORMATION (SC-1, SC-4)

3.02 After the units digit has been dialed the full called number information is available to the marker. When DC operates R(-) in the marker, the marker functions to terminate the call and accepts the digit information accordingly.

3.03 If the call is from a station to a station or from a tie trunk to a station, a junctor class of call completion is required. On a junctor class of call, when DC operates, the junctor terminating relays, JT(A,B) in the marker operate through the normally closed contacts of the TR relay. A trunk type of call will require that the TR relay be operated. The register cut through relays, RCT in the marker operate when DC operates on a trunk class of call.

CALLED LINE IS BUSY AND BUSY TONE TRUNK BUSY

3.04 If a calling station or dial repeating tie trunk dials a line which is busy, the marker routes the call to the busy tone trunk which returns busy tone to the calling line. If, however, the busy tone trunk is engaged and the marker finds the called line busy, the marker signals the register to return busy tone to the calling line.

3.05 Relays BTC, BY, RPA(0-1) in the marker in operating cause the BY relay in the register to operate which connects busy tone through the tone coil in the register to the calling line or trunk. The BY relay locks operated through its own contact to ground from the ON relay, opens the RR(0-1) and DC(-) leads to the marker and releases the DC relay. Thus the release of the register is prevented until it times out (as explained in 5.08) or until the calling line disconnects and the reseizure of the marker is prevented.

4. RELEASE OF REGISTER

GENERAL

4.01 The register is released under one of the following conditions: (1) normal or trouble release by the marker and (2) timeout within the register itself.

ABANDONED CALL (SC-5, SC-6)

4.02 If calling line disconnects before the marker release during the origination of a call, the L relay releases. The L relay in releasing releases the SR relay which in turn releases the ON relay and the register hold magnets.

4.03 If the calling line disconnects after the DC relay operates, the marker in testing for the originating circuit finds the line disconnected and proceeds to time itself out. The marker then functions to operate its release relays which transmit release ground over the RR(0,1) leads to the register to operate the RRL relay. RRRL locks to its own contacts, opens the tip and ring to the calling line, releases the DC relay which in turn releases the L relay which opens the holding circuit for the SR relay. The SR relay restoring to normal releases the ON relay which releases all other operated relays in the register and reallots it for subsequent usage.

NORMAL RELEASE

4.04 After the marker has completed its function of terminating a call, its release relays transmit a release ground

signal over the RR(0,1) leads which operate the RRL relay. Relay RRL locks to its own contact through the operated ON relay. The RRL relay in operating opens the tip and ring leads to the L relay and opens the battery supply to the DC relay releasing both relays. The DC relay released also opens the 200-ohm bridge across the tip and ring toward the calling line. The L relay in releasing opens the holding circuit for the SR relay which releases. The SR relay in releasing releases relay ON which releases the rest of the register allowing it to be reallotted for subsequent usage.

TIME-OUT RELEASE

4.05 If, for some reason, the marker does not release the register after its functions are completed, the TMO relay operates. The TMO relay operates relay RRL which releases the register as in 4.02 and 4.03. Further analysis of this case is explained in 5.08.

5. REGISTER TIME-OUT

GENERAL

5.01 In order that the register will not be permanently engaged by a receiver off-hook or by incomplete dialing, thereby reducing traffic efficiency, a timing circuit operates on every register seizure to insure that suitable terminating action occurs to release it within a nominal period of time. This timing circuit consists of relays PU and TMO which operate from time pulses originating in the power plant.

5.02 The power plant furnishes two timing pulses, TM and PU, which are of 1/4 second duration and separated in time by approximately 1/5 second, each of which has a cyclic rate of 1 pulse every 8 seconds.

5.03 Because of the pulse stagger, two timing extremes are possible. The first condition, for minimum time-out, occurs when the PU pulse coincides with the seizure of the register. The PU pulse duration is long enough for the slow operate PU relay to function. PU prepares the operate path for the TMO relay. Approximately 8 seconds later, the TM pulse occurs, operating relay TMO. The second condition, for maximum time-out, occurs when the tail end of the PU pulse is just passing as the register is seized. Under these conditions, the register has to wait approximately 7.5 seconds before the next PU pulse arrives. When the PU pulse does arrive, the PU relay operates preparing the operate path for relay TMO. Eight seconds later the TM pulse occurs, operating the TMO relay. Thus, the time out extremes are approximately 8 and 15.5 seconds, respectively.

5.04 In a normal call, PU will have its battery supply fed through the normal break contacts of relays SW and DC. The SW relay operates when relay RA releases after the first digit is dialed but releases when the dial goes off-normal for the second digit, if the PU relay has not previously operated.

5.05 In a normal call, with PU operated, after the first digit has been dialed, the SW relay operates and locks to relay PU. When relay DC operates on dial completion the battery is removed from relay PU. The PU relay releases causing relay SW to release. The SW relay normal provides battery to relay PU again, preparing it for reoperation when the PU ground reoccurs. The register is thus retimed upon dial completion.

PERMANENT SIGNAL TIME-OUT

5.06 When the ON relay operates and if the PU ground pulse is present, relay PU operates and locks through its own contact to an ON relay ground. Since no dialing action takes place when the TM ground pulse appears, relay TMO operates. The TMO relay operating supplies ground through make contacts of the ON relay to operate the RRL relay. The RRL in operating releases the register as explained in 4.02 and 4.03.

PARTIAL DIAL TIME-OUT (SC-8)

5.07 If only the first digit of a directing code is dialed before time-out, a partial dial condition exists. Under this condition, the tens digit is registered in a TD(-) relay. With relay PU operated when the TM ground pulse appears, relay TMO operates and releases the register as explained in 4.02 and 4.03.

TIME-OUT AFTER DIAL COMPLETION (SC-7)

5.08 If for some reason the register is not released by the marker upon completion of its functions, the register times itself out and releases. With relay BY operated the operate path for the RRL relay is prepared. When the PU relay releases relay SW as explained in 5.01 to 5.05, or DC releases when relay BY operates the reoperate path for relay PU is prepared. The timing sequence of PU and TMO follow. When the TMO relay operates, RRL relay operates and the register releases as in 4.02 and 4.03.

6. REGISTER TESTING

6.01 When the register is to be tested, the No. 310 plug of the test cord is inserted into the TST jack in the register. Insertion of the plug into the jack causes the RT relay to operate, opens the tip and ring towards the marker, closes the tip and

ring toward the register through to the test cord, prevents hold magnets HM-8 and HM-9 in the link from operating, prevents marker seizure by opening the ground to lead DC(0,1), lights the RT lamp in the register indicating that there is an off-normal condition to be cared for in the PBX, and makes the register busy to the marker by opening the ONG lead ground.

Caution: When testing the 293A (TD- or UD-) relays avoid the use of any testing equipment which might permit currents over 0.5 ampere to pass through the reeds. Do not use headsets with low resistance receivers, such as the 56-ohm 529 receiver or the 101G hand set unless a 1000-ohm resistor is put in series with the unit. Such a resistor has been made available in SD-69471-01, the alarm, and test circuit as the RB resistor (terminal HRB). When using a lamp as the testing device, take particular care that tungsten filament lamps are not used.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.01 Maximum External Loop Resistance for Dial Pulsing - 2000.

1.02 Maximum External Loop for TOUCH-TONE Calling - 1 mile.

1.03 Voltage Limits

Voltage	Min	Max
-48	-45	-52

2. FUNCTIONAL DESIGNATIONS

2.01 The functional meanings of the designations of the relays of the register are listed below.

2.02 Relays

Designation	Meaning
BY	Busy
DC	Dial Completion
KRA	Key Pulsing Register Advance
L	Line
ON	Off-Normal
OT	Only Tens
P1-P5	Pulse Counter
P2A	Pulse Counter Auxiliary
PU	Pick-Up
RA	Register Advance
RRL	Register Release
RT	Register Test
SR	Supervisory
STR	Steering
SW	Switching
TD(0-9)	Tens Digit Register
TMO	Time-Out
TR	One Digit Trunk
UD	Units Digit
UD(0-9)	Units Digit Register

3. FUNCTIONS

3.01 To make itself busy under either of the following conditions: Register engaged on a service call, register under test by means of a plug in the test jack.

3.02 To hold the register work and memory hold magnets in the link circuit under control of a slow release supervisory relay when the marker releases.

3.03 To transmit terminating class of service information to the marker to determine whether the call is a junctor or trunk type.

3.04 To transmit dial tone to the calling line when the register has been connected to the line and is ready to receive dial pulses.

3.05 To disconnect dial tone after the first pulse (Q option) of the tens digit has been received.

3.06 To count the number of pulses in each digit.

3.07 To register the tens digit count on a group of 10 tens register relays on a 1 out of 10 basis.

3.08 To register the units digit count on a group of 10 units register relays on a 1 out of 10 basis.

3.09 To recognize one-digit dialing codes.

3.10 To engage the marker after the units digit has been dialed or after a single digit code has been dialed.

3.11 To hold the register after dial completion so that the calling subscriber cannot release the connection while the marker is engaged.

3.12 To release when the marker grounds the RR(-) leads and return to normal.

3.13 To release if the digits are not dialed, or are only partially dialed within 7.5 to 15 seconds.

3.14 To release, if the marker does not signal the register to release within 8 seconds after dial completion.

3.15 To return busy tone if an unequipped number is dialed.

3.16 To supply busy tone to the calling line when the busy tone trunk is engaged.

4. CONNECTING CIRCUITS

4.01 When this circuit is listed on a key-sheet the information thereon is to be followed. This circuit will function with the following local station system circuits.

(a) Marker Circuit - SD-69468-01.

(b) Alarm and Test Circuit - SD-69471-01.

(c) Line, Link and Connecting Circuit - SD-69469-01.

(d) Auxiliary Relay Circuit for Direct Station Selection by Stations - SD-69467-01.

(e) TOUCH-TONE Calling Receiving Circuit - SD-67027-01.

(f) Power Supply Circuit - SD-81577-01.

(g) Call Progress Indicating Circuit - SD-69472-01.

5. TAKING EQUIPMENT OUT OF SERVICE

5.01 The register can be taken out of service by inserting a No. 258 plug in the TST jack in the register unit.

Note: Make sure that the register is not in use before inserting the No. 258 plug.

6. MANUFACTURING TESTING REQUIREMENTS

6.01 The dial pulse register shall be capable of performing all the service functions specified in this circuit description and meeting all the requirements of the Circuit Requirements Table and also shall be capable of functioning under test conditions listed below.

6.02 The pulsing and counting functions of the register shall be checked with the following conditions:

(a) A precision pulse generating circuit such as SD-25680-0113 or equivalent capable of generating dial pulses within the limits of accuracy given in Fig. 1 in the Information Note 301 on the SD.

6.03 Nominal circuit conditions may be employed in these tests except as specified in (a) and (b).

(a) The pulsing and counting features of the register circuit under test shall be checked using the pulsing and loop conditions covered in Note 301 on the drawing. Two digits, a digit of less than five pulses (preferably a two or three) followed by a digit of more than five pulses (preferably a nine or zero), shall be dialed under each condition and all digits dialed shall be correctly registered.

(b) The test circuit shall provide an interdigital interval of 183 ±13 msec for the pulsing conditions of Fig. 1C. For other pulsing conditions this time may be exceeded.

6.04 All timing and operation tests shall be performed with the test voltages within the following limits: 45/52 volts.

7. ALARM INFORMATION

7.01 An operated fuse supplying the dial pulse register circuit is indicated by a major alarm at the plant service center if alarm transmitting features are provided and in any case a visual signal will be given locally.

7.02 The operated fuse must be replaced or removed to restore the alarm circiut to normal.

SECTION IV - REASONS FOR REISSUE

B. Changes in Apparatus

B.1 SUPERSEDED	SUPERSEDED BY
P2A Relay, AF63 - Fig. 1 - N Option	P2A Relay, AF156 - Fig. 1 - M Option

B.2 ADDED

N Connector, KS-14672,L2 - Fig. 1 - M Option

DT Resistor, KS-13490,L1 - 3,000 ohms - Fig. 1 - M Option

D. Description of Changes

D.1 The code of the P2A relay is changed to provide a faster operating relay to make the register circuit function more reliably with the TOUCH-TONE calling option. The AF63 code is designated N option, rated Mfr Disc., and superseded by the AF156 code which is designated M option.

D.2 The DT resistor is added in the dial tone supply path to reduce the dial tone level to a value which will not interfere with a TOUCH-TONE Calling Receiving Circuit. The DT resistor is designated M option and rated AT&TCo Std. K option is added to short circuit the DT resistor when TOUCH-TONE calling is not required.

D.3 FS6 and connections to the TOUCH-TONE Calling Receiving Circuit are added. Prior to this issue, these leads were shown

connecting to an MF receiver circuit, the leads were designated differently, and a connector plug was not specified. The change is made without record since a suitable receiving circuit was not heretofore available and therefore these leads were never connected at any installation.

D.4 The reference to terminal 18 in the cross-connection field shown on Sheet B3 was formerly erroneously shown as terminal 21. This was changed without record to agree with the manufactured product. In addition to this change, functional designations for the punchings were added in parentheses to clarify the circuit. Also terminal numbers were added on some punchings for the sake of uniformity.

D.5 On sheet B5, the contact configuration in the Marker Circuit for the RCG(0,1) lead was corrected.

D.6 Note 102 was revised to reflect the TOUCH-TONE calling options and Note 106 was added.

D.7 Miscellaneous small changes were made in the Sequence Charts to correct errors.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-AEG-HFH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
ALARM AND TEST CIRCUIT

CHANGES

D. Description of Changes

D.1 On sheet 1, the sheet index is brought up to date.

D.2 On sheet 5, lead DT is added for recorded telephone dictation trunk.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 2120H[illegible]-WHO-WHK)
DEPT. 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
ALARM AND TEST CIRCUIT

CHANGES

D. Description of Changes

D.1 Sheet A1 is brought up to date.

D.2 On sheet 5, cross reference information is added to CAD 1.

D.3 These changes are made on a class D - no record basis per agreement with WECo.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7120HW-RHO-JGW)
DEPT 5337-RAV

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
ALARM AND TEST CIRCUIT

CHANGES

D. Description of Changes

D.1 Note 1 is added on sheet 5 and CAD's 1 and 6 are revised to provide for the application of TOUCH-TONE calling and the 404C tone generator.

F. Changes in CD Sections

F.1 In SECTION III - CONNECTING CIRCUITS,

Add:

3.6 TOUCH-TONE Calling Receiver Applique Unit - SD-66888-01.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-RAB-JGW)
DEPT 5337-RAV

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
ALARM AND TEST CIRCUIT

CHANGES

D. Description of Changes

D.1 In App. Fig. 2 the 68A connecting block is rated "Mfr. Disc." and replaced by the 73C.

D.2 App. Fig. 3 is rated "Mfr. Disc."

D.3 CAD 3 is rated "Mfr. Disc."

D.4 In App. Fig. 4 the 68A connecting block is rated "Mfr. Disc." and replaced by the 73A.

D.5 Equipment note 201 is added.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 7760HW-EWS-JGW)
DEPT 5337-RAV

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
ALARM AND TEST CIRCUIT

0. CHANGES

0.1 CHANGED AND ADDED FUNCTIONS

None.

0.2 CHANGES IN APPARATUS

Added:

1 - KS-14603, List 2A, 511-ohm resistor "W" option (FAN)

0.3 CHANGES IN CIRCUIT REQUIREMENTS
(Not Associated with 0.2 Above)

None.

0.4 DESCRIPTION OF CIRCUIT CHANGES

(a) "W" option is added and rated standard to remove a hazard.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-GA-HFH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
ALARM AND TEST CIRCUIT

CHANGES

C. CHANGES IN CIRCUIT REQUIREMENTS OTHER THAN THOSE CAUSED BY CHANGES IN APPARATUS

C. 1 The information for insulating relay AL is changed from 3(AL) to 5(AL) to show the correct value.

C. 2 Under Test Clip Data (Conn Grd) 2L(FAC) is added and the test set preparation is changed to B/G to show correct connection.

C. 3 The Test Clip Data (Conn Grd) for relay TMO is changed from 1U(PU) to 1U(TMO) to show correct connection.

D. DESCRIPTION OF CHANGES

D. 1 On sheet 2 the notation for the AR key is changed from 1 to 3 and its rearrangement is shown on sheet 3 to agree with manufacturing information.

D. 2 The CAD figures have been changed to provide an alternate routing of leads, in conjunction with the redesign of the crown layout, to facilitate the use of the plug-in add-on and key telephone line units.

All other headings, no change.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-PB-HFH

CD-69471-01
Issue 1
Appendix 1-A
Dwg. Issue 2-A

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
ALARM AND TEST CIRCUIT

CHANGES

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 This circuit is being reissued to change the 3 make contact of the (AL) relay to the 5 contact and the 12 make contact of the (TMO) relay to the 9 contact in order to improve the reliability of the Marker Timing Alarm.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 5332-PAB-HFH-MR

Printed in U.S.A.

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
ALARM AND TEST CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. GENERAL METHOD OF OPERATION

1.1 This circuit provides for a visual indication of a trouble condition at the location of the local station and for the transmission of an alarm signal to a plant service center. There are three types of troubles which will cause this circuit to function and give an alarm indication. The first is the operation of either a positive or negative 48 volt battery supply fuse. The second is the operation of a 10V AC fuse in the power supply. The third is a marker trouble which prevents the marker from timing out and releasing within a period of 7.5 to 15 seconds.

This circuit also provides a test line termination and battery and ground test points for maintenance testing.

SECTION II - DETAILED DESCRIPTION

1. ALARM CONDITIONS

1.1 Negative 48V Fuse Failure

When any negative 48V fuse associated with this local station operates it connects 48 volts through the alarm bus bar to the winding of the FAN relay which causes the relay to operate. The operation of the FAN relay releases the normally operated TR relay which in turn lights the TR lamp. The release of the TR relay also sends a signal to the alarm receiving circuit in the plant service center by closing the loop, "Z" option or by removing battery and ground from the loop, "Y" option. When the fuse is replaced the FAN relay will release and the TR relay will reoperate and the circuit will return to normal.

1.2 Positive 48V Fuse Failure

When a positive 48V fuse operates it connects positive 48 volts through the alarm bus bar to the winding of the FAP relay which causes it to operate and lock-up to ground through contacts 1-2 of the AR key. The operated FAP relay will release the TR relay and cause the alarms to function as described in Paragraph 1.1.

1.3 10V AC Fuse Failure

When the 10V AC fuse operates in the power supply it connects 10V AC to the FAC varistor which causes the FAC relay to operate. The operated FAC relay will release the TR relay and cause the alarms to function as described in Paragraph 1.1.

1.4 Marker Timing Circuit Failure

When the MT (A,B) relays of the marker have operated they prepare a path for operating the PU relay of this circuit. Within a period of time of 0 to 7.5 seconds after the MT (A,B) relays operate ground from the interrupter circuit will be placed on the "MTPU" lead from the marker circuit and the PU relay will operate. The PU relay will lock operated under control of the MT (A,B) relays of the marker and will prepare an operate path for the TMO relay of this circuit. If the marker circuit has completed its function at this point the MT (A,B) relays will release and cause the PU relay to release also and restore the alarm circuit to normal. However, if trouble is encountered in the marker timing circuit, the MT (A,B) relays will remain operated. Seven and one half seconds after the interrupted ground has been removed from the "MTPU" lead, a ground will be placed on the "TMO" lead from the interrupter and the TMO relay will operate and lock under control of the MT (A,B) relays of the marker. The operation of the TMO relays opens the locking path of the PU relay and causes the operation of the AL relay. It also causes the operation of the RLS and RLSA relays in the marker to release the marker for a new call. The operated AL relay locks to itself under control of the AR key and causes the TR relay to release and function the alarms as described in Paragraph 1.1. The alarm indications are released by operating the AR key which restores the AL relay to normal thus causing the TR relay to reoperate.

2. TEST LINE

The circuit provides for station 39 to be used for a test line to process the various types of calls when routining the equipment or locating trouble.

3. TEST BATTERY

This circuit provides 48 volt battery and ground and also a high resistance battery "HRB" which has a 1000 ohm resistor in series to prevent excessive current flow for testing purposes.

SECTION III - REFERENCE DATA

1. FUNCTIONAL DESIGNATIONS

The functional meanings and the designation of the relays of the alarm and test circuit are listed below.

Relay Designation	Functional Meaning
AL	Alarm
AR (N.L. Key)	Alarm Release
FAN	Negative Fuse Alarm
FAP	Positive Fuse Alarm
FAC	10V AC Fuse Alarm
PU	Pick-Up
TMO	Time Out
TR	Trouble

2. FUNCTIONS

This alarm and test circuit is designed to perform the following functions:

2.1 To give a visual alarm when trouble is encountered.

2.2 To transmit an alarm signal to a plant service center when provided.

2.3 To lock in a marker timeout alarm under control of an AR key which must be manually operated to restore the circuit to normal.

2.4 To time out at a predetermined time if a trouble is encountered in the marker and release the marker making it available for another call.

2.5 To provide for using station 39 as a test line.

2.6 To provide 48 volt battery, ground, and 48 volt high resistance battery test points for testing purposes.

3. CONNECTING CIRCUITS

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

3.1 Marker Circuit - SD-69468-01.

3.2 Power Supply Circuit - SD-81577-01.

3.3 Line, Link and Connector Circuit - SD-69469-01.

3.4 Key Telephone Line and Add On Circuit - SD-69466-01.

3.5 Extension Alarm Circuit - SD-95484-01.*

*Typical Circuit

4. MANUFACTURING INFORMATION

4.1 This circuit shall be capable of performing all the service functions specified in this circuit description and meeting all of the requirements of the Circuit Requirements table.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 5332-PB-HFH-JW

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
CALL PROGRESS INDICATING CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

This circuit provides indicating lamps for monitoring the operation of relays in the switching system No. 400 Marker circuit and the connector portions of the Register and Line, Link, and Connector circuits.

2. GENERAL METHOD OF OPERATION

The indicating lamps in this circuit are furnished in a portable box equipped with a plug-ended cable. These plugs are designed to be inserted in mating connections provided as part of the No. 400 system slide equipment. When the indicating lamps are connected to the slide equipment in this manner a lamp will light when the similarly designated relay in the slide equipment operates. When a relay releases the associated indicating lamp will be extinguished.

It is expected that the indicating lamps will be useful to a maintenance man when checking the operation of a No. 400 system and for training purposes. The indicating lamps will enable a user to focus his attention on a relatively small field of lamps rather than relays located in several slides of equipment when checking the sequential operation of the relays in the system.

The indicating lamps are to be regarded as a maintenance aid but will not substitute for a thorough knowledge of the method of operation of the No. 400 circuits which the lamps monitor.

SECTION II - DETAILED DESCRIPTION

1. GENERAL

This circuit consists of a number of lamps each bearing a designation. The designation in each case corresponds to the relay in the No. 400 system which will light the lamp when operated. The functional meaning of the designation will be found in the circuit descriptions of the connecting circuits.

2. LAMP GROUPING

Physically, the lamps are segregated into eight groups and each group relates to

a particular connecting circuit function. These groups are as follows:

2.1 Marker Tens Selection and Preference Group

This group consists of the RO, R1, T1 thru T5, RPO, RP1, TP1 thru TP5, and TA1 thru TA5 lamps and monitors the tens selection and preference functions of the marker circuit.

2.2 Marker Tens Miscellaneous Group

This group consists of the TEO, ARB, AC, RG, and TAC lamps which monitors some miscellaneous marker circuit functions.

2.3 Marker Units Selection Group

This group consists of the LUC, UL, UE, UO thru U9, RUC, SE, and SO thru S9 lamps. This group monitors the units selection functions of the marker circuit.

2.4 Marker Junctor Register Group

This group consists of the JTB, JTAA, JRE, JRO thru JR5, WU, and ZU lamps. The WU and ZU lamps monitor the units alternating feature and the remaining lamps monitor the junctor register functions in the marker circuit.

2.5 Marker Line Group

This group consists of the LSA, LE, LT2, thru LT9, TRL, LB, LSH, ALB, WLG, WLGA, ZLG, WL, ZL, WIL, and ZIL lamps and monitors the link testing and link selection functions of the marker circuit.

2.6 Marker Timing Group

This group consists of the MTA, TOK, TOL, TM, TO, TA, ST, SA, NC, NA, TR, RLS, and RCK lamps. These lamps monitor the timing and time out check functions of the marker circuit.

2.7 Marker Sequence and Route Control Group

This group consists of the BTT, TRK, TRCA, BTC, RCTA, BY, HC, BSYA, BSY, SOA, SMT, SMR, HMTA, HMT, HMK, RHK, DCK, and RLA lamps which monitor the sequence and route control, downcheck, and release functions of the marker circuit. Also included in this group are the RAO and RA1 lamps which monitor the register allotter feature of the marker circuit.

2.8 Connector Group

This group consists of the RCO and RC1 lamps which monitor the connector relays in the register circuit and the TC1 thru TC5 and the SMC1 thru SMC5 lamps which monitor the tens connector and select magnet connector relays in the Line, Link and Connector circuit.

3. LAMP COLORS

Red, green, and white lamp caps are provided on the indicating lamps so that lamps within a group may be more readily distinguished from one another. In some instances, a green lamp will indicate the start of a particular marker function (e.g. LSA - link start) and a red lamp the end of a function (e.g. LE - link end).

SECTION III - REFERENCE DATA

1. FUNCTIONS

1.1 To provide indicating lamps to monitor relay operation in the No. 400 system.

2. CONNECTING CIRCUITS

2.1 Marker Circuit - SD-69468-01.

2.2 Register Circuit - SD-69470-01.

2.3 Line, Link, and Connector Circuit - SD-69469-01.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 5332-AEG-HFH-EP

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
KEY SHEET

CHANGES

D. Description of Changes

D.1 On sheet A1, the sheet index is brought up to date.

D.2 On sheets A2 and B1, circuits and connecting information for TOUCH-TONE calling and PBX interface trunk are added.

BELL TELEPHONE LABORATORIES, INCORPORATED

(WECo 2120HW-RHO-WHK)
DEPT 5337-LAH

STATION SYSTEMS
SWITCHING SYSTEM NO. 400
KEY SHEET

1. PURPOSE OF KEY SHEET

This key sheet lists the circuits for use in the Switching System No. 400 and shows the manner in which the circuits interconnect. It also shows the tie trunks and long line circuits which may be used with this switching system and the range information for the tie trunks interconnected with distant PBXs.

2. EXPLANATION OF CONVENTIONS

For explanation of conventions see page 1 of the MASTER KEY SHEET, SD-90250-01.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-FWW-HFH

STATION SYSTEMS
KEY TELEPHONE SYSTEMS 1A1
KEY TELEPHONE LINE AND ADD-ON CIRCUIT

CHANGES

D. Description of Changes

D.1 On sheet -012, M and K options are added to disconnect the secondary of the TR inductor and thus remove a cause of line imbalance when relay S1 operates.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-GR-HFH

5. DISCONNECTION

When the station disconnects on either incoming or outgoing calls, the A and AH relays release and the circuit restores to normal.

6. EXTENDING INCOMING CALL TO SWITCHING SYSTEM STATION

6.1 Dialing Switching System Station

To extend an incoming central office call to a switching system station, the attendant will place an incoming call on hold, operate the pickup key of the switching system line of the associated add-on circuit, and dial the desired number.

6.2 Operation of Transfer Key

The attendant may transfer immediately upon hearing ringing induction. To accomplish a transfer, the attendant depresses the TR key on the telephone set. Ground from the TR key over the "SG" lead, through operated A relay contacts, and through normal W and W1 relay contacts operates the W relay. As there is ground on both sides of the Z relay at this time, Z relay will not operate. The operation of the W relay cuts the tip and ring of the central office line circuit in series with the TR1 inductor winding; provides an alternate path to keep the central office line lamp lighted over the "L" and "±10V" leads; prepares a path for the Z relay to operate; and shunts down the operated H relay in the central office line circuit. When the TR transfer key is released, ground is removed from the "SG" lead and the shunt is removed from the Z relay. The Z relay now operates to ground on a make contact of the W relay. The operation of the Z relay connects the tip and ring of the station line circuit in series with the S relay. The station in answering will cause the junctor to reverse battery and ground on the tip and ring operating the S relay which in turn operates the S1 relay. The attendant may then hang up.

6.3 Attendant Retires from Connection

When the attendant disconnects, the A and AH relays of the line circuit on which he was talking will release. The time out relay TO will also release if no other AH relays in the group are operated.

If the attendant disconnects before the called station answers, the release of the A and H relays will cause the station line lamp to flash at the 30-ipm rate.

6.4 Called Station Answers

When the called stations answers, the junctor circuit used in the connection will reverse the battery and ground polarity on the tip and ring conductors, causing the S relay to operate. The S relay in operating will operate the S1 relay which locks operated to the operated W relay, changes the station line lamp from flashing to steadily lighted, and replaces the TR inductor bridge on the tip and ring conductors toward the station line with a bridge consisting of the winding of the W1 relay in series with the S1 diode.

7. DISCONNECTION OF EXTENDED CALL

7.1 Automatic Disconnect

When an established central office to station call or station to central office call is completed and the station hangs up, the bridged relay in the switching system junctor releases, reversing battery and ground over the tip and ring to the station side of the add-on circuits, releasing the S relay. Polarity of the S1 diode causes current to flow through the winding of the W1 relay thus operating it. The W1 relay, in operating, releases the W relay which in turn releases the Z and S1 relay.

7.2 Attendant Disconnect

Should it be necessary for the attendant to disconnect the station from the central office, he can enter the central office line and momentarily operate the transfer key. This action puts ground on the "SG" lead through the operated A relay to the W relay which will be shunted down. When the transfer key is released, the Z relay will release, releasing the S and S1 relays and restoring the add-on circuit to normal. The central office line therefore is under control of the attendant at all times, thus preventing a station from tying up a central office line.

8. CENTRAL OFFICE NUMBER REQUESTED BY A SWITCHING SYSTEM STATION

A switching system station desiring an outside number will dial an attendant who has an outside line and the connection procedures will be the same as in the preceding paragraph for the incoming call except the attendant will place the station line on hold.

9. TIME OUT

The operation of the R relays, either in the central office line circuit or the station line circuit, closes ground to the

"TO" lead which, assuming the equipment to be idle, closes the battery path through the heater winding of the TO relay. If the call is abandoned or the TO relay is not operated within 30 seconds, the lower contacts of the TO relay act as a time-out device and open the locking path of the R relay in the line circuit. Any connecting line circuit which is operated other than the incoming call will connect ground to the "CO" lead and operate the TO relay. The top contacts of the TO relay open battery from the heater winding, thereby preventing time out.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.1 Lines

See 1A and 1A1 key telephone systems range charts.

1.2 Voltage Limits

14 to 26 volts dc
75 to 105 volts ac
7 to 11 volts ac

2. FUNCTIONAL DESIGNATIONS

Desig	Functional Meaning
A	Control
AH	Auxiliary Control
R	Ring Up
H	Hold
TO	Time Out
Z	Station Connect
W	Central Office Connect
S	Station Answer
S1	Auxiliary Station Answer

3. FUNCTIONS

This circuit provides for:

(a) Flashing visual signals on incoming calls.

(b) Common audible interrupted ringing at key telephone sets.

(c) Steady visual signals to indicate busy lines.

(d) Winking visual signals on held calls.

(e) Connecting outside central office lines with any station in the switching system.

(f) Attendant forcing disconnect of station to central office call connecting by add-on circuit if desired.

(g) Automatic disconnect of station to central office call connected by add-on circuit when station hangs up.

4. CONNECTING CIRCUITS

(a) Line, Link and Connector Circuit - SD-69469-01.

(b) Key Telephone System No. 1A1 - Key and Telephone Circuit - SD-69219-01.

(c) Power Supply Circuit - SD-81577-01.

(d) Alarm and Test Circuit - SD-69471-01.

5. MANUFACTURING TESTING REQUIREMENTS

This circuit shall be capable of performing all the service functions described herein, and meet the requirements in the circuit requirements table.

6. TAKING EQUIPMENT OUT OF SERVICE

Block Z and W relays down with blocking tools if circuit is not assigned.

SECTION IV - REASONS FOR REISSUE

B. CHANGES IN APPARATUS

B.1

Removed	Replaced By
AF6 relay W	AJ36 relay W
AJ36 relay Z	AF6 relay Z
KS-13492, L1 res - 110 ohm W	KS-14603, L1A res - 215 ohm W
KS-13492, L1 res - 215 ohm Z	KS-14603, L2A res - 110 ohm Z

D. DESCRIPTION OF CHANGES

D.1 The W and Z relays and resistances have been interchanged to obtain an early make-break contact (EMB6 on the present W relay) for controlling the W-Z combination in place of the make-break contact (MB6 on the present Z relay) formerly used.

D.2 The lead from 12B of the W1 relay, which is now connected to the upper winding terminal of the Z relay, was formerly connected to the lower winding terminal of the Z relay.

D.3 The codes of the resistances, diodes, thermistors, varistors, and inductors were added on the circuit to conform with key telephone unit circuit drawing practice.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5332-PB-HFH

STATION SYSTEMS
KEY TELEPHONE SYSTEMS 1A1
KEY TELEPHONE LINE AND
ADD-ON CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. GENERAL DESCRIPTION OF OPERATION

This add-on circuit with two line circuits provides a means of connecting a central office line to a switching system station with the assistance of a person at the telephone set where central office line appears.

An incoming call is answered by a person, hereinafter designated as an attendant, at whose key telephone set a central office line and an associated switching system line appear. The central office line is answered and placed on hold after determining which switching system station is desired by the calling party. The attendant dials the desired switching system station over the station line associated with the held central office line and operates the nonlocking transfer key momentarily. This releases the held central office line and connects it to the station through the add-on circuit. The attendant can hang up or stay on the established connection, as desired.

An outgoing call from a switching system station to a central office line is handled by the attendant using the reverse of the procedure described above.

The disconnect of the add-on circuit is under control of the switching system station or the attendant.

If there is no answer on an incoming call to the attendant telephone set, the time out feature will disconnect the locked-in flashing in about 30 to 45 seconds.

An incoming call produces a 60-ipm flashing line lamp and a held call produces either a 120-ipm winding or steady line lamp depending upon the option wired. A busy line is indicated by a steady line lamp. A

ringing switching system station is indicated by a 30-ipm flashing lamp.

An incoming call produces a 60 flashing line lamp and a held call produces either a 120 winking or steady line lamp depending upon the option wired. A busy line is indicated by a steady line lamp. A ringing switching system station is indicated by a 30 flashing lamp.

SECTION II - DETAILED DESCRIPTION

1. INCOMING CENTRAL OFFICE CALL

1.1 Ground Ringing - V Wiring

When ringing current is applied to the ring of the line on an incoming call, the ac component flows through a break contact of relay AH, capacitor R, thermistor R, and the secondary of relay R to ground on one half of the cycle, and through varistor R to ground on the other half of the cycle. Contacts of relay AH and of relay A shunt the winding of relay H and varistor H and serve to bypass ringing current and prevent the establishment of a false hold condition which might otherwise occur when a number of ringers are bridged across the station side of the line. The 317A varistor R1 protects varistor R and thermistor R from transient currents. The thermistor has a cold resistance in the order of 50,000 ohms which prevents relay R from operating when ringing current is first applied, preventing false operation on disconnect or other transients. Power absorbed from the ringing current increases the temperature of the thermistor and reduces its resistance to the order of 3,000 ohms in about 1/2 second, permitting sufficient current to flow to operate the R relay on the half-wave rectified current due to varistor R. Relay R locks operated on its primary winding under control of relay A and the "LK" lead. Operation of relay R causes the line lamp to flash, connects ground to the "TO" lead to start the time out described in 9., and closes the circuit to the common audible signal circuit, if provided.

1.2 Metallic Ringing - X Wiring

Operation of the circuit using metallic ringing return (X wiring) is the same as that for grounded ringing, described in 1.1, except that ringing is returned to the tip of the line instead of to the ground. This arrangement is designed to reduce noise due to cooling of the R thermistor and/or potential differences.

2. ATTENDANT ANSWERS

An incoming call is answered by operating the pickup key associated with the line being rung and by removing the handset from its mounting. Operation of the telephone set switchhook connects ground through the pickup key to the "A" lead, operating relay A. Operation of relay A closes a circuit to operate relay AH; changes the line lamp from flashing to steady; opens the operating path of the hold relay H, preventing it from operating falsely; and opens the locking path of relay R, allowing it to release. Operated relay AH disconnects the ringing bridge from the ring of the line, grounds the "CO" lead to disable the time-out circuit, and prepares a circuit from the "LW" lead to the line lamp.

3. OUTGOING CALL

The procedure for making an outgoing call is the same as for answering an incoming call. The R relay will be in the released condition. Operation of telephone set switchhook connects ground through the operated pickup key to the "A" lead, operating relay A. Operation of relay A closes a circuit to operate relay AH; opens the operating path of the hold relay; opens the operating path of the R relay; and lights the line lamp steadily. Operated relay AH grounds the "CO" lead to disable the time-out circuit. This places the telephone set across the line.

4. HOLDING

4.1 Attendant Holds Call

An incoming or outgoing call can be held by operation of the HOLD key in the telephone set which opens the ground on the "A" lead and permits relay A to release. Release of relay A closes the operate path to the winding of relay H, allowing it to operate on line current through the telephone set; prepares a holding path for the slow-release relay AH and changes the line lamp from steady to winking (or steady) over the path previously prepared by operation of relay AH. Operation of relay H closes a make contact, connecting its winding across the line as the holding bridge, and also closes a holding path for the slow-release relay AH in time to prevent its release. The 317B varistor H is in parallel with the winding of relay H to stabilize the sensitivity of the H relay when subjected to varying voltages.

4.2 Release of the Holding Bridge

When any station of the key telephone system seizes the line by operating the associated pickup key and removing the handset from the mounting, relay A is operated. Relay A operated opens the locking path of relay H, causing it to release and remove the holding bridge. This restores the circuit to the talking condition.

POWER SYSTEMS
POWER SUPPLY CIRCUIT
AC, DC & RINGING SUPPLY
J86812A & B

CHANGES

A. Changed and Added Functions

A.1 An additional dc output (-96 volts) is provided for operation of the "Make Busy and Busy Display" test feature.

B. Changes in Apparatus

B.1 Added

Fig. 6, "S" Option, -96 Volt Applique

D. Description of Changes

D.1 An applique is provided, "S" option, to add a -96 Volt dc output having a low ac ripple content.

D.2 Circuit notes 102, 103 and the option index are revised. Information note 302 is added. The Maintenance Specification BSP number is added to the drawing.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5153-SR-DET-EAF

POWER SYSTEMS
POWER SUPPLY CIRCUIT
AC, DC & RINGING SUPPLY
FOR SWITCHING SYSTEM 400
J86812 A & B

CHANGES

B. Changes in Apparatus

B.1	Superceded	Superceded By
	410A Transformer	410B Transformer
	"V" option	"T" option

D. Description of Circuit Changes

D.1 This drawing is reissued to rate the use of the 410A transformer, T1, "MFR DISC", replaced by the 410B transformer.

D.2 Circuit note 103 and the option index are revised.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5153-SR-DET-EAF

POWER SYSTEMS
POWER SUPPLY CIRCUIT
AC, DC & RINGING SUPPLY
FOR SWITCHING SYSTEM 400
J86812A & B

SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 To provide power, ringing and tones for Switching System 400.

2. GENERAL DESCRIPTION OF OPERATION

2.01 The 105 to 129 volts commercial ac power is supplied from a nearby outlet through the plug, cord and line switch to the input distribution point, TS1. Output distribution is on TS2, J1 and J2.

SECTION II - DETAILED DESCRIPTION

1. -48V RECTIFIER

1.01 Negative 48 volts dc power is supplied by the KS-19642 rectifier. Capacitors C5 and C6 in the switching system are provided on the -48V output as protection against power failures of less than 0.25 second duration.

2. POSITIVE 48V DC SUPPLY

2.01 Positive 48 volts dc supply is provided from the output of the T1 transformer, rectified by CR1 diode, and filtered, by capacitors C3 and C4 to reduce output noise.

3. ±10V AC SUPPLY

3.01 10 volts 60 cps is obtained from a tap on the secondary winding of the T1 transformer. To maintain the outputs of T1 transformer within working limits the input winding is equipped with taps for nominal 111-, 117-, or 123-volt service.

4. FREQUENCY GENERATOR RING G

4.01 Ringing is supplied by the RING G frequency generator that converts 60 to 20 cps and connects to a circuit consisting of C1 capacitor and winding (1-2) of L1 inductor. This circuit resonates at about 460 cps and is shock excited by the current pulses due to an abrupt drop in voltage across the V1 gas tube each time the tube fires. The current through the tube is controlled by the circuit consisting of C2 capacitor, R1 resistor and winding (3-4) of L1 inductor. With the circuit constants used, the tube fires twice on each positive and negative half cycle supplying 40 pulses per second. The resulting output is 460 cps modulated at 40 cps which produces a pleasing tone.

5. FREQUENCY GENERATOR LT

5.01 Low Tone is supplied by the LT frequency generator that converts 60 to 600 cps modulated at 120 cps. On lead "[LT1]" the output is approximately 2 volts and is interrupted at 60 IPM to provide busy tone.

6. TONE GENERATOR TT

6.01 TOUCH-TONE dial tone is provided by the 404C tone generator. On lead "[TT1]" the output is approximately 1.75 volts for dial tone.

7. INTERRUPTER INT

7.01 A small 10 volt ac motor in the INT interrupter drives a series of cams through a gear arrangement. The rotating cams open and close contacts to provide various timing pulses as shown in Table A.

8. ALARMS

8.01 Provisions for fuse failure alarms are supplied on -48 volts to the ringing circuit and 10 volts ac to the output and interrupted circuits.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.01 AC Input:

105 to 129 volts 60 cps.

1.02 Outputs

(a) DC Outputs

Nominal Volts	Voltage Range Volts	Load Range Amperes
-48	-45 to -52.6	0.5 to 8.0 normal 12 intermittent
+48	40 to 60	0.1

(b) AC Output

Nominal Volts	Voltage Range Volts	Load Range Amperes
±10, 60 cps	8 to 11	2.1

1.03 Output

Nominal Volts DC		
-48	Noise max. 34 dbrnc BRDG Ripple max. 0.050 peak to peak at 8 Amp load	
+48	Noise max. 52 dbrnc BRDG Ripple max. 1.0V rms	

1.04 AC Outputs (Ringing and Tone Supply)

(a) Ringing - 75 to 100 volts, 20 cps

(b) Busy Tone - 2.0 volts, [LT1]

(c) TOUCH-TONE Dial Tone - 1.75 volts, [TT1]

2. FUNCTIONAL DESIGNATIONS

None

3. FUNCTIONS

3.01 This circuit is designed to perform the following functions:

(a) To provide -48 volts dc for relay and talking power for switching systems with no reserve battery.

(b) To provide +48 volts dc for direct station selection.

(c) To provide 10 volts ac for lamps in sets and interrupted power.

(d) To provide low tone for busy tone.

(e) To provide TOUCH-TONE dial tone.

(f) To provide 20 cps ringing current with an audible ringing tone of 460 cps modulated at 40 cps.

(g) To provide machine ringing.

(h) To provide signaling interruptions.

4. CONNECTING CIRCUITS

4.01 This power supply connects to SD-69471-01 No. 1 Slide Equipment and other switching circuits.

SECTION IV - REASONS FOR REISSUE

CHANGES

B. Changes in Apparatus

B.1 Superseded	Superseded By
C5, C6, C7 Capacitors, KS-19076, 7000 uf each- Fig. 3	C5, C6 Capacitors, Sprague D39159 16,000 uf each- Fig. 5
C5, C6, C7 Capacitors, KS-19319, 7000 uf each- Fig. 4	C5, C6 Capacitors, Sprague D39159 16,000 uf each- Fig. 5

D. Description of Changes

D.1 Figs. 3 and 4 were rated "Mfr Disc." replaced by Fig. 5 which was added to the drawing.

D.2 Circuit note 103 was brought up to date to add reference to changes on issues 3D and 4D.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5153-HMK-DET-EAA