

**CIRCUIT DESCRIPTION**

**CD-65680-01**

**Issue 12-D**

**Dwg. Issue 12-D**

## **PBX SYSTEMS**

**NO. 507A OR 507B**

**STATION LINE, TRUNK, CONNECTING,  
TELEPHONE, RINGING, BUZZER AND  
2 WAY RINGDOWN TIE TRUNK CIRCUITS  
ARRANGED FOR USE WITH  
MANUAL OR DIAL CENTRAL OFFICES**

### **CHANGES**

#### **B. CHANGES IN APPARATUS**

<b>B.1</b>	<b>Superseded</b>	<b>Superseded By</b>
	In Fig. 20,	
	"G", 500L-3 (Manual) Tel Set	"ZF", 500LR-3 (Manual) Tel Set
	"H", 500M-3 (Dial) Tel Set	"ZG", 500MR-3 (Dial) Tel Set

#### **D. DESCRIPTION OF CIRCUIT CHANGES**

**D.1** In Fig. 20, "G", 500L-3 (Manual) Tel Set and "H", 500M-3 (Dial) Tel Set are superseded by "ZF", 500LR-3 (Manual) Tel Set and "ZG", 500 MR-3 (Dial) Tel Set, respectively.

**D.2** Fig. 8 is rerated to Mfr. Disc.

**D.3** Note 103 is rerated to Mfr. Disc.

All other headings under Changes, no change.

## 2. WORKING LIMITS

### 2.1 Max. Conductor Loop Resistance

Trk. Signaling 20~  
1200 ohms

Cent. Off. Trk. Supv.  
\*

\*The trk. conductor loop res. plus the max. station loop res. shall not exceed the central office sub. cond. loop res. less 22 ohms.

### 2.2 Max. Ext. Ckt. Loop

		Min. Voltage at PBX							
Local Connections		16V.	18V.	20V.	22V.	24V.	26V.	28V.	30V.
Station Signaling	Fig. A	150 $\omega$	240 $\omega$	330 $\omega$	420 $\omega$	510 $\omega$	600 $\omega$	690 $\omega$	780 $\omega$
	Fig. B or C	675 $\omega$	850 $\omega$	1000 $\omega$	1150 $\omega$	1300 $\omega$	1450 $\omega$	1450 $\omega$	1750 $\omega$
Station Supervision		900 $\omega$	1065 $\omega$	1230 $\omega$	1400 $\omega$	1565 $\omega$	1730 $\omega$	1900 $\omega$	2065 $\omega$
Station Transmission without Long Line Ckt.		220 $\omega$	260 $\omega$	300 $\omega$	335 $\omega$	375 $\omega$	415 $\omega$	450 $\omega$	490 $\omega$

### 2.3 Min. Insulation Resistance

Central Office trunk or individual station

Manual, Panel or Crossbar Area 20,000 $\omega$

Step-by-Step area 30,000 $\omega$

All stations combined

26V.  
4350 $\omega$

52V. (Max. PBX Voltage)  
8700 $\omega$

## 2.4 Tie Trunk Connections

Type of Ringing	Option	Max. Cond. Loop With Min. Ringing Voltage		
		60V.	75V.	95V.
1. Thru Blocking Condensers	S	1200 $\omega$	1700 $\omega$	1950 $\omega$
	T	7000 $\omega$	10000 $\omega$	12000 $\omega$
2. By-Passed Cond. or Rep. Coil or Relay or Direct	—	2000 $\omega$	3000 $\omega$	4000 $\omega$
	S	4500 $\omega$	7500 $\omega$	8000 $\omega$
3. Magneto Line 3 Bar Gen.	—	3000 $\omega$		
	S	7000 $\omega$		
4. Magneto Line 5 Bar Gen.	—		3600 $\omega$	
	S		8250 $\omega$	
Min. Ins. Res. 10,000 $\omega$				

## 2.5 Holding Range for Varistor Circuit

Type of Central Office	Max. Cent. Off. Sub. Cond. Loop Limit	Cent. Off Min. Volts	Max. Trk. Cond. Loop*	
			Opt. ZA, ZC	Opt. ZB
Manual Nos. 1, 1C, 1D, 10 and 11	635	20	200	450
	675	21	240	490
	785	20	305	600
	835	21	365	650
	1200	24	745	1050
Mach. Ring. #11			**	**
No. 9C and 12				

## 2.5 Holding Range for Varistor Circuit (Cont.)

Type of Central Office	Max. Cent. Off. Sub. Cond. Loop Limit	Cent. Off Min. Volts	Max. Trk. Cond. Loop*	
			Opt. ZA, ZC	Opt. ZB
<b>Panel</b>				
	635	21	220	450
	785	24.5	355	600
	885, 1000, or 1200	45	**	**
<b>Crossbar</b>				
No. 1			**	**
No. 5	1200	45	1045	**
<b>Step-by-Step</b>				
	635, 735 or 885	45	730	**
	735 or 885	48	830	**
	1200	45	1000	**
	1300	48	1100	**

\* For Loops which exceed these holding ranges the 1A Key Telephone Hold Ckt. may be used as shown in Figs. 102 and 103.

\*\* Not Limiting.

### 3. FUNCTIONS

- 3.01 To connect the attendant to any station or to a tie trunk circuit.
- 3.02 To connect the attendant to a central office.
- 3.03 To provide for attendant's dialing to dial central offices.
- 3.04 To hold the central office connection when the attendant disconnects.
- 3.05 To connect any PBX station to any other station or to a tie trunk circuit.
- 3.06 To supply talking battery on local connections.
- 3.07 To ring any station or the tie trunk circuit.
- 3.08 To connect any station or the tie trunk circuit to a central office.
- 3.09 To provide through dialing to a dial central office.
- 3.10 To provide for night connections to a central office.
- 3.11 To give a visible and audible line signal on incoming calls from a station, tie trunk circuit, or a central office trunk.
- 3.12 To give visible and audible supervisory signal on disconnect.
- 3.13 To give flashing supervision when a station recalls.
- 3.14 To give through supervision to a central office.
- 3.15 To give emergency magneto central office service in case of failure of the battery or ringing supply.
- 3.16 To give a steady visible and audible signal on rering from central office when the hold key is operated.
- 3.17 To provide means of cutting off the audible and visual signals on night connections.
- 3.18 To provide emergency ringing.
- 3.19 To provide an audible signal operated on ringing current.
- 3.20 To provide an audible signal operated on PBX battery.
- 3.21 To provide for silencing the audible signal with a foot operated switch.
- 3.22 To provide means for answering a trunk when all connecting circuits of the 507B PBX are busy (Mfr. Disc.)

#### 4. CONNECTING CIRCUITS

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

4.1 Standard Subscriber's Line Circuit in Manual, Panel, Step-by-Step or Crossbar Central Offices—SD-32133-01 (Typical).

4.2 Standard PBX Ringing and Battery Supply at Central Office—SD-90230-01 and SD-98232-01.

4.3 Emergency Transfer Key Circuit—SD-66451-01.

4.4 Two-way Trunk Circuit to Magneto Central Office—SD-66408-01.

4.5 Standard Ringdown Tie Trunk Circuits—SD-66401-01.

4.6 1A Key Telephone Systems — SD-69128-01 and SD-69129-01.

4.7 1A Key Telephone System Hold Circuit—SD-69091-01.

4.8 Auxiliary Line Circuit—SD-66475-01 (Typical).

#### 5. DESCRIPTION OF OPERATION

When a receiver is removed at one of the PBX stations, the lamp associated with the line lights over the station loop when Fig. A is specified. If the station loop is too great to properly light the lamp, Fig. B or C, line relay or a long line ckt. is specified. The line relay operates over the station loop and lights the line lamp through its front contact. If the night key is normal and the (BUZZER) key (Fig. 6 Mfr. Disc.) is in the "ON" position or (Fig. 22) is in the "ETS" or "ET" position, auxiliary relay (T) will also operate and close the auxiliary audible signal circuit as described later. The attendant answers the call by operating one of the station keys associated with the calling line position (A), (B), (C), (D) or (E) and a key of the same designation at the attendant's key circuit. This closes the tip and ring of the station line through to the attendant's telephone set. Talking battery is supplied through the retard coil of the same designation as the operated keys. The (A) condenser is bridged across the battery feed pair from central office. Operation of the station key extinguishes the station lamp and the auxiliary signal relay and also closes ground to the supervisory lamp in the interconnecting circuit through the back contacts of the supervisory relay. The supervisory relay, however, operates in series with the station loop or the attendant's telephone circuit and prevents the lamp from lighting. Due to the operate time of the relay and the adjustment of the station key, the supervisory lamp may flash at this time.

#### 7. CONNECTING CIRCUITS

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

## **6. CONNECTING TO A STATION**

To extend the call to another station the attendant operates a station key associated with the desired station to the same position as the operated attendant's key and station key. This connects the tip and ring conductors of the called station to the calling station and to the attendant's telephone. To ring the station the (R) key of the called station is operated and when the called party answers the connection is completed and the attendant restores the attendant's key.

## **7. DISCONNECTION**

Supervision on disconnection is controlled by the last station to disconnect since the supervisory relay is held from both stations. When the last party disconnects the supervisory relay releases and closes ground from the station key to the supervisory lamp, which lights. If the night key (N) is normal and the (BUZZER) key (Fig. 6 Mfr. Disc.) is in the "ON" position or (Fig. 22) is in the "ETS" or "ET" position the (T) relay will operate in series with the lamp and operate the auxiliary audible signal. Both station keys must be restored to normal before the supervisory lamp is extinguished.

## **8. OUTGOING CALLS TO MANUAL CENTRAL OFFICE**

8.1 The attendant may call the central office by operating one of the keys in the attendant's circuit to position (A), (B), (C), (D) or (E) and a key associated with one of the trunks to the corresponding position. This opens the local battery and the retard coil from the circuit and closes the tip and ring of the attendant's telephone to the central office and the call is made in the usual manner. The supervisory relay in the connecting circuit operates in series with the tip and ring but performs no useful function at this time.

8.2 To extend a station call to central office, a trunk key is operated to the same position as the operated station key. The attendant listens out by restoring the talking key in the attendant's circuit. The tip and ring of the station are then connected through to the central office and the call made in the usual manner. The supervisory relay in series with the tip and ring of the connecting circuit operates to prevent the supervisory lamp from lighting. The station may flash both the supervisory lamp at the PBX and the supervisory lamp at the central office and will operate both on disconnection. The supervisory lamp in the connecting circuit may or may not light before the central office operator answers, depending upon the resistance of the line relay at the central office.

## **9. OUTGOING CALLS TO DIAL CENTRAL OFFICE — ATTENDANT DIALING**

Outgoing calls to a dial central office are made in the same manner as to a manual central office as described in Paragraph 8 except that after dial tone is received the attendant dials the number. The supervisory lamp in the connecting circuit may flash during the dialing. If the attendant extends the call to a station after dialing, it will be necessary to listen in until the station answers or to operate the associated hold key (H) in order to hold connection. If the station has called the attendant to obtain central office, it will be necessary to restore the station key during dialing by the attendant.

## **10. OUTGOING CALLS TO DIAL CENTRAL OFFICE — THROUGH DIALING**

The attendant answers the station call as described before and then connects to the dial central office as in making a call to a manual central office. Before the station can dial the attendant must listen out by restoring the talk key. The supervisory relay in the connecting circuit may follow dial pulses and causes the supervisory lamp to flash. This condition will be readily recognized by the attendant. Supervision will be controlled by the station.

## **11. INCOMING CALLS FROM MANUAL OR DIAL CENTRAL OFFICE FIG. 7 (MFR. DISC.)**

The trunk circuit, Fig. 7, 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 3,000 ohms thus giving an operating circuit for relay (L1) from either side of the line to ground.

Varistor (L) is provided for two purposes, (1) to provide a low resistance operating path for the thermistor and (2) to shunt relay (L1) on one-half of the ringing current cycle so that the relay (L1) will operate steadily during the ringing period on the other one-half cycle.

(F) Option (Mfr. Disc.)

The (M) resistance limits the current through the (L) varistor when it is conducting, which lengthens the life of the (L) varistor. The (M) varistor permits a better current flow on

## **9. OUTGOING CALLS TO DIAL CENTRAL OFFICE —**



the one-half cycle which operates the (L1) relay (i.e., better than through the (M) resistance). The combination of the (M) resistance and (M) varistor limits the over-all current flow which in turn reduces the heating of thermistors, thereby increasing thermistor life and affording less chance of line unbalance and interference from induced voltage from excess and uneven thermistor heating.

(E) Option (Mfr. Disc.)

Varistor (D) is provided as a voltage limiting device to shunt any surge or transient voltage which might damage the (T & R) thermistors. Relay (L1) operated locks up through its front contact and the trunk keys and lights the trunk signal lamp through another front contact. The call is answered and completed in the usual manner.

### TRUNK SIGNAL CIRCUIT (FIG. 21)

The trunk circuit (Fig. 21) consists of a capacitor, thermistor, varistor and a relay winding bridged across the tip and ring of the line. If ringing current is applied to the tip and ring of the line at the central office, one half cycle will flow through the capacitor R, thermistor R and varistor R which shunts the secondary winding of relay L1. The other half cycle will be blocked by varistor R to cause the flow through the secondary winding of relay L1, thermistor R and capacitor R to operate relay L1. Relay L1 operated, (1) locks through its own contacts, and (2) lights the trunk lamp and operates the audible signal if connected. When the call is answered in the usual manner, the locking path (leads "A" and "B") for relay L1 is opened and relay L1 releases. Relay L1 released extinguishes the trunk lamp and silences the audible signal if connected.

Varistor D serves two purposes, (1) protects the thermistor R and varistor R and (2) shunts relay L1 to eliminate false signals. Varistor D has a very high resistance on normal ringing and dialing voltages, but on the high voltage transient and surges its resistance becomes low so as to shunt the high voltage away from the thermistor, varistor and relay.

Varistor R serves two purposes, (1) provides a low resistance operating path for thermistor R and (2) to shunt relay L1 on one-half of the ringing cycle so that relay L1 will operate steadily during the ringing period.

## 12. HOLDING AND RERING

A hold key (H) is provided at the bottom of each trunk key unit. Operation of this key connects a holding bridge across the trunk, consisting of an inductor and a varistor. The resistance of the varistor when it is used to hold a central

office trunk will be low but will increase to a relatively high value if the attendant neglects to restore the hold key after the trunk connection has been extended to a station which has its receiver "off hook." When the station is added in parallel to the holding bridge, the voltage across the bridge and the current through it decreases. This decrease in current causes the resistance of the varistor to increase since the varistor has a very high resistance at low values of current and decreases non-linearly to low resistance at high values of current. The inductor is necessary in series with the varistor to avoid undue transmission loss because the impedance of the varistor is low.

The hold key must be operated before the attendant's key is restored and when the attendant again listens in on the connection the hold key must not be released until after the attendant's key is operated. When the attendant's key is restored, the supervisory lamp in the connecting circuit will light if the station key is operated and will release when the station comes back on the connection. When the hold key is operated to hold a connection which has been set up on a talking path (E), that is, with trunk, talk and station keys operated to position (E), the central office connection may be released. This is due to the open period between the release of the trunk key (E) and the operation of (H) since in this case the trunk key has to be released because it is on the same key lever as the hold key. In the case of a manual central office this open period will flash the "A" operator's supervisory lamp, but in the case of an outgoing call to dial central office it may release the connection.

If the central office operator rings back on the connection, the station bells will ring provided the keys associated with the trunk and station are operated and the trunk lamp re-lights during ringing.

### 13. TIE TRUNK CIRCUIT

This circuit provides means whereby a ringdown tie trunk may be connected to a station in the PBX or to central office trunks. The tie trunk is terminated on the first station key of the PBX. This key is wired to the terminal strip in such a way that by strapping the proper terminals, a normal station key will result. For tie trunk operation the straps are cut, and the tie trunk unit is wired to the terminal strip. Talking battery is supplied on station to tie trunk connections through the positional battery supply circuit. The tie trunk is of the ringdown variety in which signals are transmitted from this PBX and in the reverse direction by 20 cycles signaling. The circuit between the two PBX's may be established through the toll plant and the line may or may not be equipped with

office trunk will be low but will increase to a relatively high value if the attendant neglects to restore the hold key after the

telephone repeaters or composite ringers. The (A) resistance connected to the "RN" and "TN" leads is provided as a balancing network for lines equipped with telephone repeaters in order to reduce the tendency for the line repeaters to sing when the circuit is idle at the PBX. On an incoming signal from the distant PBX ringing current through the varistors is changed to direct current to operate relay (L2). Relay (L2) locks up in series with the line lamp causing the line lamp to light when Fig. 11 is connected to Fig. 10. The call is answered by the attendant operating a key to position (A), (B), (C), (D) or (E) and a key of the same designation in the attendant's key circuit. This connects the attendant through the repeating coil to the line. Operation of a connecting circuit key in Fig. 10 causes the (G) relay in Fig. 11 to operate over the "T" and "R" leads from the positional battery supply. (G) operated short-circuits the locking winding of relay (L2) which releases, opening the circuit to the line lamp.

The tie trunk circuit can be used for terminating a magneto central office line except when night connections are required. The repeating coil in the tie trunk prevents ringing current from the central office reaching the station bell. Incoming night service from a magneto central office can be provided to a single station if an emergency transfer key (described in Paragraph 18) is provided in connection with a local talking battery common battery signaling station. Outgoing service can also be provided by equipping the station with a hand generator.

When the tie trunk circuit is used to terminate a magneto party line, the signal circuit is made nonlocking in order to distinguish code rings.

If the tie trunk is connected to an auxiliary line circuit arranged for terminating Railroad Company message or phantom circuits which are connected to lines equipped with train dispatching signaling apparatus, relay (S) Fig. 13 is provided in order to provide operation of equipment associated with the Railroad Company's equipment in the auxiliary line circuit. Relay (S) operates when a tie trunk key is operated and shorts the locking winding for relay (L2) which retires the line lamp in the usual manner in Fig. 10.

Connection is established to stations in the usual manner by operating the corresponding station key and ringing the station. When one of the station keys is operated, ground is placed on the "A" lead of the corresponding connecting circuit which causes the (F) relay in Fig. 11 to operate. (F) operated short-circuits the locking winding of (L2) and opens the circuit to (G) which releases and leaves a condenser bridge between the (4-3), (8-7) windings of the repeating coil.

Supervision is given to the attendant when the station answers, if the attendant's talking key is restored before the station answers, by the supervisory relay in the connecting circuit operating over the station loop from battery through the battery supply retardation coil.

Connections are completed to central office trunks by the attendant restoring the tie trunk key and dialing the connection in the usual manner through to the central office trunk. When dialing is completed, the attendant reoperates the associated tie trunk key which connects the tie trunk across the connection and the attendant may restore the attendant's talking key at this time. The central office connection is held under this condition by the bridge consisting of the repeating coil windings and the 190 ohm winding of relay (G). No supervision is given to the PBX attendant when the connection is completed unless the PBX operator at the distant end "rings off."

A ring-off signal from the distant end is similar to an originating signal except that the lamp is not locked up and restores when the distant end stops ringing.

On outgoing calls the attendant operates the ringing key on the tie trunk similar to ringing on a station connection. The operation of the ringing key disconnects all apparatus at the PBX from the line and applies ringing current directly to the line to operate the distant apparatus. Connections may be established to the tie trunk from central office trunks or from other stations in the PBX.

"T" wiring is provided to extend the range of this circuit when it is used with condenser type tie trunks with long loops. The ringing combination is connected from the midpoint of the repeating coil to ground. Ringing on either side of the line will operate relay (L2) in the usual manner.

## 14. NIGHT CONNECTIONS

A night connection is set up by operating a key in the station circuit and a key of the same designation in the trunk circuit. This connects the tip and ring of the station line through to central office with relay (L1) connected to the line and the supervisory relay in the connecting circuit is in series with the tip and ring of the line. Key (N) in the attendant's circuit must also be operated to remove the local battery from the lamps, line relays, auxiliary signal relay and D-C buzzer circuits. If desired, the attendant's telephone set may also be connected to the same trunk by operating the attendant's key of the same designations as the trunk key. On incoming calls the station bell will ring on ringing current from central office. Ringing will be tripped by the station. Care should be taken in

swers, if the attendant's talking key is restored before the station answers, by the supervisory relay in the connecting circuit operating over the station loop from battery through

not connecting too many stations to one trunk because the ringing bridges may adversely affect dialing and may cause false tripping of incoming ringing.

## **15. RINGING CIRCUIT**

Ringing current may be supplied from the central office or from a local ringing supply and is connected to the normally open contacts of the (R) key of each station through the resistance lamp. Operation of the (R) key rings the bell of the particular station connected to that key. In case of failure of the ringing supply the hand generator may be used to ring the bells.

## **16. AUXILIARY AUDIBLE SIGNAL CIRCUIT**

The (BUZZER) key (Fig. 6 Mfr. Disc.) in the "ON" position disconnects direct battery from the station line lamps, the trunk lamps and the connecting circuit supervisory lamps and connects them to battery through relay (T). When a trunk lamp, line lamp or connecting circuit supervisory lamp lights the (T) relay operates and closes a circuit to the audible signal. The audible signal operates through inductor (G) either from the A-C supply when Fig. 8 (Mfr. Disc.) or Fig. 20 is used, or from direct current when Fig. 9 is used.

The BUZZER key (Fig. 22) in the "OFF" position connects direct battery to the trunk, extension line and connecting supervisory lamps. Relay T will remain unoperated when any lamp is lighted and the operating path for the audible signal will remain open. The BUZZER key in the "ETS" position connects battery through relay T to the trunk, extension line and connecting supervisory lamps. Any lamp lighted operates relay T which closes the path to operate the audible signal. The BUZZER key in the "ET" position connects battery through relay T to the trunk and extension line lamps, and directs battery to the connecting supervisory lamps. Any trunk or extension line lamp lighted, will operate relay T which closes the path to operate the audible signal.

## **17. SIX BUTTON KEY TELEPHONE SET OPERATION (MFR. DISC.)**

17.1 To enable the attendant of a 507B PBX to answer a trunk when all the connecting circuits are busy, a six button key telephone set is connected as shown in Fig. 101. This telephone set is then specified for the attendant in place of the one shown in Fig. 8. For normal operation of the PBX and attendant's key circuit, the attendant must keep the sixth pick-up button depressed in order to connect the telephone set to the attendant's key circuit. When all the connecting circuits are busy and an incoming trunk call cannot be answered through

them, the attendant can answer the trunk with the telephone set by depressing the button associated with that trunk. The trunk lamp is retired by operating and restoring the (N) key. If the call is an important one, the attendant can reach the called station by breaking up the call on one of the connecting circuits and completing the call in the usual manner. For less important calls the attendant can answer the trunk as described above and then hold it with the trunk holding circuit. The attendant must remember to depress the sixth button to reconnect the telephone set to the attendant's key circuit before normal operation is resumed.

17.2 When the trunk loop exceeds the range over which the varistor hold circuit can be used, the 1A key telephone system may be connected to the PBX as shown in Figs. 103 or 102 and 104. This condition uses a telephone set with 5 pick-up keys and one hold key for the attendant in place of Fig. 8. In the connection shown in Figs. 102 and 104 the attendant can pick up the trunks by depressing the button associated with the desired trunk as described in Paragraph 17.1. To pick up the fifth trunk, however, all the keys in the attendant's key circuit must be normal in addition to the fifth pick-up key being operated. To hold a trunk which has been picked up, the attendant must depress the hold key on the telephone set. Once the fifth trunk is held by picking it up and depressing the hold key, the attendant's key may be moved off-normal without dropping the trunk. For normal operation of the attendant's key circuit and telephone set the fifth pick-up button must be depressed.

The connection in Fig. 103 shows less than five trunks being used. For this case the telephone set is connected to the attendant's key circuit through the fifth pick-up button. Trunks may be picked up by depressing the corresponding pick-up keys on the telephone set. Holding is accomplished by depressing the hold key after the trunk has been picked up. For normal operation of the attendant's key circuit and telephone set, the fifth pick-up button must be depressed.

## **18. EMERGENCY TRANSFER KEY CIRCUIT OPERATION**

Should there be a failure of the PBX battery or ringing supply when the PBX is associated with a magneto central office the emergency transfer key associated with this circuit is operated thereby providing emergency central office service from the station arranged for this service.

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them, the attendant can answer the trunk with the telephone set by depressing the button associated with that trunk. The trunk lamp is retired by operating and restoring the (N) key. If the