SAGE DATA TRANSMISSION SYSTEMS

GROUND-TO-AIR DATA SYSTEMS

TRANSMISSION ASPECTS OF VOICE CHANNELS

CONTENTS PAGE

1. GENERAL

1.01 This section describes the transmission features of the voice and signaling trunks of the ground-air radio communications equipment of the SAGE System. It is being reissued to include information on the interconnection of the SAGE and BUIC networks via a switched environment.

1.02 The SAGE Ground-Air Radio System permits personnel at a SAGE Region Control Center (RCC)* to talk with aircraft operating in their assigned area. Communication with the aircraft is established by radio from a series of ground stations (called radio sites) by either of two methods of operation: Common User Group (CUG) or Dual Facility (DF) terminal equipment. Wire lines for control and voice are provided between the radio site and the RCC. Wire lines interconnecting dual facility terminals will be point-to-point circuits. CUG terminals, however, may be interconnected on a point-to-point basis or via the AUTOVON switched network. Each radio site is equipped to handle as many as twenty-two 2-way radio channels. Up to 20 of these channels are for tactical or normal use; the other two, designated AICC and emergency, are for special operational use.

* Formerly known as a Direction Center (DC).

1.03 An alternate operation, backup interceptor control (BUIC), is provided by BUIC Norad Control Centers (BNCCs) in the event an RCC becomes disabled.

1.04 Figure 1 is a diagram of a typical RCC or BNCC and its radio sites. Frequently, one of the radio sites is located in the vicinity of the RCC or BNCC and the wire line connections are routed locally. Most sites which are located a considerable distance from the RCC are routed through AUTOVON. In order to provide maximum protection for these circuits, each of two different routes carries approximately one half of the trunks required between the RCC and each radio site.

1.05 Each voice channel, together with its control and signaling equipment, is provided on a 4-wire basis. Provision is made for automatic as well as manual switching to alternate channels in case of trouble or high noise level on the channel in use. Channel selection and alternate channel switching are provided through the use of dual facility equipment or common user group equipment.

1.06 The following drawings describe items of equipment referred to in this section:

(a) Dual Facility Trunk Equipment, SD-95805-01

(b) Patch Test and Alarm Panel, SD-69279-01

(c) Alternate Route Transfer Equipment, SD-1G084-01

(d) Remote Control Unit, SD-95803-01

(e) Ground-Air Testboard, SD-1G037-01

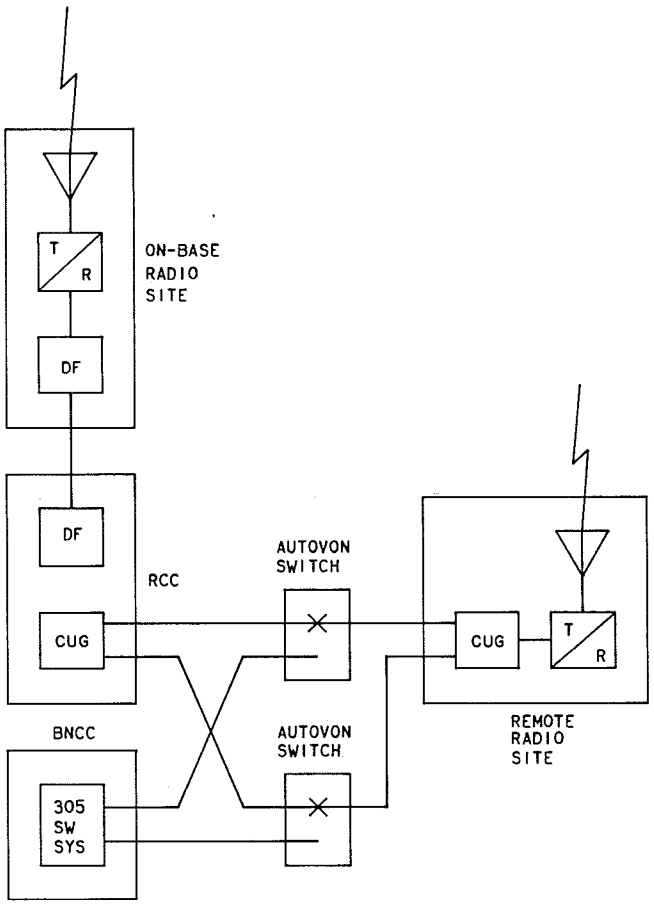


Fig. 1—Typical Configuration of RCC, BNCC, and Radio Sites

(f) Remote Radio Line, SD-1G176

(g) Local Radio Line, SD-1G177

(h) Transfer Circuit, SD-1G183

(i) Radio Monitoring Circuit, SD-1G179.

2. AIR-GROUND FACILITIES—TYPES AND DESIGN

2.01 Air-ground facilities are divided into three general categories:

(a) Point-to-point facilities—These are 2-point circuits interconnecting dual facility terminals or common user group terminals

(b) 4-wire subscriber lines—Common user group circuits appear as 4-wire subscriber lines into an AUTOVON office and the terminals are subsequently interconnected via the AUTOVON switched network

(c) BNCC radio lines—These lines appear as 4-wire subscriber lines into an AUTOVON office. They are dialed through the AUTOVON network to connect to the A/G circuits at the radio site when the BNCC is in control.

2.02 All 4-wire subscriber lines and some point-to-point circuits route via a dial restoration panel (DRP) at most SAGE and BUIC locations. The DRP serves as an access point for G/A circuits, PBX lines, data, and point-to-point G/A and data lines. The point-to-point circuits are routed through the DRP when the site served has AUTOVON switching capability. Sections 981-273-100 and 314-561-100 contain additional information on the DRP.

2.03 Dual facility circuits will not have access to the AUTOVON switched network and therefore will not appear at a DRP.

2.04 Certain SAGE locations may not have a sufficient quantity of circuits to justify a DRP. For these locatons, a transfer control unit or dial arrangement is provided.

2.05 SAGE-BUIC AUTOVON air-ground 4-wire subscriber lines are considered normal voice grade facilities and should be conditioned in accordance with Sections 309-200-300 and 851-100-103. The losses between CUG terminals and the serving AUTOVON office and for point-to-point operation are shown in Fig. 8 and 9. The levels for BNCC AUTOVON A/G radio lines are shown in Fig. 10.

2.07 Pads are adjusted at the drop side of the carrier equipment and at the line side of the CUG terminals to meet specified levels. The net losses between CUG terminals are constant whether the terminals are interconnected by point-to-point facilities or routed via the AUTOVON switched network.

3. DUAL FACILITY OPERATION

3.01 Figure 2 shows dual facility equipment at the RCC and similar equipment located at a radio site. Dual facility operation is the accepted method of operation when the radio site is in the same general area as the RCC. A dual facility terminal unit is provided at the terminals for each

of the 22 voice channels. Each dual facility terminal unit provides a regular and an alternate 4-wire voice and control trunk. Usually the regular 4-wire trunk has a geographical routing in the toll plant which is different from the routing of the alternate. Associated with the dual facility terminal unit at the radio site are a radio transmitter and receiver. At the RCC, the dual facility terminal unit is controlled by an intercept director console. The arrows in Fig. 2 show the direction of signaling and voice communication on the individual trunk pairs.

3.02 Signaling and control features on the trunks are provided by 43A1 carrier telegraph equipment using a voiceband "slot" technique as discussed in 6.01. In the normal condition, ie, the regular 4-wire trunk in use and no voice communication taking place, the 43A1 carrier telegraph equipment maintains a pilot tone of 2670 Hz on the trunks outgoing from the RCC and 2500 Hz on trunks outgoing from the radio site. Loss of the pilot tone, due either to the opening of the speech path or to failure of the signaling equipment, gives an alarm indication at both ends of the circuit. This indication is used at each end to automatically switch to the alternate trunk. If the alternate trunk is in use, the switch is made to the regular trunk. A control is provided at the intercept director console which permits the operator to manually switch to the alternate channel in the event that noise or other interference renders unsatisfactory communication on the regular channel. Note that this alternate switching can take place only between the trunks associated in the same dual facility terminal unit.

3.03 The other control and signaling features are provided by the 43A1 carrier telegraph equipment using the frequency shift technique. In the center-to-radio site direction, the frequency shift from 2670 to 2600 Hz (channel 14 in the 43A1) turns on the radio site transmitter and provides a visual indication. In the other direction, the frequency shift from 2500 to 2430 Hz (channel 13 in the 43A1) provides an indication of receiver CODAN operation or a transmitter "carrier on" indication.

4. COMMON USER GROUP OPERATION

4.01 Common user group equipment puts all trunks to a given site in a common pool available to all operating consoles or to all radio receivers. A maximum of forty 4-wire trunks is provided. Figure 3 shows common user group equipment at an RCC and at an associated radio site. The 22 radio channels at the site are all connected to the common user group terminal, as are the 23 consoles at the RCC. For each radio site, the RCC will have one common user group terminal. As previously mentioned, CUG terminals may be interconnected on a point-to-point basis or via the AUTOVON switched network.

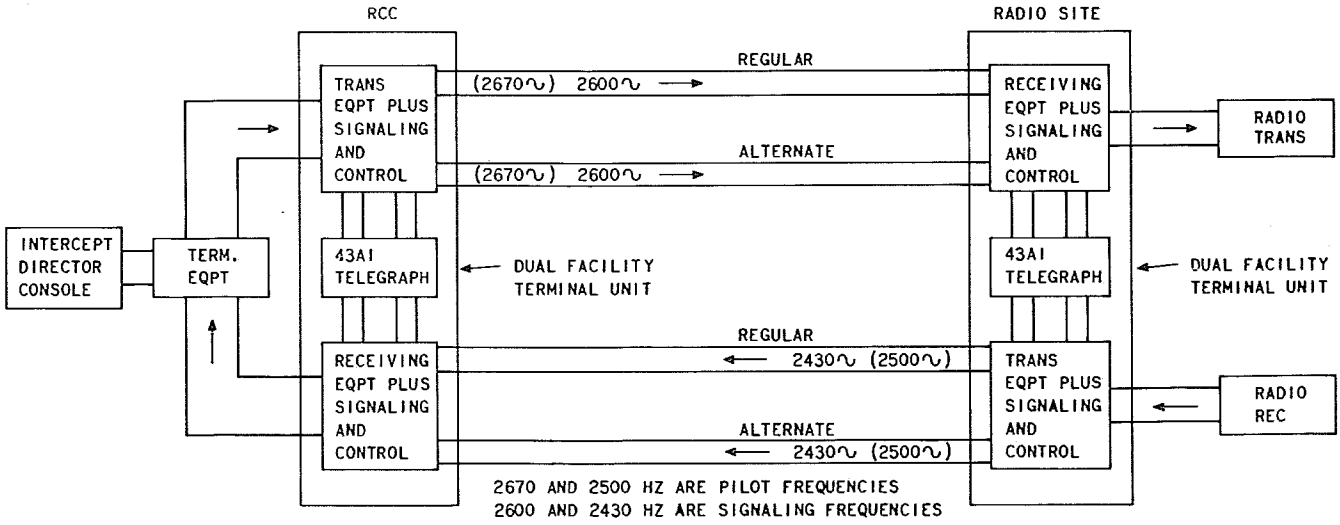


Fig. 2— Dual Facility Operation

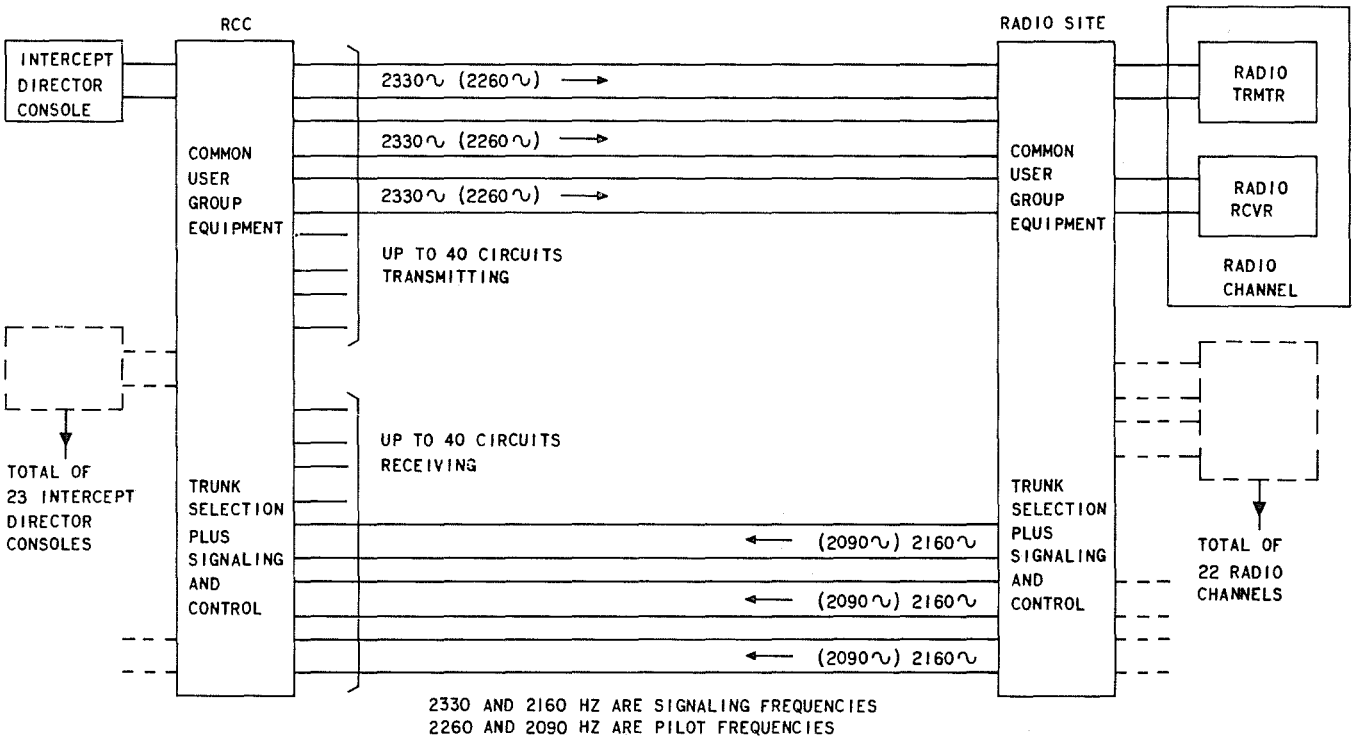


Fig. 3—Switched Network Common User Group Operation

4.02 The control and alternate trunk switching operations associated with the common user group equipment are identical with those of the dual facility equipment, except that the signaling frequencies of the 43A1 carrier are changed when operation over the AUTOVON switched network is required. This is necessary to disable echo suppressors and permit full duplex operation.

4.03 For switched network operation in the RCC-to-radio site direction, the frequency shift from 2260 to 2330 Hz (channel 12 in the 43A1) turns on the radio site transmitter and provides a visual indication. In the other direction, the frequency shift from 2090 to 2160 Hz (channel 11 in the 43A1) provides an indication of receiver CODAN operation or a transmitter "carrier on" indication.

4.04 In a connection from a console to a radio site, a site selection button at the console is operated. This causes the trunk selection circuit in the common user group equipment to hunt for an idle 4-wire trunk and connect it to the console position. When this is connected, a code for the particular channel wanted is sent to the equipment at the radio site. This code at the radio site connects the particular trunk with the radio channel corresponding to the code. Once the connection is made, operation is the same as described in 4.03.

4.05 A call from an aircraft operates a CODAN relay in a radio receiver at the site. This causes the common user group equipment at the site to hunt for and connect to an idle 4-wire trunk to the RCC. A code signal is sent over the trunk to the equipment at the RCC. This signal selects the desired channel and operates the CODAN lamp at the assigned console. With the connection complete, operation is the same as before.

4.06 In case of a trouble or an unsatisfactory circuit, switching is made to any other 4-wire trunk in the route which may be idle. This is done automatically by either the 43A1 telegraph pilot tone and the common user group switching equipment or manually from the intercept director console.

5. SAGE/BUIC OPERATION

5.01 The 305 Switching System at a BNCC is designed to provide emergency control of

SAGE radio sites by the BNCC in the event an RCC is disabled.

5.02 The 305 Switching System provides a maximum of eight radio channels each, at up to ten radio sites. Access is provided to five tactical channels plus the A1CC and an emergency channel.

5.03 Transfer of control of the A/G circuits from the RCC to a BNCC is controlled at the site DRP. The operator must release the circuits to the RCC and redial to the BNCC. The radio site contains equipment for bypassing a portion of the CUG equipment when the BNCC is in control.

5.04 A radio monitoring circuit is provided for air/ground calls at the 305 attendant console in the BNCC. The circuit permits selective monitoring of received signals from one or more sites simultaneously over the position loudspeaker. The attendant may also monitor through the headset. The monitoring is accomplished via a high-impedance bridge.

6. TRANSMISSION CONSIDERATIONS

A. Inband Signaling

6.01 The SAGE ground-air equipment uses the 43A1 carrier telegraph for signaling and control. Pilot tones or control tones are present on working trunks between the RCC and the radio sites at all times. To prevent interaction between the voice and telegraph currents, a "slot" technique using band rejection filters is used. Figures 4 and 5 show part of the terminating equipment and arrangement of the 43A1 carrier telegraph terminals at an RCC and at a radio site. Figure 4 will apply for dual facility operation. Figure 5 depicts CUG equipment used in conjunction with the AUTOVON switched network.

6.02 As indicated in Fig. 4, for dual facility operation, pilot tones of 2670 and 2500 Hz are transmitted between 43A1 terminal equipments when the trunks are in idle condition. When the trunks are in use, the signaling and control operations are indicated by shifting the 43A1 tones to 2600 and 2430 Hz, a shift of 70 Hz in each case. The 202E and 202F band elimination filters (Fig. 6), tuned to frequencies midway between the pilot and the control and signaling tones, provide about 34 dB of attenuation to the 43A1 tones. This prevents the signaling and control frequencies from interfering with the speech. When the voice currents are transmitted, the filters provide attenuation of 2 dB or more over a voiceband about 300 Hz wide centered on 2465 Hz for the 202F filter and on 2635 Hz for the 202E filter. At the telegraph frequencies of 2430 and 2600 Hz, these filters provide 34 dB of attenuation to the voice currents and prevent interference with the telegraph receiver.

6.03 As previously stated, the operation of CUG equipment shown in Fig. 5 is identical to dual facility operation except for the frequencies of the 43A1 carrier. In CUG operation, signaling and control functions are indicated by shifting the 43A1 tones to 2090 and 2260 Hz, a shift of 70 Hz in each case. The 733A and 733B filters prevent the signaling and control frequencies from interfering with the speech.

6.04 The band elimination filters reduce the quality of the voice transmission from that which might be expected with normal 3000-Hz band transmission. This produces a transmission impairment of approximately 2 dB. In other words, removing the 300-Hz signaling band is equivalent to an increase in circuit loss of about 2 dB for voice facilities having cutoff frequencies above 3200 Hz. For facilities having cutoff frequencies about 3000 Hz and below, the transmission impairment will be about 1 dB.

6.05 The output level of the 43A1 carrier telegraph transmitter is maintained at a level of 21 dB below the voice signal level at the point in the circuit where the telegraph signal is applied. This relatively low level for 43A1 carrier telegraph is required to make the 202- and 733-type filters effective in the telegraph-to-voice direction and to ensure optimum noise performance when used on compandored toll facilities. A continuous tone, such as that provided by the signaling features of the 43A1 carrier telegraph, opens the compandor and increases the line noise level detected at the output of the channel unit. The carrier telegraph tone level selected for the SAGE air-ground system is the maximum level suggested. An increase in this level on a compandored system such as N carrier may increase the output noise sufficiently to cause complaints.

6.06 The A/G circuits between the radio site and the BNCC make use of the 43A1 carrier

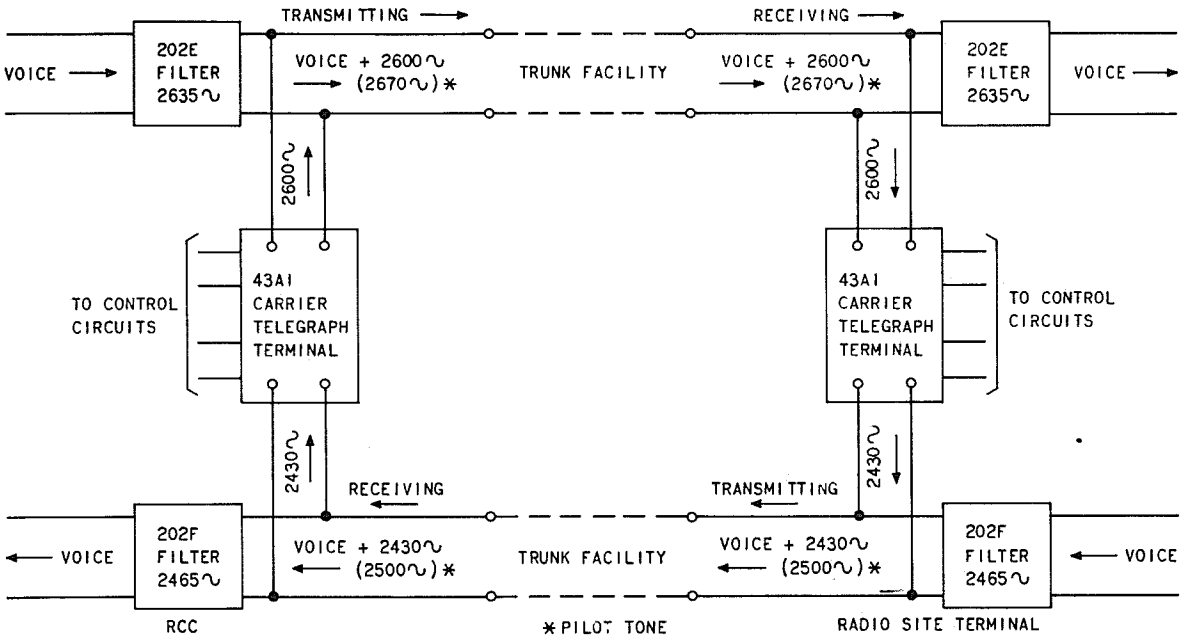


Fig. 4—Slot Signaling in the Voiceband—Dual Facility or Non-DRP Common User Group Operation

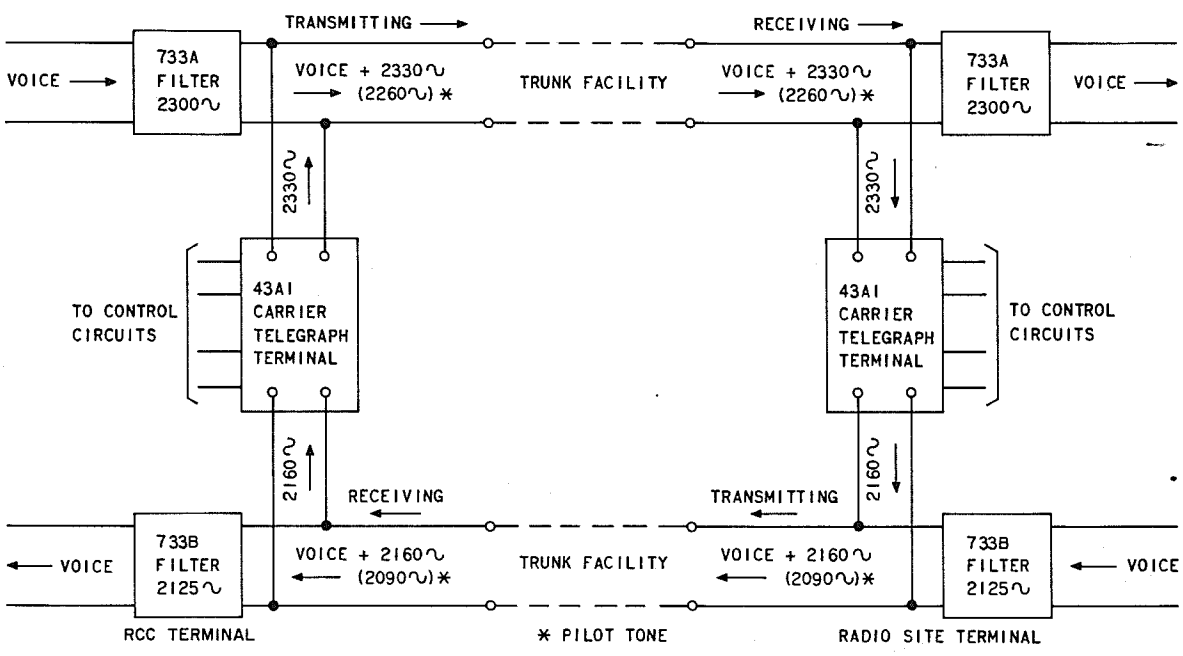


Fig. 5—Slot Signaling in the Voiceband—Switched Network Common User Group Operation

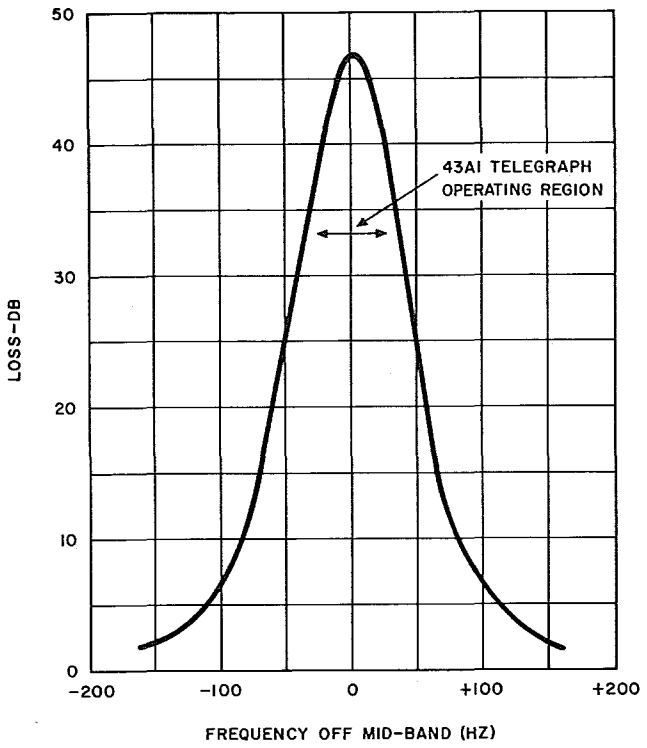


Fig. 6—202E, 202F, 733A, or 733B Filter

system for signaling. The carrier level is −21 dBm referred to a 0 TLP.

6.07 The nominal carrier center frequencies are 2295 Hz transmitting and 2125 Hz receiving referred to the BNCC. Band rejection filters are used at both ends to remove the 43A1 tones from the voice path.

B. Circuit Losses and Line Levels

6.08 Table A shows the 1000-Hz loss, between 600 ohms, expected in the transmitting and receiving terminals of the dual facility and common user group equipment. These losses are taken between the input and output terminal of the dual facility or common user group equipment and include a small allowance for wiring loss.

TABLE A

	TRANS. TERM. LOSS	REC. TERM. LOSS
Dual Facility Unit	4 dB	2 dB
Common User Group Equipment	1 dB	1 dB

6.09 Table B shows the 1000-Hz losses found on the 4-wire facilities between the RCC and the radio sites. These assume that the AUTOVON trunks in a common user group switched connection are zero loss. The losses of Table B are also based on the use of 2-wire attendant telephone circuits when in the air-ground mode. This is the case where 112A key equipment per SD-69261-01, Fig. 1 or 27, is used.

TABLE B

	LOSS BETWEEN DUAL FACILITY TERMINALS	LOSS BETWEEN COMMON USER GROUP TERMINALS
RCC to Off-Base Radio Site	——	10 dB
Off-Base Radio Site to RCC	——	5 dB
RCC to On-Base Radio Site	10 dB	——
On-Base Radio Site to RCC	5 dB	——

6.10 The loops from the telephone building at the off-base radio site to the radio transmitter and receiver buildings (Fig. 9) should have as small a 1000-Hz loss as possible. This loss should be low enough so that indicated levels may be met and also provide some margin for adjustment of the T and R pads.

6.11 Figure 7 shows the layout when the radio site is collocated with the 305 Switching System at a BNCC. The levels between the two systems are adjusted by 1C pads located in the local radio line circuit SD-1G177, Fig. 1. These pads were provided so that allowances could be made for outside plant loss where Fig. 1 and 2 were in different buildings. Because of the system levels when transmitting from the 305 System, there is only a 2-dB allowance for the loss of the repeating coils in the circuit and for the outside plant loss. However, since these loops will not use carrier facilities and because the radio transmitter has a compressor in its input, it is felt that the outside plant loss could go as high as 7 dB before external gain would be required in this direction

of transmission. Note that the allowable loss (before gain is required in the other direction of transmission) is 9 dB.

6.12 Figures 8 and 9 show levels that should be provided at various locations when the radio sites are a considerable distance from the RCC (off-site) and common user group equipment is used at the trunk terminals. Figure 10 illustrates the equipment arrangements and levels for SAGE/BUIC operation. As indicated in Table B, the loss between common user group terminals for switched and point-to-point operation should be the same. Pads are adjusted at the drop side of the carrier equipment and at the line side of the CUG terminals to adjust for appropriate levels at the DRP and the CUG equipment. Further adjustments are then made at the T and R pads to produce specified levels at the radio transmitter and receiver.

7. REFERENCES

7.01 The following is a list of sections and other related information on the equipment and systems mentioned in this section.

SECTION	EQUIPMENT/SYSTEM
314-550-ZZZ	SAGE Data Transmission Systems
314-553-100	Ground-to-Air Data Systems—Description
314-555-ZZZ	Air-Ground Voice Communication System
314-561-100	Dial Restoration Panel for SAGE

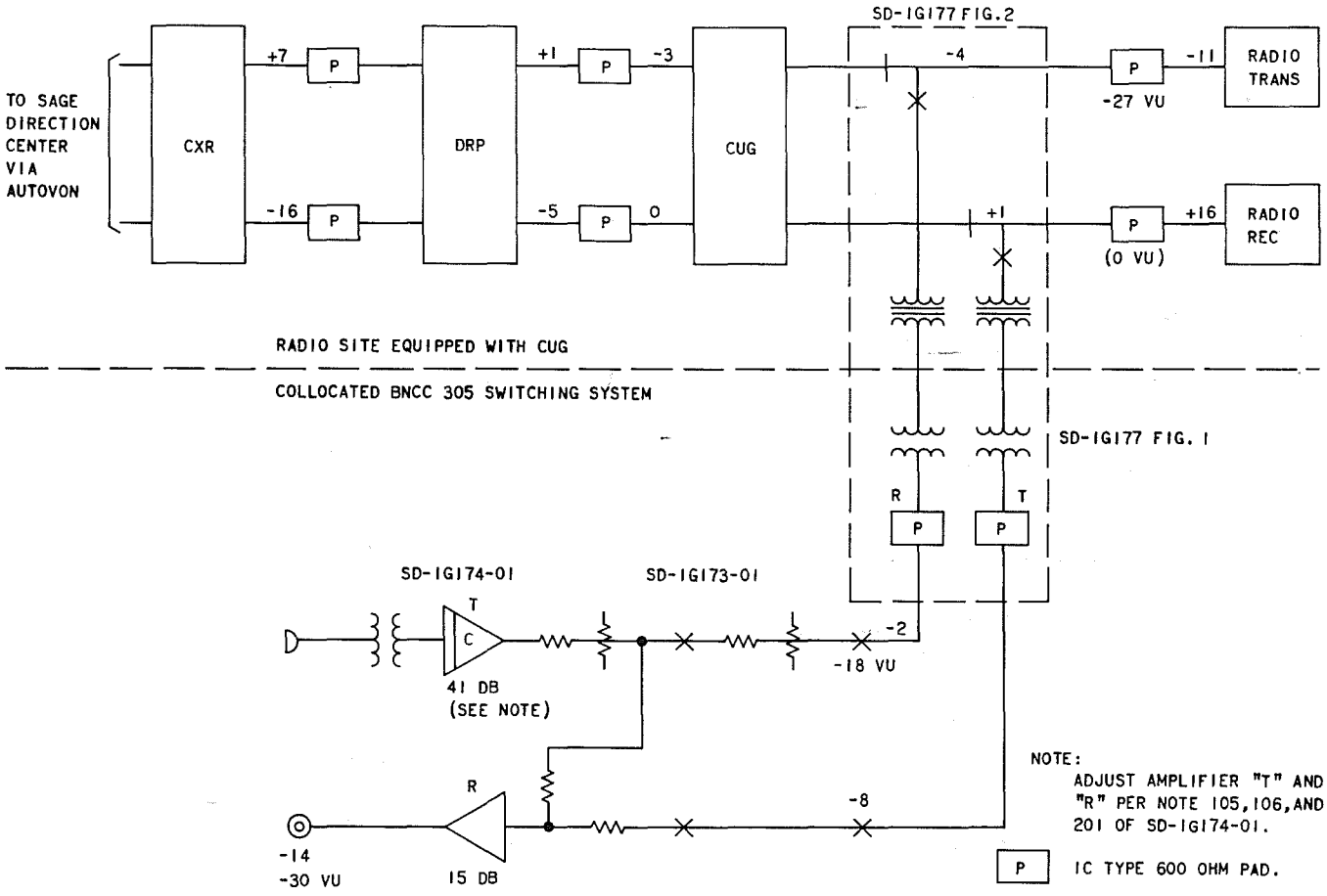
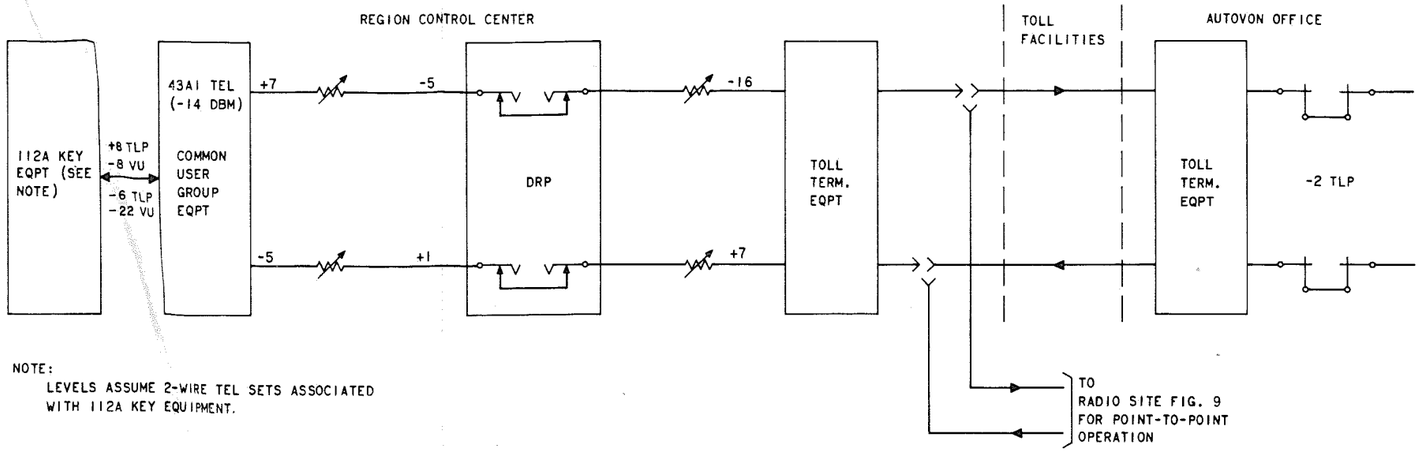


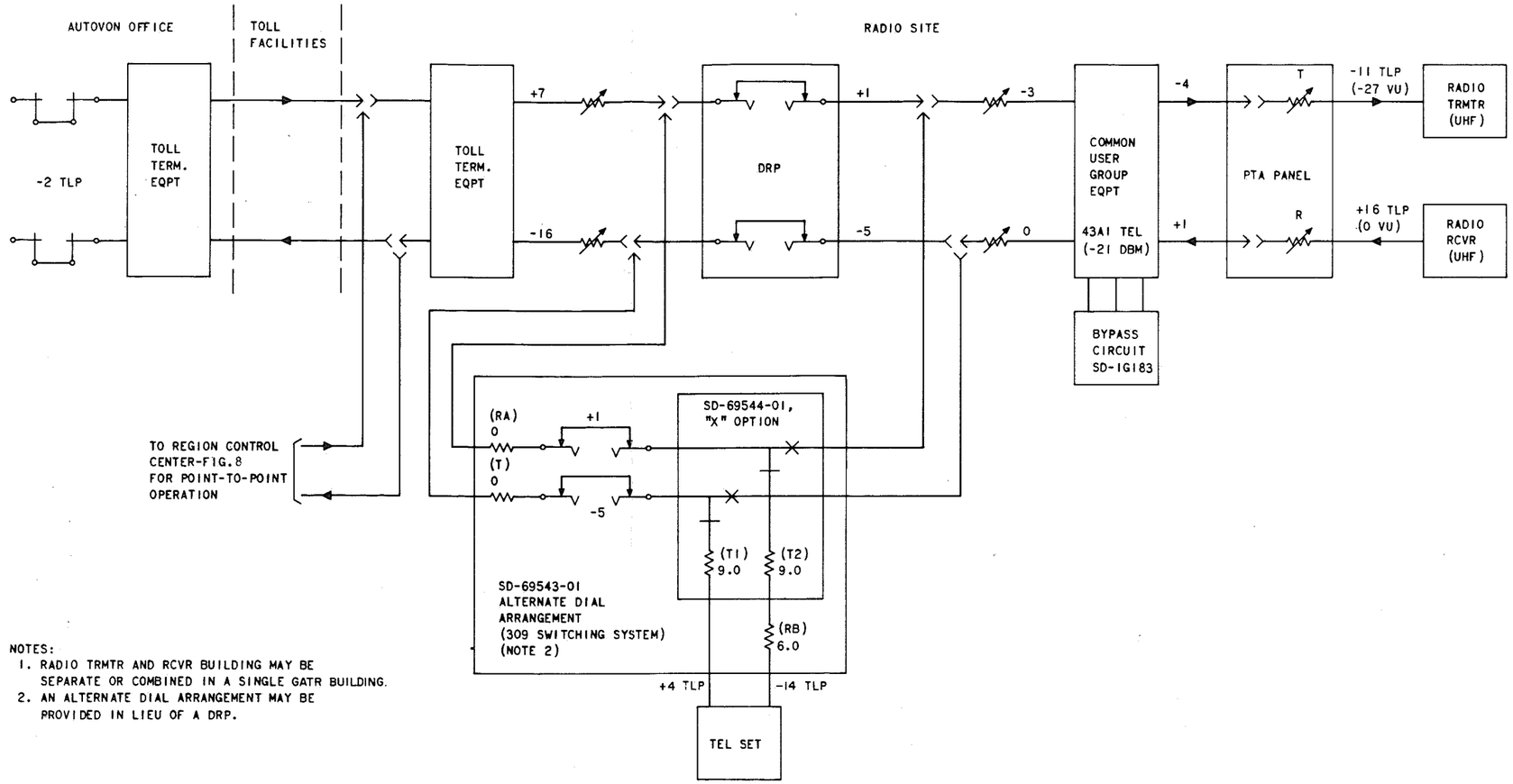
Fig. 7—BNCC Collocated at Radio Site with Access to 7 of 22 Local Radio Frequencies via the 305 Transfer Circuit

SECTION	EQUIPMENT/SYSTEM	SECTION	EQUIPMENT/SYSTEM
480-510-ZZZ	112A Key Equipment	981-273-100	Dial Restoration and Auxiliary Control for SAGE/BUIC III
981-201-100	SAGE/BUIC Phase III	E.L.15	SAGE/AUTOVON—305 Switching System—Transmission Plan
981-207-ZZZ	No. 305 Switching System		
981-271-100	Dial Restoration Panel (AUTOVON)	E.M.1442	SAGE/AUTOVON CUG Tones



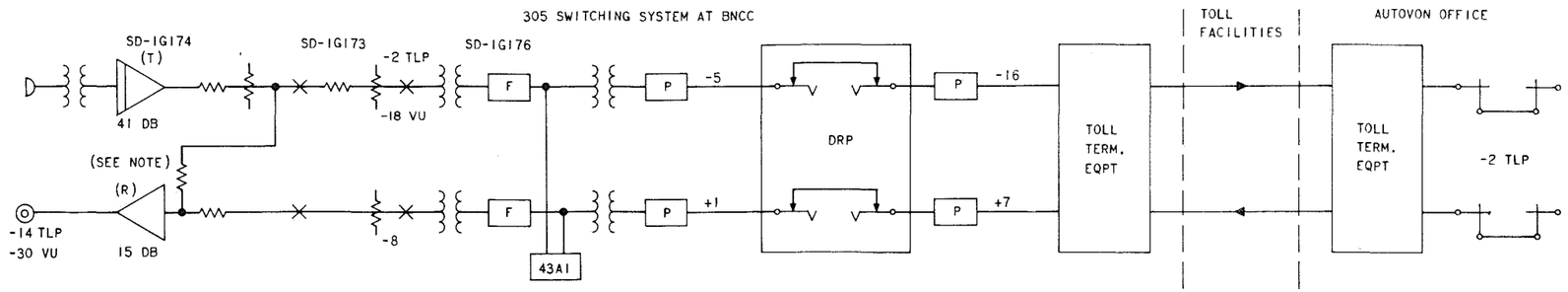
NOTE:
LEVELS ASSUME 2-WIRE TEL SETS ASSOCIATED WITH 112A KEY EQUIPMENT.

Fig. 8—Levels for CUG Equipment at a Region Control Center



NOTES:
1. RADIO TRMTR AND RCVR BUILDING MAY BE SEPARATE OR COMBINED IN A SINGLE GATR BUILDING.
2. AN ALTERNATE DIAL ARRANGEMENT MAY BE PROVIDED IN LIEU OF A DRP.

Fig. 9—Levels for CUG Operation at a Radio Site



NOTE:
ADJUST AMPLIFIERS "T" AND "R" PER NOTES 105, 106, AND 201 OF SD-1G174-01.

F 43A1 SLOT FILTERS

P 1C TYPE 600 OHM PAD

Fig. 10—Levels for 305 Switching System Remote Radio Line Circuit at BNCC