

CIRCUIT DESCRIPTION

CD-66520-01
ISSUE 19D
APPENDIX 5D
DWG ISSUE 24D

PBX SYSTEMS
NO. 555
CORD, TELEPHONE, DIAL,
CENTRAL OFFICE TRUNK,
STATION LINE, BUZZER,
RINGING, AND BATTERY
CIRCUITS

CHANGES

B. Changes in Apparatus

<u>B.1</u>	<u>Changed</u>	<u>Changed to</u>
	Varistor B, 3B, H option, Mfr Disc.	Varistor B, 104A, YR option

D. Description of Changes

- D.1 The 3B varistor, designated B, is changed to the more reliable 104A varistor.
- D.2 The rating of the drawing is changed to A&M Only.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 3214-RT-GES

Printed in U.S.A.

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CIRCUIT DESCRIPTION

CD-66520-01
Issue 19D
Appendix 1D
Dwg Issue 20D

PLEASE NOTE AND RETURN:

BURNS, J. G. 3
DIVINS, G. G. 0
JACKSON, C. C. 5
KLAISS, M. J. 5
PERRIN, A. E. 5

PBX SYSTEMS
NO. 555
CORD, TELEPHONE, DIAL,
CENTRAL OFFICE TRUNK,
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CIRCUITS

Drawings for SD-66520-01 have been converted to 8-1/2 by
11 inch handbook size.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5336-LEVD-EVDL

PBX SYSTEMS
NO. 555
CORD, TELEPHONE, DIAL,
CENTRAL OFFICE TRUNK,
STATION LINE, BUZZER,
RINGING, AND BATTERY
CIRCUITS

CHANGES

B. CHANGES IN APPARATUS

- | | | |
|-----|--|-----------------|
| B.1 | Superseded | Superseded by |
| | (RB) relay UA98
Fig. QP | UA150 Fig. Q |
| | (C), (D) diodes,
400E Option ZQ | 400J Option ZR |
| | (P) inductor, 274L
Option YD | 274AJ Option YE |
| | 6A dials | 6R-3 |
| | D5AD dial cord
Option YB | D5AJ Option YC |
| | Footswitch, 4C | KS-16821, L1 |
| B.2 | Added | |
| | (P) resistor, KS-13492, L1 Option YE | |
| | (E) capacitor, KS-14105, 125 MF
Option YE | |

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 Administration of the options for the cord bridge resistance and type of supervision is being improved by provision of a permanently operated relay (RB) in place of the (RB) inductor. The options may then be disconnected or connected by insulating or not insulating the relay contacts. Plastic sleeving is to be used as contact insulation.

This will end the necessity of dismounting each cord unit in order to change any of these options.

Figure Q supersedes Fig. P, Options ZW, ZX, ZY and ZZ supersede Figs. K, J and Option T, W respectively. Circuit Note 108 is added to cover these arrangements.

D.2 One of the results in designing this PBX to operate on a wide range of voltage has been that the attendant transmitter current and efficiency was roughly proportional to the PBX voltage. Thus when the voltage was low the attendant's speech

transmission was down about 6 db because of the low transmitter current. This is materially improved by replacing the 200/200 ohm inductor with a 12/12 ohm inductor, and adding a 13N ballast lamp in parallel with a 3000 ohm resistor, in series with the battery lead.

The 12/12 ohm inductor has considerably less inductance than the 200/200 ohm inductor and there is consequently more tendency for the attendant's speech to be audible as crosstalk in the battery supply to the PBX. This is remedied by provision of a 125 MF capacitor (F) connected across the power supply leads at the PBX.

This change involves the addition of a ballast lamp, an electrolytic capacitor, a pigtail resistor, and the replacement of one 274 type inductor by another.

D.3 Figs. 10 and 11 specified spider cords for multiple night connections. These will hereafter be found on drawing SD-66537-01. Figs. 10 and 11, Notes 108 and 109 are deleted.

D.4 The use of 400B diodes, Option ZQ in this circuit is rated Mfr. Disc. The code is replaced by Code 400J, Option ZR.

D.5 Prior to Issue 18-D it had been agreed with the shop that Options ZU and ZV would be used to record the replacement of the 8A buzzer by the 8C. Issue 18-D inadvertently used letters ZQ and ZR. These are changed to ZU and ZV on a "no record" basis to agree with the shop manufacturing information.

D.6 The terminal numbers have been omitted on the drawing for the KS-13486 capacitor because the numbers cannot be seen when the capacitor is mounted and there is no electrical or other need to identify the terminals.

D.7 Notes 102, 103, the Options Used table, and the Circuit Requirements table are changed to reflect Issue 19-D.

All other headings under Changes, no change.

1. PURPOSE OF CIRCUIT

1.1 These circuits provide means of which the PBX attendant may connect a station to another station, to central

office trunk or to a tie trunk or may answer calls from the central office trunk and extend them to PEX stations or to a tie trunk extend them to PEX stations, to a central office trunk or to another tie trunk.

2. WORKING LIMITS

2.1	Station Supervision Fig. 1			Station Signaling† Fig. 5						Fig. 6
	Min. Voltage			Min. Voltage						
	16V	18V	20V	16V	18V	20V	22V	24V	26V	
Max. Ext. Ckt. Loop	450 ω	600 ω	780 ω	150 ω	240 ω	330 ω	420 ω	510 ω	600 ω	
Min. Insulation Res.	30,000 ω	30,000 ω	30,000 ω	*	*	*	*	*	*	**8000 ω

*Limited by Fig. 6

**Combined Insulation Resistance of all Station Lines without line relays (Fig. 5) Common to one (NL) relay (Fig. 6).

†Where Message Waiting Service is provided, the Max. Ext. Ckt. Loop for station signaling is reduced 35 ohms.

	Central Office Trunk Supervision Fig. 1	Central Office Trunk Signaling Fig. 3
Max. Conductor Res.	***	1,200
Min. Insulation Res. Manual Panel or X-bar	20,000 ω	20,000 ω
Step-by-Step	30,000 ω	30,000 ω

***The trunk conductor loop res. plus the maximum station loop res. shall not exceed the central office sub. loop res. less 35 ω .

Trunk Circuit
Fig. 9

Max. Conductor Loop Res. - Ohms

	72V AC	80V AC	84V AC
Ring up range	1700 Ω	2200 Ω	2400 Ω
Min. Insulation Res.	20,000 Ω	20,000 Ω	20,000 Ω

2.2 Min. and Max. Allowable Feeder Resistances from 45-50 Volt Battery.

Number of Cords	Maximum Feeder Resistance in Ohms	Minimum Feeder* Resistance in Ohms
4	112	0
5	99	0
6	94	0
7	89	0
8	80	3
9	77	5
10	69	9
11	66	11
12	63	12
13	59	14
14	57	16
15	52	18
16	50	19
17	48	21
18	47	22
19	44	23
20	43	23

*Where minimum feeder limit cannot be met by a single pair use 24 volt supply.

PBX Voltages Obtained with
Various Feeder Resistances

Number of Cords	16V	18V	Volts 20V	AT 22V	24V	PBX 26V	28V	30V	32V	34V
4	112	93	78	65	54	46	38	31	25	19
5	99	82	68	57	48	40	33	27	22	18
6	94	78	65	54	45	38	31	26	21	17
7	89	74	61	51	43	36	30	25	20	16
8	80	66	55	46	39	32	27	22	18	14
9	77	63	53	44	37	31	26	21	17	13
10	69	57	47	40	33	27	23	19	15	12
11	66	55	45	38	32	27	22	18	14	11
12	63	52	43	36	30	25	21	17	13	
13	59	49	41	34	29	24	20	16		
14	57	47	40	33	27	23	19			
15	52	43	37	30	25	21				
16	51	42	35	29	24	20				
17	48	40	33	28	23					
18	47	39	32	27	22					
19	44	37	30	26						
20	43	32	29							

3. FUNCTIONS

- 3.01 Provides an individual visual and common audible line signal on incoming calls from station, central office, trunk or tie trunk circuits.
- 3.02 Provides for answering a call from station, central office trunk or tie trunk circuits with the cord circuit.
- 3.03 Provides for connecting the attendant to any cord circuit.
- 3.04 Provides for the attendant dialing to dial central offices.
- 3.05 Provides for the attendant establishing connections to manual central offices.
- 3.06 Holds the central office connection when the attendant disconnects from the cord circuit.
- 3.07 Provides for establishing connections from a station to another station, to a central office trunk or tie trunk, from a central office trunk to a station or to a tie trunk or from a tie trunk to a station, to a central office trunk or to another tie trunk.
- 3.08 Supplies talking battery on local connects.
- 3.09 Provides for manual ringing on calls to stations.
- 3.10 Provides "Through dial" connections from stations to dial central offices.
- 3.11 Provides for night connections to any central office.

- 3.12 Provides visual supervision on both cords and an audible supervisory signal on the right hand cord.
- 3.13 Provides supervision when a station recalls.
- 3.14 Provides optional supervision to the central office as follows: "through supervisions" or "non-through supervision" on all calls or "non-through supervisions" on inward calls and "through supervisions" on outward calls. (Automatic discrimination.)
- 3.15 Provides a steady nonlocking visual signal on the trunk line lamp on recall from central office.
- 3.16 Provides for adjusting the volume of and for cutting off the audible signal.
- 3.17 Provides for disconnecting the battery from the position when unattended.
- 3.18 Provides emergency hand generator ringing.
- 3.19 Provides optional handset, head set, or bracket transmitter.
- 3.20 Provides battery supply for long line circuits when required.
- 3.21 Provides ringing current, either power or hand, for ringdown tie trunks.
- 3.22 Provides an optional means for reducing interference from longitudinal line noise, caused by transmission unbalance.

- 3.23 Provides for a busy test on incoming central office calls, on local station calls and for a single cord busy test when multiple appearances of lines or trunks are provided.
- 3.24 Provides for supplying battery to the PBX from 24 or 48 volt central office battery leads, from local building battery or from a local PBX battery.
- 3.25 Provides for starting the voltage control feature in the charge and discharge circuit when a local battery is provided at the PBX.
- 3.26 Provides for monitoring on established connection.
- 3.27 Provides for the attendant to talk to the station on a trunk connection while holding the trunk connection on a split cord basis.
- 3.28 Provides for lighting a message waiting light at the PBX station.

4. CONNECTING CIRCUITS

When this circuit is listed on a key-sheet, the connecting information thereon is to be followed. The following circuits are typical.

- 4.01 Standard Subscriber's Line Circuit in Manual, Panel. Step-by-Step or Crossbar Central Office - SD-11560-01, SD-21712-01, SD-31531-01, SD-25003-01.
- 4.02 Standard PBX Ringing and Battery Supply Circuits - SD-90230-01, SD-90232-01, SD-80740-01.
- 4.03 Standard Common Battery Signaling Telephones.
- 4.04 555 PBX Tie Trunk to a Dial PBX - SD-66523-01.
- 4.05 555 PBX Automatic Tie Trunk Circuit - SD-66524-01.
- 4.06 555 PBX Ringdown Tie Trunk Circuit - SD-66522-01.
- 4.07 Two-way Trunk Circuits to Magneto Central Office - SD-66408-01.
- 4.08 555 PBX 2 party, Commercial Office and Order Turret Line Circuits - SD-66537-01.
- 4.09 555 PBX Conference Circuit - SD-66531-01.
- 4.10 555 PBX Arranged for 2 Positions - SD-66521-01.
- 4.11 Long Line Circuit - SD-96034-01, SD-96234-01, SD-66060-01 Typical.

- 4.12 551A, 551B, 551D or 555 PBX Emergency Reporting Line Circuit - SD-65610-01.
- 4.13 551A, 551B, 551D, 555 or 604C PBX Crash Alarm Circuit - SD-65611-01.
- 4.14 Message Waiting Service Key, Interrupter and Power Supply Circuit - SD-65784-01.

DESCRIPTION OF OPERATION

5. STATION LINE CIRCUIT - FIG. 5

5.1 Incoming Calls

When the receiver is removed from the switchhook at the associated station the line lamp lights in series with the subscriber's set. The audible signal operates if the buzzer key is operated. When the plug of the cord is inserted in the jack the line lamp is extinguished and the auxiliary contact under control of the tip spring is operated to connect ground to the sleeve of the jack for operation of the cord circuit as described later.

5.2 Outgoing Calls

When the station associated with a line circuit is to be called, the plug of a cord circuit is inserted in the jack but no operation takes place in the station line circuit other than the opening of the tip and ring spring contacts and the closing of the tip auxiliary contact which connects ground to the sleeve of the jack for the operation of the cord circuit.

5.3 Message Waiting Light

Where message waiting service is provided, ZS option provides a connection to the message waiting key circuit. There is a varistor across the L and R leads poled to permit the series line lamp to light. The back resistance of the varistor is such that when the message waiting key is operated, the -180V dc which it connects to the ring of the station line does not light the series line lamp. Where message waiting lights are not provided for, ZT option is used.

6. TRUNK CIRCUIT - FIGS. 3 & 4 (MFR. DISC.)

This circuit is equipped with thermistors in the ring-up relay circuit to provide a delay in order to prevent false line signals when the central office equipment functions after a connection is taken down at the PBX. These elements normally are extremely high resistance (over 50,000 ohms) but when ringing current is applied for approximately half a second or longer the resistance of the thermistor connected to the side of the line to which ringing current is connected is reduced to less than

3000 ohms thus giving an operating circuit for relay (R) from either side of the line to ground.

Varistor (A) is provided for two purposes, (1) to provide a low resistance operating path for the thermistor and (2) to shunt relay (R) on one-half of the ringing current cycle so that relay (R) will operate steadily during the other one-half cycle. The varistor (A) is so poled that the operating and locking circuits of relay (R) are aiding.

Option (ZC) Mfr. Disc.

The (N) resistance limits the current through the (A) varistor when it is conducting, which lengthens the life of the (A) varistor. The (E) varistor permits a better current flow on the half cycle which operates the (R) relay (i.e. better than through the (N) resistance). The combination of the (N) resistance and the (E) varistor limits the over-all current flow which in turn reduces the heating of the thermistors, thereby increasing thermistor life and affording less chance of a line unbalance, or interference from induced voltages from excess and uneven thermistor heating.

Option (ZE)

The (F) varistor in Fig. 3 functions as a current limiting device which protects the 8A thermistors and 400E varistor by shunting any high voltage surges.

6.1 Incoming Call

On an incoming call from the central office, ringing current causes relay (R) to operate and lock up through the contacts of the jack and light the associated trunk lamp in addition to operating the buzzer if the buzzer key is in the "ON" position.

6.2 Answering

The call is answered by inserting the left plug of a cord circuit (trunk) in the jack associated with the lighted lamp. Relay (R) releases extinguishing the lamp as the locking circuit is opened by the operation of an auxiliary contact on the jack. The auxiliary contact on the tip spring connects the ring side of the line through to the ring spring for purposes described later and the second auxiliary ring contact connects battery through the (B) resistance lamp to the sleeve of the jack to cause the operation of the cord circuit relay described later.

6.3 Outgoing Calls

Outgoing calls require that when the trunk plug is inserted in the jack, the ring spring shall be open until the tip

spring starts to move to avoid a possible short-circuit of the tip and ring springs while the plug is entering the jack. This prevents a false pulse to the central office equipment. When the plug is fully seated in the jack the tip and ring conductors are extended to the cord circuit in the usual manner. Battery through resistance lamp (B) is connected to the sleeve of the jack to cause the operation of the cord circuit relay. Condensers (T) and (R) and thermistors (T) and (R) are connected across the line but because of their very high resistance there is no interference with dialing. Condensers (T) and (R) prevent any d-c from affecting the resistance of the thermistors.

7. CORD CIRCUIT - FIG. 1

The supervisory relay (AS) in this cord circuit differs from that generally used in that it has no noninductive shunt connected across the relay. The transmission path is through the inductive winding but the impedance of this winding is very low because it is parallel wound with another winding on the relay which is short-circuited. The talking impedance is approximately twice the d-c resistance and where this may be objectionable from a transmission standpoint or because of noise on lines exposed to inductive noise, the relay winding is shunted by condenser (C) which provides a very low resistance path to inductive noise interference and for transmission.

7.1 Local Connections

This cord circuit is normally dry. That is, there is no battery or ground connected to the tip and ring of the cord until the right hand cord is inserted in a station jack. When a plug is in the station jack, ground on the sleeve of the station jack causes relay (S) to operate which (1) splits the cord, (2) connects condensers (A) and (B) between the right and left plugs, (3) connects battery and ground to the "station" end of the cord through relay (RB) and (4) connects battery and ground to the "trunk and station" end of the cord through relay (CS). The battery and ground is reversed at condensers (A) and (B) to improve the transmission by reducing crosstalk which may leak through relay (RB) and relay (CS). The circuit through relay (RB) is reversed to that through relay (CS) to further reduce the possibility of crosstalk between adjacent cord circuits.

7.11 Answering Station

A calling station is answered by inserting the RIGHT (station) plug in the jack associated with the lighted line lamp. The line lamp is extinguished and lamp (C) associated with the trunk end of the cord is lighted. The (A) lamp is not lighted because

relay (AS) operates over the station loop on battery supplied by relay (RB) when relay (S) operates. The attendant operates the "Talk and Dial" key connecting the attendant's telephone set across the cord.

7.12 Completing Local Connections

If a local connection is desired the "TRUNK AND STATION" plug (left) is inserted in the station jack of the called line. The "Ring Left" key is then operated connecting ringing current to the line to signal the called station.

7.13 Called Station Answers

When the receiver is removed from the switchhook at the called station relay (CS) operates, extinguishing lamp (C) to indicate that the called party has answered. The attendant may restore the "Talk and Dial" key before ringing the station or after ringing the station as she may desire.

7.14 Recall

Either station may recall the attendant by operating the switchhook. This causes the release and operation of the associated (AS) or (CS) relay lighting in turn the associated (A) or (C) lamp. The attendant answers by operating the associated "Talk and Dial" key.

7.15 Disconnect

When both stations disconnect, relays (AS) and (CS) release in turn lighting the associated supervisory lamps as disconnect signals. The cords are then withdrawn from the associated jacks and the circuit restores to normal.

7.16 Half Connections

With the station plug in a station jack, relay (S) is operated and makes the cord wet. That is talking battery is supplied to both the right and left cords. If the "trunk and station" (LEFT) end of the cord is inserted in a station jack and the station plug (RIGHT) is removed from the other station jack, relay (S) releases. No provision is made for supplying talking battery to the station which may be connected at this time to the cord circuit or to light the cord lamp.

7.2 Trunk Connections

7.21 Answering Incoming Calls

An incoming trunk call from either a manual or dial central office is answered by inserting the left cord of a pair in the trunk jack associated with the lighted lamp. The cord may be inserted with either the "TALK & DIAL" key operated or with the key normal. The lighted trunk lamp is

extinguished when relay (R) is released by the operation of the trunk jack springs. Relay (T), Fig. 1, operates from battery through the resistance lamp in the trunk circuit over the sleeve of the jack and the sleeve of the left cord through the night key contact to the winding of relay (T). Relay (T) operated; (1) connects the winding of retardation coil (H) across the cord to trip machine ringing and to provide a bridge for holding the central office connection, (2) connects the windings of relay (CS) in series with resistance (G) so that relay (CS) is used as a local circuit relay, described later, (3) disconnects ground from the winding of relay (CS) and (4) opens the circuit to relay (S) to prevent its operating later when the connection is extended to a station.

7.211 Cord Arranged for Through Supervision - Fig. J (M.D.) Option (ZX)

When the circuit is arranged for through supervision on all calls a locking path is provided for relay (CS) (9 to 12, Fig. J) so that the holding bridge (winding of retardation coil (H)) will not be reconnected when the station disconnects, therefore the central office equipment will be released immediately. The lead between 7 and 15 Fig. J performs no useful circuit function but is provided for supporting resistance (H) when relay (AD) is not furnished.

7.212 Cord Arranged for Nonthrough Supervision - Fig. K (M.D.) Option (ZW)

When the cord is arranged for non-through supervision, the winding of retardation coil (H) is connected in series with resistance (H) across the cord circuit when the station answers so that later when the station disconnects there will be no open interval given to the central office while relays (AS) and (CS) release and reconnect the retardation coil across the cord to hold the central office connection.

7.213 Cord Arranged for Automatic Discrimination Between Inward and Outward Calls in Order to Provide "Nonthrough" Supervision on Inward Calls and "Through" Supervision on Outward Calls. - Fig. H

Relay (AD) operates under control of the "Ring Right" key when a call is extended to a station. Relay (AD) operated locks up and opens the locking circuit for relay (CS) so that the holding bridge will be reconnected to prevent the release of the central office connection at the end of the conversation on an inward call. This provides for the station recalling the PBX attendant without releasing the central office equipment. On outward calls relay (AD) does not operate (because the

"Ring Right" key is not operated) so that at the end of the conversation, relay (CS) being locked up, the central office equipment will release immediately when the station disconnects.

7.214 Completing Incoming Trunk Calls to Station or Tie Trunk

Incoming trunk calls are completed to a station by inserting the right cord in the station jack and operating the ringing key in the usual manner. When the station answers, supervisory lamp (A) which was lighted over the sleeves of the station jack and the cord circuit through the back contact of relay (AS) is extinguished when relay (AS) operates in series with the called station. Relay (CS) operates from the front contact of relay (AS) and raises the resistance of the holding bridge or opens the holding bridge as described heretofore. Calls to tie trunks are completed by inserting the right cord in the tie trunk jack. If the tie trunk is of the ringdown type the operation of the ringing key associated with the tie trunk circuit will signal the distant PBX in the usual manner. Other types of the tie trunks are signaled as indicated in the particular tie trunk circuit.

7.22 Completing Calls to Manual or Dial Central Office

Outgoing trunk calls from the station are originated with the station receiver off the switchhook, the right plug in the station jack, relay (S) operated to supply battery and ground to the cord circuit and relay (AS) operated over the station loop to extinguish the right cord lamp (A). When the left plug is inserted in the trunk jack, relay (T) operates from battery over the sleeve of the trunk jack; (1) prepares relay (CS) in a local circuit, (2) disconnects ground from relay (CS), (3) opens the circuit to relay (S), (4) opens the circuit to the left lamp (C), and (5) connects the winding of retardation coil (H) across the trunk. Relay (S) in releasing; (1) removes battery and ground from the right cord, (2) removes battery and ground from the left cord to the tip and ring of the right cord. The station is then connected direct to the central office trunk in series with relay (AS).

7.221 Completing Connections to Manual Central Offices

Battery and ground are supplied from the manual central office line circuit through the line relay to the PBX then through the winding of relay (AS) to the station. Retardation coil (H) is also bridged across the trunk. If the trunk loop is near the maximum and the station loop is also near the maximum, relay (AS) may not receive sufficient current under

this condition to operate. On short loops, however, with high central office voltage, relay (AS) may operate and extinguish the right lamp and cause relay (CS) to operate and remove the bridge from across the cord. In either case when the central office operator answers, sufficient current is provided by the central office cord circuit to operate relay (AS) in series with the station loop when it is shunted by the cord bridge. Relay (AS) operated, extinguishes the right lamp and closes the circuit to relay (CS) which operates and prepares the through or nonthrough supervision condition outlined in Paragraphs 7.211, 7.212 and 7.213.

Either the PBX attendant or the station can pass the information to a central office operator. The PBX attendant can disconnect from the connection either before or after the central office operator answers by restoring the "Talk and Dial" key to the normal position.

7.222 Completing Connection to Dial Central Offices

Battery and ground are supplied from the dial central office line circuit through the line relay to the PBX then through the winding of relay (AS), then the station. Retardation coil (H) is also bridged across the trunk. If the trunk loop is near the maximum and the station loop is also near the maximum, relay (AS) may not receive sufficient current under this condition to operate. On short loops, however, with high central office voltage, relay (AS) may operate, extinguishing the lamp, and causing relay (CS) to operate and remove the shunt from across the cord circuit. In either case when the central office pulsing circuit is connected, sufficient current is provided to operate relay (AS) in series with the station loop when shunted by the cord bridge. Under this condition relay (AS) operates, extinguishes the lamp associated with the right cord and closes the circuit to relay (CS) which operates and prepares the through or nonthrough supervision condition outlined in Paragraphs 7.211, 7.212 and 7.213. Either the PBX attendant or the station can dial the central office. If the station is to dial, the attendant disconnects by restoring the "Talk and Dial" key and operates the "Night and Through Dial" key which releases relay (T) and removes the holding bridge.

The attendant dials as described under Paragraph 8.3

7.23 Recall by Station on Manual Central Office Calls or Attendant Dialed Calls

The station can recall the PBX attendant by operating the switchhook in the

usual manner. If the cord is arranged for through supervision, (Paragraph 7.211) the central office equipment may release when the station flashes if the flashing rate is very slow. The cord lamp lights as long as the switchhook is in the "down" position. Relay (CS) does not release as Fig. J is provided.

If the cord is arranged for non-through supervision, (Paragraph 7.212) flashing of the switchhook only lights the lamp on the PBX cord circuit.

If the cord circuit is arranged for automatic discrimination, (Paragraph 7.213) the central office equipment will not be affected on incoming trunk connections as relay (AD) is operated and locked up opening the locking circuit for relay (CS) which releases and restores the low bridge across the cord to hold the central office connection. The high bridge consisting of retard (H) winding in series with resistance (H) prevents release of the central office equipment during the period from the open at the station when the switchhook contact breaks to the closure of the low bridge when relay (CS) releases. On outgoing calls flashing of the switchhook causes the operation described before for cord circuit arranged for through supervision.

7.24 Disconnection

At the end of a trunk connection on either an inward or outward call the (RIGHT) lamp lights when the station disconnects.

With cord circuits arranged for automatic discrimination (Paragraph 7.213) the central office releases immediately on outward calls. On inward calls the central office is held until the cord circuit is taken down. With cord circuits arranged for through supervision (Paragraph 7.211) the central office is released immediately while with cords arranged for nonthrough supervision (Paragraph 7.212) the central office is held until the cord is taken down.

When the right cord is removed from the station jack the cord lamp is extinguished.

7.25 Night Connections

Night connections are established by first operating the "Night and Through Dial" key which opens the circuit to both relays (T) and (S). The right cord is placed in the station jack and the left cord in the trunk jack. On an incoming call relay (AS) may follow ringing current and on outgoing calls to a dial office, relay (AS) may follow the dial pulses. The (A) lamp will not light while the battery key Fig. 6 is operated to the "OFF" position. Before taking down night connections

the battery key is turned to the "ON" position to observe if any cord is busy to avoid interference with an established connection.

7.26 Recall with Cord in Trunk Jack

On an outgoing call to central office such as to a DS "A" operator or toll operator where the trunk cord is in a trunk jack with the holding bridge across the cord or on a through connection when the "Night and Through Dial" key is operated and the station has replaced the receiver on the switchhook a recall signal can be received from the central office. This comes in on the trunk lamp and is controlled from relay (R) which operates on the ringing current from the central office as long as ringing continues. Under this condition the station bell will be rung if the receiver is on the switchhook.

7.27 False Supervisory Lamps

The right cord lamp may light on through dial connection due to the (AS) relay releasing on the open period between dial pulses. The (AS) relay may also release if the central office operator, rings on a connection when the receiver is off the switchhook at the station.

8. ATTENDANT'S TELEPHONE CIRCUIT - FIG. 2

8.1 Answering or Talking on an Established Local Connection

Operation of the talk and dial key connects the attendant's telephone set across the cord circuit associated with the operated key. Condenser (S) in series with the induction coil is charged to the cord circuit potential and the receiver circuit is closed last by No. 1T contact of the (Talk and Dial) key to prevent a click being heard by the attendant when the key is operated. The primary circuit of the attendant's telephone circuit is closed over the "P" lead to energize the transmitter. The attendant now may talk to either station on the cord circuit.

Resistances (C), (D), (E) and (F), when Fig. M is provided, are connected in series with the two windings of retardation coil (A) under this condition to prevent taking too much current from the battery supply circuit of the left cord circuit.

8.2 Answering on a Trunk Connection

Trunk connections may be answered with the talk and dial key operated or by operating the talk and dial key on an established connection. In either case relay (BT) operates on battery from the trunk sleeve through the talk and dial key contacts and removes the battery and ground through resistances (C), (D), (E) and (F)

from the winding of retardation coil (A) to prevent interference with the central office circuit. The primary of the induction coil is energized over the "P" lead and No. 1T contact of the talk and dial key closes the circuit to the receiver last to prevent a click to the attendant.

8.3 Dialing

The attendant dials on outgoing trunk connections or on dial tie trunk connections with the "Talk and Dial" key operated. Upon the operation of the dial, relay (ON) operates, when the (BB-W) contact breaks, in series with the primary circuit of the attendant's telephone circuit and (1) closes the circuit to relay (SP), (2) short-circuits the attendant's receiver to prevent the attendant hearing clicks on the subsequent operation of the dial circuit and (3) connects resistance (B) in series with condenser (A) across the station end of the dial circuit. Further operation of the dial off-normal contacts short-circuits the tip and ring of the dial circuit to provide the minimum resistance loop possible to the central office.

Relay (SP) operated (1) locks up to the "P" lead, (2) splits the right end of the dial circuit from the left end leaving the telephone circuit connected to the station on the right end of the cord, (3) bridges the 1-2 winding of retardation coil (B) across the left (trunk end) of the cord, (4) bridges the 3-4 winding of retardation coil (B) in series with condenser (A) across the station and the induction coil, (5) connects battery and ground through retardation coil (A) to the station for talking and signaling battery supply after the dial restores to normal. At that time the station and attendant can talk to the central office through retardation coil (B) which then acts as a repeating coil. While the dial is off-normal resistance (B) is connected across the 3-4 winding of retardation coil (B) for purposes described later.

While the dial is restoring to normal contact Y-BK makes and breaks the pulsing circuit to the central office free of any series impedance or bridged capacity in the dial circuit. When the dial restores to normal it removes the short-circuit across the tip and ring of the dial circuit (1-2) winding of retardation coil (B) and short-circuits relay (ON) which releases. Relay (ON) released removes the short-circuit from the attendant's receiver and removes the (B) resistance from across the 3-4 winding of retardation coil (B). This combination of the dial, removing the short-circuit from the retardation coil on the 1-2 winding, and the (ON) relay removing the resistance shunt on the 3-4 winding prevents a false pulse to the central office due to the impedance of the retardation coil being connected in series with the line.

Subsequent operation and release of the dial causes the subsequent operation and release of the (ON) relay. When the complete code has been sent the attendant may restore the "Talk and Dial" key if the station remains on the connection or the attendant may wait until the called party answers and then ring the station in the usual manner.

8.4 Busy Test

8.41 On Central Office Trunk or Tie Trunk Connections

The attendant makes a busy test on central office trunk or tie trunk connections by touching the tip of the right cord to the called station jack. If the circuit is busy, ground on the jack will cause a click to be heard in the attendant's receiver due to the difference of potential between the tip of the cord and the sleeve of the station jack.

8.42 On Local Connections

On local connections with the right cord in the calling station jack, when the left cord tip is touched to the sleeve of a busy jack a click is heard in the attendant's receiver due to the difference in potential between the tip of the cord and the jack. The tip of the cord is above ground at this time due to the winding of retardation coil (A) in Fig. 2 and resistances (C) and (D) (Fig. M) being bridged across the cord, causing a current flow through the windings of relay (CS). The resulting click is sufficient for a busy test. Battery through the potentiometer consisting of resistances (C), (D), (E) and (F) does not interfere with this test.

8.43 On Idle Cord

In case a busy test is required with an idle cord Fig. M is provided. Resistances C, D, E and F provide a potentiometer which is connected to retardation coil A so as to provide a potential on the tip of the cord when the talk and dial key is operated. The usual busy test may be made with either the right or left cord.

9. BATTERY SUPPLY

Battery may be supplied to this PBX from either a 24 or 48 volt central office PBX battery feeder circuit a building battery or from a local battery at the PBX.

Battery is supplied to the cord circuit, telephone circuit and the various lamps in the PBX through the battery cut-off key. With this key operated to the "off" position, battery is disconnected from these circuits. Battery, however, remains connected

to long lines and long trunk circuits at this time, if they are provided, for use on night connections.

10. BUZZER OR AUXILIARY SIGNAL CIRCUIT

The adjustable volume control buzzer operates on ringing current when relays (NC) and/or (NL) operate whenever any trunk, station line, tie trunk or a cord lamp is lighted. The buzzer is silenced by operating the buzzer key to the off position. The buzzer will not operate when ringing current is being supplied by the hand generator and "A" option is used.

11. RINGING

Ringing current is generally supplied from a central office through a resistance lamp at the central office to number of PBX positions. The (AC) lamp is provided at the PBX to prevent a trouble ground on the ring side of a line or a short-circuit from excessively lowering the voltage to the other PBX positions.

Central office ringing current is normally supplied to the cord circuit ringing keys and the ringdown tie trunk circuits. In case of failure of the central office ringing supply, operation of the hand generator crank, when provided, automatically disconnects the central office ringing supply circuit and connects the hand generator directly to the cord circuits and the tie trunk circuits.

12. TIE TRUNK CIRCUITS

Tie trunk circuits may be provided for this PBX to connect to a dial PBX or to another manual PBX on an automatic signaling basis or on a ringdown basis. The description of the operation of the cord and telephone circuits with these tie trunk circuits is covered in the associated circuit descriptions.

13. MONITORING

The normal connection of the attendant's induction coil provides maximum efficiency for talking to a station or a central office trunk. This would, however, cause an undesirable loss when the attendant monitors on an established connection due to the bridging loss and the room noise picked up by the transmitter. The monitoring key opens the transmitter side of the coil raising its impedance to a satisfactory value for monitoring and preventing interference from room noise.

14. SPLITTING

Operation of the (splitting) key, with a Talk and Dial key operated, causes the operation of relay (SP). This disconnects the trunk end of the cord from the attendant's telephone circuit and the station end of

the cord permitting the attendant to talk to the station with secrecy. Talking battery for the station is provided through retard coil (A) and the trunk is held by retard coil (B) which is short-circuited by a contact of the "split" key. The attendant may reconnect the station to the trunk by restoring the (split) key. The talking circuit is then through retardation coil (B), until the "Talk and Dial" key is restored.

15. SLEEVE PROTECTION

Varistors (C) and (D) are provided to reduce the potential which would be impressed on the cord sleeve when a plug is removed from a jack. These varistors are of the point contact type using Germanium as the active element. Ordinarily the current flowing through the varistor when the associated relay is operated, is very low. (Less than 0.1 milliamperes.) Resistances (K) and (L) are connected in series with the associated varistors to reduce the current flow to max. 50 milliamperes in case the battery supply should, for any reason, become reversed.

16. The purpose of the M resistance in Fig. 2 is to reduce the intensity of clicks to the calling station when the attendant, after having completed a connection to a dial central office or after having split a connection reoperates the Talk and Dial key.

17. TRUNK CIRCUIT - FIG. 4 & 9

This circuit is equipped with a thermistor - Varistor combination in the ring up circuit which prevents false line signals from operating the trunk relay (R).

The 8A thermistor normally has a high resistance (over 50,000 ohms) but when ringing current is applied for approximately half a second or longer the resistance is reduced giving an operating path for relay (R).

Varistor (B) is provided for two purposes, (1) to provide a low resistance operating path for the thermistor, (2) to shunt relay (R) on one-half of the ringing current cycle so that relay (R) will operate steadily during the other one-half cycle.

Varistor (F) is provided for two purposes, (1) the shunt reduces the effective (heating) current through the thermistor due to dialing transients to such an extent that false relay operation is eliminated. (2) Protects Varistor (B) and thermistor (T) by offering a very high resistance on normal ringing and dialing voltages, but on very high transients and surges it's resistance becomes low so as to shunt the high voltage around the varistor and thermistor.

17.1 Incoming Call

When ringing current is applied to the trunk at the central office, one half cycle will flow thru condenser T, thermistor T, and varistor B and by-pass relay R, but the other half cycle will be blocked by varistor B causing the current to flow thru the secondary winding of relay R, thermistor T and condenser T to operate relay R. Relay R operated, (1) locks operated thru the primary winding and contacts of the jack, (2) lights the trunk lamp and (3) operates the auxiliary signal circuit.

17.2 Answering

A call is answered as described in Paragraph 6.2.

17.3 Outgoing Calls

Outgoing calls require that when the trunk plug is inserted into the jack, the ring spring shall be open until the tip spring starts to move to avoid possible short-circuiting of the tip and ring springs while the plug is entering the jack. This prevents a false pulse to the central office equipment. When the plug is fully seated in the jack the tip and ring conductor are extended to the cord circuit in the usual manner. Battery through resistance lamp (B) is connected to the sleeve of the jack to cause the operation of the cord relay. Condenser (T) in series with varistor (F) is bridged across the trunk in parallel with thermistor (T) in series with the secondary winding of relay (R). Varistor (B) and thermistor (T) because of their high resistance offer no interference to dialing. Condenser (T) prevents any D-C from affecting the resistance of either varistor (F) or thermistor (T).

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DEPT. 2233-HOD-PWS-PA